Store and forward teledermatology

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ABSTRACT

Store and forward and real time or videoconferences are the two types of teledermatology services practiced. Dermatology and radio-diagnosis are visual specialties suited for store-and-forward teledermatology (SAFT). Advances in information technology, electronic instruments and biotechnology have revolutionized and brought changes in SAFT. Cellular phone, digital camera, personal digital assistants, Wi-Fi, Wi-Max and computer- aided-design software are incorporated to deliver the quality health care to remote geographic regions. Complete SAFT care equivalent to face-to-face consultation (Gold standard) is essential. Health care providers in rural areas are the 'eyes' for the consultants. Consultants to guide them should have a rapid periodic audit of visual parameters and dimensions of lesions. Given this background, this article reviews advances in 1) capture, store and transfer of images. 2) Computer Aided measurements of generalized and localized lesions and 3) the integration model to meet all the above two requirements in a centralized location. This process enables diagnosis, management, periodic assessment and complete follow-up care to achieve patient and physician satisfaction. Preservation of privacy and confidentiality of digital images is important. Uniform rules and regulations are required. Indian space research organization (ISRO), Government of India has demonstrated telemedicine pilot projects utilizing the satellite communication and mobile telemedicine units to be useful in meeting the health care needs of remote and rural India. we have to join hands with them to meet dermatology problems in rural areas.

Key Words: Teledermatology, Store and forward, Capture, Transfer, Measure

INTRODUCTION

The World Health Organization defines telemedicine as practice of healthcare using interactive audio, visual and data communications. It includes transfer of medical data, consultation, diagnosis and treatment, education and health care delivery. Telemedicine reduces travel, waiting time, treatment costs, minimizes follow-up visits and delivers specialty healthcare services to remote geographic regions.

Telemedicine is divided into:

1. Real time or videoconference and
2. Store and forward (SAF) system.

Real time or videoconference teledermatology (VCTD)

The dermatologist analyzes the patient by direct interaction using audio-video signals similar to face-to-face consultation through the videoconferencing equipment in the presence of a general practitioner or nurse. Diagnostic accuracy of VCTD ranges from 54 to 80%[1] (compared to face-to-face consultation considered as gold standard). Videoconference

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teledermatology achieves high levels of physician and patient satisfaction compared to store-and-forward teledermatology (SAFT), as there is direct and two-way interaction.

Store and forward teledermatology (SAFT)

The SAF stores patient data (digital images, clinical and demographic information) sent by general practitioners (GPs) in an electronic medium for future access by consultants in referral centers to deliver quality healthcare in remote geographic regions. Simultaneous presence of the clinician is not required. SAFT compared to VCTD is cheap, convenient for the healthcare provider with a high level of accuracy, however, it lacks the immediacy of direct patient contact.

Complete SAFT care equivalent to that of face-to-face consultation is essential. Given this background, the article reviews developments in 1) capture, store and transfer of the images, 2) computer-aided measurements of generalized and localized lesions and 3) the integration model to meet the above two requirements in a centralized location. This process enables diagnosis, management, periodic assessment and complete follow-up care to achieve physician and patient satisfaction.

Electronic devices, transfer medium and software used to capture, transfer and measure the skin images respectively are classified as follows:

Capture: Digital camera, cellular phone and personal digital assistants.

Transfer: Internet, Wi-Fi, Wi-Max and satellite communication (satcom based telemedicine network).

Measure: Computer-aided design (CAD) software

Developments in capture, store and transfer of skin lesions have been taking place by leaps and bounds.

CAPTURE

Skin imaging for SAFT care has shown rapid progress. The availability of cost-effective photographic equipment and quick electronic transfer of high quality digital images favors SAFT. Digital cameras, cellular phones and personal digital assistants (PDA) promote capture, store and transfer.

Digital camera

SAFT uses digital camera with an average 640 x 480 pixels image resolution; a diagnosis agreement of 68%,[2] 89%,[3] 58%[4] and 48%[5] has been documented. The images are rapidly transferred[1] and stored in JPEG (Joint photographers expert group; http://www.jpeg.org) format using the internet. Diagnostic agreement varies from 41 to 95%.[6] It is low (48%)[5] for cutaneous malignancies. Poor image quality, lack of referral proforma data and cutaneous malignancies that are often difficult to diagnose with face-to-face contribute to poor agreement. SAFT promotes follow-up care in wound management by periodic monitoring of slough (concordance 84.6%), necrosis (concordance 98.2%) and granulation tissue formation (concordance 76.4%).[7]

Cellular phones

Inbuilt digital camera and networking features enable capture and transfer. Cellular phones[8] and Personal digital assistants[9] allow taking good quality images and sending them to the expert from remote geographic regions via a wireless network e.g., global system for mobiles (GSM) and universal mobile telecommunication system (UMTS). New generation cellular phones allow to take good quality images and transmit them directly to other cellular phones (via multi media messages) and computers (via e-mail or bluetooth wireless connection).[8] Cellular phones have a high potential to improve patient care as immediate image access and direct interaction are performed. A feasibility study[8] confirmed the importance of cellular phone in telemedical wound care. In 5% cases insufficient quality of images (after e-mail transfer) are noticed.[8] Transfer of skin images using cellular phones with a diagnosis agreement of 70% is documented.[10]

PDA

Laptops, handheld computers that are convenient to handle and offer combined features like camera, computing and networking are called PDA.[9] Massone *et al*[9] demonstrated the importance of PDA in teledermatology with a 79% diagnosis agreement.

TRANSFER (FORWARDING DATA)

The various media of data transmission are Internet, Wi-Fi, Wi-Max and Satellite communication (satcom-based telemedicine network), Digital lines called 'Integrated services digital network' (ISDN) have data-carrying capacity or bandwidth from 128 kbps to 256 or 384 kbps.[1] Wi-fi and Wi-Max are super speed wireless network connections that enable high-speed transmission of the data. Wi-Fi is wireless fidelity that enables connections to mobile devices, digital camera, computers and personal digital assistants. Wi-fi uses radio waves and needs radio transmitter called router and receivers called access points (hotspots).The speed is 6Mbps. Superior to Wi-Fi is Wi-Max (worldwide interoperability for microwave access). It is a broadband wireless access technology providing super speed access at 70 mbit/s. Speed of the transfer medium is important for rapid and easy retrieval of large data. Therefore, a telemedical center should have Wi-Fi or Wi-Max installation for quality and speed of data transmission.

Satellite communication (Satcom-based telemedicine network)

Satellite connectivity is the feasible solution being demonstrated currently by the Indian space research organization (ISRO).[11] Cost-effective and rapid connectivity are achieved with satellite communication to reach inaccessible geographic regions where connectivity cannot be established through ISDN. Very small aperture terminals (VSAT) are used for this purpose. The complex network management is performed with a wide antennae installation called hub.

Developments in computer-assisted measurements of generalized and localized lesions

Assessment of melanoma by topodermatographic image analysis[12] and digital imaging of cutaneous lesions[13] are the early reports of measurements in digital imaging. Computer-aided image analysis to assess the extent of psoriasis,[14] computer-assisted planimetry from color photographs[15] and computer color segmentation methods[16] were developed. They[14-16] involve time-consuming processing of photographs and are technically demanding. To overcome these disadvantages CAD mapping[17] and SCORAD card[18] (Scoring of atopic dermatitis) are proposed. They are rapid and practical. Computerized wound measurements are calculated after digital imaging. Tables 1 and 2 summarize the developments[17-27] in computer-assisted measurements of generalized and localized lesions respectively.

The integration model for quality healthcare in remote areas[28]

Healthcare professionals in rural areas are the 'eyes' for the

Table 1: Summary of the developments in Computer Aided Measurement of Generalized Lesions.

Author / Year	Contribution	Software	Model	Principle
Kanthraj *et al.*[17,20], 1997and 2005	Computer Aided Design (CAD) mapping method to determine Body Surface Area involvement in psoriasis, vitiligo.erythroderma, and Atopic dermatitis	CAD	Auto CAD Auto DESK Sanrafael CA, USA	Proportionate graphical representation of involved area, automatic calculation and expression of values in percentage
Kanthraj et al.[19]1999	Non occlusive (open) method to quantify the scale protein loss in erythroderma	CAD	Auto CAD Auto DESK Sanrafael CA, USA	Noting total Body Surface Area, involved area by CAD Mapping Method, Scale lost per unit area, protein content per gram of scale
Tanaka et al.[16] 2000	Computer image analysis for Psoriasis	C++	Turbo C++, Ver1.01 (Borland)	Shade correction and image analysis
Tripodi et al.[18,21] 2003 and 2005	Computerized transposition of SCORAD (Scoring of atopic dermatitis)	SCORAD Card©	TPS Production Rome, Italy	Similar to CAD method

Table 2: Summary of the developments in Computer Aided Measurement of Localized Lesions

Author/ Year	Contribution	Soft ware	Model	Principle
Smith *et al.*[22] 1989	Measurement of Venous ulcer	BBC micro Computer	Acorn computers Ltd. Cambridge. UK	Contact (Direct) tracing with a sonic digitizer and measurement
Solomon *et al.*[23] 1995	Measurement of Venous ulcer	Frame grabber	Media grabber version 2.2 software. Rasterps corporation CA, USA	Record video image, capture and computer analysis followed by correction for limb convexity
Kanthraj *et al.*[24] 1998	Measurement of Wound and vitiligo	CAD	Auto CAD, Auto Desk Sanrafael CA, USA	Tracings followed by measurement (area and perimeter)
Rajbhandari *et al.*[25] 2002	Measurement of various ulcers	Design CAD 97	Viacrafix corporation, Pryor, UK	Digital imaging and measurement
Samad *et al.*[26] 2002	Measurement of venous ulcers	LUTM software, Release version 1.36	SAA Soft Ltd., UK	Digital imaging, measurement and periodic monitoring of wound regression on an in built graph
Moore *et al.*[27]	Wound measurement	Visitrak Software	Visitrak, Smith and Nephew, UK	Wound tracing and Digital plannimetry to measure area and perimeter
2005 Kanthraj,[28] 2005	Integration model for telemedical wound measurement and care	CAD	Auto CAD, Sanrafael, California, USA	Functional integration of electronic devices and software to capture, transfer, measure and follow up with minimal human intervention

expert. Computerized measurements are rapid, easy, precise and well suited for SAFT.

Inter and intraobserver variations in computerized measurements occur during capture of images. Mapping or tracing error could occur due to human intervention. To overcome these shortcomings the integration model is proposed.[28] This involves the systematic functional integration of electronic devices and software to capture, transfer, store, measure and follow up with minimal human intervention to deliver complete teledermatology care. Broadly it can be applied for a) generalized and b) localized lesions. The concept of the integration model is illustrated in Figure 1.

SETTING UP A TELEDERMATOLOGY CENTER[11]

Video-conference teledermatology

The hardware consists of a) computer b) video conferencing equipment c) and communication hardware.

Computer: It consists of desktop PC or Laptop (patient end), Desktop/Rack mount server at the telemedicine specialist counter (specialist end). Personal digital assistants or palmtops can also be used. Ideal computer— Pentium IV or above models with 512 MB of RAM having large hard disc (>10 GB) and 19" high-resolution monitor.

Videoconferencing equipment: Details are summarized in Table 3.

Communication hardware

i) Terrestrial: LAN (local area network), WAN (wide area network), ISDN, Internet.

ii) Wireless satellite: VSAT, wireless LAN, CDMA, GSM, GPRS.

We recommend readers interested in setting up a teledermatology center to go through the telemedicine manual.[11] The specific guidelines and recommendations for practice of telemedicine are recommended by the Indian Space Research Organization (ISRO) (www.isro.gov.in).

Mobile telemedicine unit

To benefit the grassroots population of rural India, ISRO and the ministry of information technology, Government of India have taken initiative towards health and education.[11] They have developed a mobile telemedicine unit. It operates using

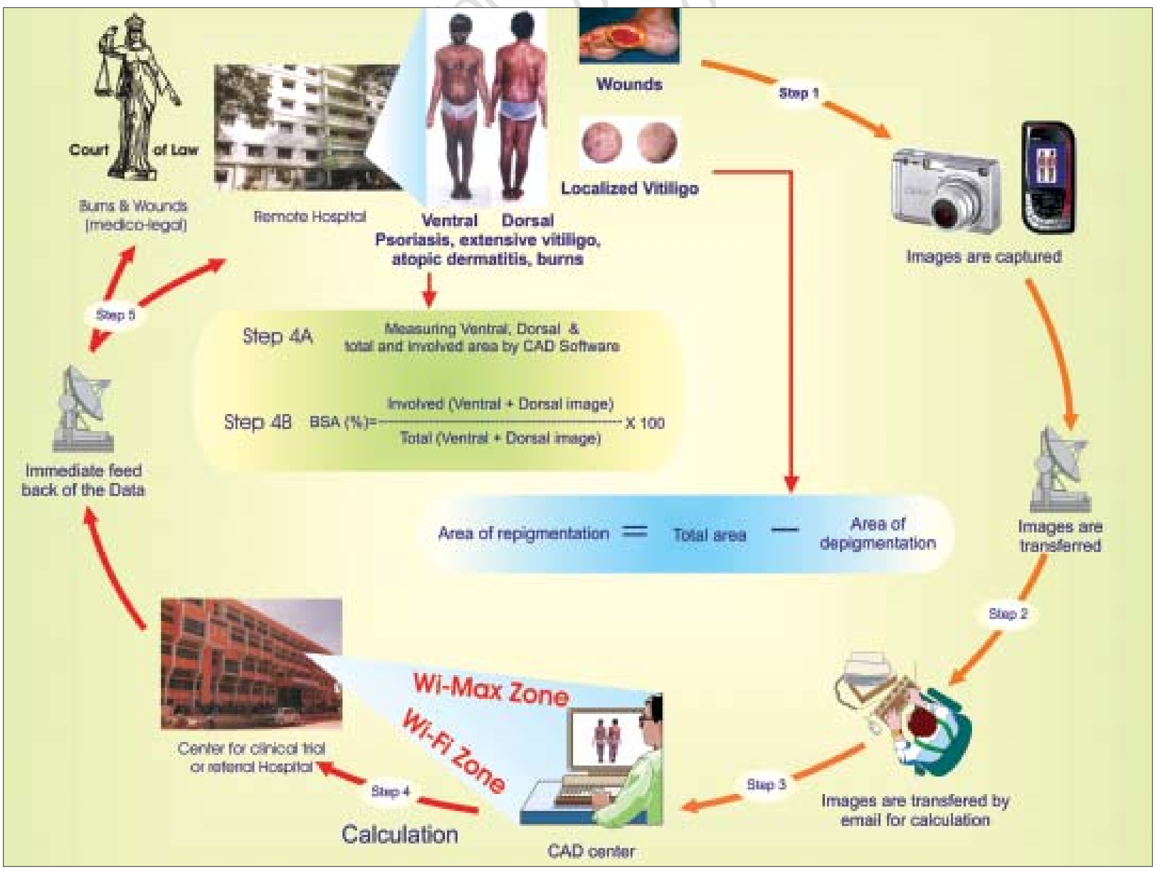

Figure 1: The integration model to capture, transfer, measure and follow up skin lesions (generalized and localized), to deliver SAF teledermatology care

Table 3: Summarize the type of videoconference, their components and cost-effective ness in setting a videoconference teledermatology center

Type	Components	Cost
Stand-alone VC	video codec with built in camera (pan, tilt and zoom), built in micro phone and audio-video interfaces to connect line/network interface ISDN/LAN	Expensive
PC based VC with PC add-on card codec	PC, web camera with built in microphone with audio/video output to connect ISDN/LAN	Moderately expensive
PC based VC with in-camera codec*	Built in video-camera is connected to the PC through USB port	Less expensive
PC based VC using web camera and software*	Video codec function (audio-video compression and data formatting) is done using software loaded on PC. A web camera is connected to PC using a USB port	Cheapest

*To connect to multimedia projector and achieve large display VGA/XVGA out put of the PC may be used

the satellite communication technology. It consists of telemedicine hardware, software and VSAT system mounted on a bus or a van. It can establish mobile telemedicine in any place.

The organization, functioning and beneficiaries of SAFT center[20,29]

They are illustrated in Figure 2. Incorporating CAD into the

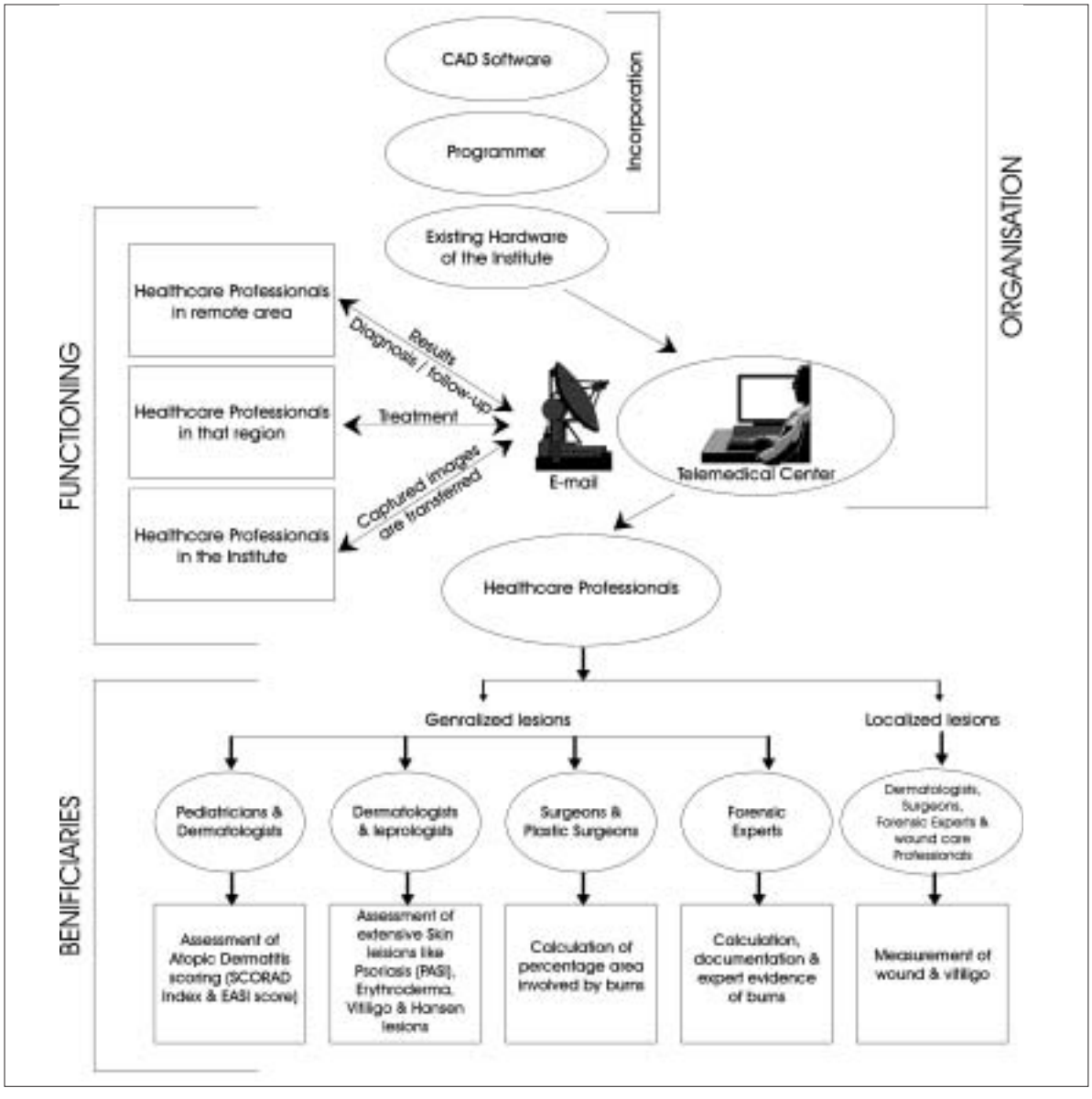

Figure 2: Organization, functioning and beneficiaries of a store-and-forward telemedical center. Modified with permission Kanthraj GR. Pediatr Allergy Immunol 2005;16:182-183. © Blackwell publishers, Oxford, UK

existing hardware of the institute avoids additional investment. Second, the existing computer programmer has basic CAD knowledge and there is no additional requirement of a new CAD programmer. The role of healthcare professionals is to capture and send the images and the programmer does the calculation and provides the results to dermatologists in the telemedical center. Business process organization (BPO) or computer professionals process without additional burden to the clinician. Therefore healthcare professionals at the telemedical center need not undergo training.

There is a delay to review the SAF consultation.[6] A referral hospital can have a fixed time on a day. The consultant can study the case with measurement as illustrated in the integration model [Figure 1] before commencement of a teledermatalogy clinic. Relevant discussions are made, as both ends are prepared. Patient, general practitioners or nurse available in the given period, can interact by e-chat or webcam or voicemail for any clarifications required from the consultant. Whited *et al*.,[6] from the economic perspective of the United States Department of veteran affairs, observed SAFT to be costly. However, Zelickson *et al*.[30] noted SAFT to be cost-effective in nursing home settings.

Table 4: Tele-medicine Glossary

JPEG	Joint photographers experts Group: Digitization of full color image. Applies for still image as in World Wide Web and store and forward teledermatology.
TIFF	Tag image file format PC and UNIX workstations support TIFF format. Currently owned by Microsoft.
MPEG 2	Moving pictures experts Group 2. Motion picture compression used in video conferencing teledermatology
HTML	Hyper text Markup Language: Portable and simple structured text document commonly used in World Wide Web.
DICOM 3	Diagnostic imaging and communication in medicine. It is for image data storage and transmission.
PIXEL	A picture element. The smallest component of an electronic picture.
RAM	Random access memory. Part of computer system where data are temporarily stored.
CCD	Changed couple Device. An array of photosensors that detects light and produce electronic signals.
INTERPOLATION	Digital image processing system to modify the image size.
UMTS	Universal mobile telecommunication system. A mobile technology programme.
GSM	Global system for mobile phones. Popular cellular phone technology enables international roaming.
BLUE TOOTH	Wireless connection to a computer, mobile phones, and laptops for exchange of data. (Blutooth; http/ / www. Bluetooth.com)
GPRS	General packet radio service. is a mobile data service to users of cellular phones.
CDMA	Code division multiple access. A mobile technology programme.
PDF	Portable Document format to send documents/ Articles are part of telemedicine education.

The process illustrated in Figure 2 and the multi-disciplinary approach makes CAD, SCORAD and SAFT accessible and economical for the healthcare providers.[20,21,31] They utilize these in a centralized location maximizing their utility and generalizability.

Imaging and the law

Photographs form important medico-legal evidence and play a vital role in the maintenance of dermatology records.[32] It has its special significance as digital images are used to capture, store, measure, transfer and deliver follow-up care. The image measurement is important for medico-legal evidence.

The US federal courts have ruled that digital images can furnish sufficient medical data to provide dermatological care.[32] The JPEG images [Table 4] are generally sufficient rather than tag image file format (TIFF), hence storage in JPEG can be produced in the court of law.[32] Preservation of privacy and confidentiality of digital images in the era of teledermatology is important.[1,33] Uniform rules, regulations and guidelines to capture, transfer, store and measure have to be framed in the interest of the patient, physician and government.

It may be possible that the referral center doctor is liable to be sued for mistakes made in diagnosis and management based on data and images alone. The legal principles of face-to-face consultation apply to any form of consultation.[1] A dermatologist must be conscious of the limitations of the equipment. In such cases when diagnosis is not sure they may offer differential diagnosis or no diagnosis and request for face-to face consultation and investigations to confirm the diagnosis.

Future directions

The mobile units utilize the V-SAT system developed by ISRO and are useful in HIV care, counseling, education and handling difficult dermatology cases in rural India. Under the GRAMSAT (Satellite communication-based technology for rural India) program ISRO has initiated several telemedicine pilot projects in 2001 specific to the needs of rural India.[11] It covers remote corners of Jammu, Kashmir, Ladakh, Andaman, Lakshadweep, northeastern regions and tribal districts like Chamarajnagar in Karnataka. A study revealed 81% cost saving in the Chamarajnagar district hospital, Karnataka using the SATCOM-based technology.[11] There is drastic reduction in travel cost that otherwise patients would have to incur while traveling to the neighboring districts. Such projects are useful in meeting the healthcare needs of remote and rural India. We have to join hands with the government and ISRO to answer the dermatology problems at the grassroots level of rural India.

On the other hand utilizing the integration model we should focus on computerized transposition of psoriasis, atopic dermatitis and vitiligo scoring system for periodic severity assessment and to deliver quality healthcare. The significant advantage in SAF is its ability to facilitate blinding in comparative studies. Wound care experts monitor as well conduct clinical trials in remote geographic regions.

Research in teledermatology is progressing in an arithmetic ratio (in additions) while advancement in information technology is progressing in geometric ratio (in multiples). High *et al*.[2] have cautioned that rapid technological advancement can render the existing technology obsolete before completion of traditional large-scale studies. We have to accelerate teledermatology research to deliver quality healthcare to remote geographic regions.

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MULTIPLE-CHOICE QUESTIONS

1. All of the following are true with respect to videoconference (real time) teledermatology except
   a. Direct interaction
   b. Good physician and patient satisfaction
   c. Expensive
   d. Simultaneous presence of clinician is not required
2. In SAF teledermatology which of the following is not a transfer medium?
   a. Internet
   b. Wi-max
   c. CAD
   d. Wi-fi
3. Poor diagnostic agreement between SAF teledermatology and face-to-face consultation (gold standard) occurs due to
   a. Poor quality of images
   b. Lack of referral proforma data
   c. Cutaneous malignancies are often difficult to diagnose even with face-to-face consultation
   d. All of the above
4. In geographic areas where land network is not available telemedicine network is established by
   a. Satcom
   b. ISDN
   b. E-mail
   d. Wi-Fi
5. Which of the following is true for Wi-fi
   a. Wireless fidelity
   b. Uses routers to transmit radio waves
   c. Receivers at access points (Hot spots)
   d. All of the above
6. The acronym Wi-max stands for
   a. Wireless maximum
   b. Worldwide inter operability for microwave access
   c. Super speed Internet access
   d. None of the above
7. The integration model aims to achieve
   a. Capture, transfer, store, retrieve and measure the lesion
   b. Measure generalized and localized lesion to deliver follow-up care
   c. Eliminate inter and intraobserver variability by minimizing human intervention
   d. All of the above
8. Cellular phones have a potential to improve patient care due to
   a. Capture and transfer of images with a good diagnosis agreement
   b. Immediate image access
   c. Direct interaction
   d. All of the above
9. GRAMSAT is
   a. Covers Health and education program to remote regions
   b. Telemedicine network project utilizes satellite communication
   c. Initiated by ISRO
   d. All of the above
10. Telemedicine is made accessible and economical by
   a. Multi-specialty sharing the technology under a centralized location
   b. Incorporating advanced software to the existing hardware of the institute
   c. Training the existing computer professional
   d. All of the above

ANSWERS TO MULTIPLE CHOICE QUESTIONS

Answers: 1. (d), 2. (c), 3. (d), 4. (a), 5. (d), 6. (b), 7. (d), 8. (d), 9. (d), 10. (d).