Telehealth: a perspective approach for visceral leishmaniasis (kala-azar) control in India

Gouri Sankar Bhunia¹, Shreekant Kesari¹, Nandini Chatterjee², Vijay Kumar¹, Pradeep Das¹

¹Department of Vector Biology and Control, Rajendra Memorial Research Institute of Medical Sciences (ICMR), Patna, Bihar, India, ²Department of Geography, Presidency University, Kolkata, West Bengal, India

Visceral leishmaniasis, also known as kala-azar, is a vector borne disease caused by the protozoan parasite, *L. donovani*. Poor and neglected populations in Indian sub-continent are particularly affected by this disease. Due to the diversity of epidemiological situations, no single diagnosis, treatment, or control will be suitable for all. Control measures through case findings, treatment, and vector control are seldom used, even where they could be useful. Modern tools like telehealth, using space technology, have now come in handy to address issues of disease surveillance, control checking, and evaluation. The present study focuses on telehealth as a current vector control strategy, perspectives on diagnosis, treatment, and control of visceral leishmaniasis as these deserve more attention and research.

Keywords: Visceral leishmaniasis, Telehealth, Disease control

Introduction

Visceral leishmaniasis (VL), also known as kala-azar in India, is a systematic protozoan parasitic disease that is caused by obligate intra-macrophage protozoa, transmitted by the female phlebotomine sandfly.^{1,2} VL is potentially lethal if untreated, and it is transmitted from animal to vector to human (zoonotic) in the Mediterranean countries, or from human to vector to human (anthroponotic) in the Indian sub-continent. Typically, patients with VL suffer from fever, cough, abdominal pain, diarrhea, epistaxis, splenomegaly, hepatomegaly, cachexia, and pancytopenia. The control measures directed against the insect vectors have been unsuccessful, therefore early detection and treatment of human cases remain as the most important strategies to reduce case deaths. There is also a lack of well-designed studies evaluating diagnosis, treatment, and prevention or control intervention of VL.

In India, VL assumes serious dimensions in Bihar, West Bengal, Jharkhand, and eastern Uttar Pradesh.^{3,4} The spraying of insecticides helped control kala-azar. But there are reports of vector *Ph. argentipes* developing resistance.⁵ Though the disease is focal in distribution, it is reported that VL mainly affects the rural economy characterized by low human

development and poverty,⁶ with the people living in villages situated far from roads and health care centers. The incidence of kala-azar in India is among the highest in the world; nearly 25 000–30 000 cases and 200–300 deaths are reported every year (Bihar State Health Society, India). VL also adversely affects productivity and welfare. In India, VL often exists in areas that are either remote, or not easily accessible, and where health facilities are inadequate. Patients from such communities often die in the villages without seeking treatment. Some may report to distant health care centers, but often, it is too late. Even they go to a hospital; they would still succumb to the illness because of the absence of the antileishmanial drug. Kala-azar has always been a critical issue in the last few decades. The conversion of traditional health strategies to telehealth is a giant, but unavoidable step. Evidences from several countries prove that the use of information and communication technologies by both individual citizens and health care providers improves access to care, increases satisfaction, and supports access to a vast amount of biomedical and health information.^{7,8} However, the mass use of telehealth application is not yet achieved.

The current hyperbole surrounding telehealth suggests that it is a revolution in the delivery of health care. The term telehealth as well as the specific boundaries for possible applications is difficult to define, as the technological tools and systems are consistently

Correspondence to: Pradeep Das, Department of Vector Biology and Control, Rajendra Memorial Research Institute of Medical Sciences (ICMR), Agamkuan, Patna 800007, Bihar, India. Email: drpradeep.das@gmail.com

changing. Telehealth enables continued education, allowing such educated health professionals, despite location and distance, to contribute to a better interdisciplinary and overall expansion of knowledge.^{9–12} According to Reid,¹³ telehealth means the use of advanced telecommunication technologies to exchange health information and provide health care services across geographic, time, social, and cultural barriers. Telehealth is frequently associated with definite and in people mind using television, computers, radio, Internet, videotapes, and fax machine.¹⁴ The association is understandable because this is the present, commonly used communication media and this allows telehealth to be currently grasped by people.¹⁵ The people in India, particularly in rural and remote areas, where VL is predominant, are struggling to receive timely medical treatment. The region of the country is characterized by poor, densely populated communities, and higher illiteracy spread over vast distances, and there is a lack of expert physicians in certain sector of the services.^{16,17} Many telemedicine projects in India have been developed with aid from Indian Space Research Organization (ISRO) in collaboration with local health professionals (doctors) and local authorities. No studies have been developed for vector borne and/or infectious disease control programs. Therefore, systematic and regular collaboration with the local authorities and leaders is essential to comprehending the problems and difficulties.

Telehealth applications in VL, including epidemiological surveillance, remote sensing, and geographical information system (GIS) may be innovative, strategic technical fields for the study of high priority disease outbreak, detection, and control. The technology provides the means for integrating and analyzing diverse data sources in a spatio-temporal context. This approach supports the development of predictive models and timely intervention. However, telehealth solutions must not be enforced from outside and grafted onto the health system, but they may serve as instruments for strengthening the social cohesion of the professional group and increasing the consciousness of the poor and illiterate rural people thus enabling the control of the disease at the microlevel. The present study focuses on the relevant aspects of telehealth and its application in VL control programs.

Method

We searched for peer-reviewed literature on telehealth using several bibliographic databases. In addition, searches for leading telemedicine journals were conducted and key papers were identified from the reference lists of the journal articles. For the original evidence report, a search was developed and designed to find all publications about telehealth. Databases and literature resources from MEDLINE,

CINAHL, HealthSTAR, NHS, PubGet, Scopus, ERMED, J-GATE, and PubMed were accessed. Also, added studies were identified from the reference lists of included papers and from online Internet searching of peer-reviewed telehealth publications: *Journal of Telemedicine and Telecare*, *Telemedicine and e-Health*, *International Journal of Telemedicine Application*, *IEEE Transactions on Information Technology in Biomedicine*, and *International Journal of Healthcare Technology and Management*. For more reports, we reviewed our original search results and identified studies relevant to our research perspectives, especially on VL. Further, we searched through telemedicine reports and compilations, including their reference lights, as well as Internet sites.

The Challenges

There are many challenges facing the successful control and eradication of VL.¹⁸ In India, VL is transmitted mainly in rural areas and the transmission is going on unabatedly (e.g. shimming transmission). Owing not only to the complexity and diversity of transmission patterns, but also absence of health care settings, control of VL in India will indeed be challenging. HIV co-infection in some endemic areas of kala-azar in India is being documented.¹⁹ However, evidently disease can be cured properly.^{20,21} But it is very difficult for these patients to get cure and they are always treated by analgesic care with much cost and morbidity. On the other hand, clinical research and development provide a unique challenge — current diagnostic techniques are invasive and complicated, and need trained staff. Treatments of VL are toxic, expensive, and difficult to govern for the rural people.^{22,23} In many areas hospital facilities are absent or underdeveloped; tools for screening and identification of patients are inadequate. Many leishmaniasis experts nowadays speak for vector control, which can be a useful approach to reduce the incidence of VL.^{24–26} Government budgets are inadequate and health ministries are overstretched with many calls on their resources, as well as practical decision support systems in VL endemic areas.

Why Telehealth Is Important in Kala-azar Epidemiology?

In a vast country like India, several constraints have still to be overcome: underestimation of true health burden, provision of timely advice on the health status, little information about peoples' access, use of diagnostic and treatment services in the public and private sectors, geographical distribution of disease, etc. Telehealth is a more generic term, where telecommunication technology is used for providing telemedicine,²⁷ medical education,^{28–30} home health care services,³¹ overseeing and surveillance,^{32–34} and other health

services over long distance.¹¹ Tulu *et al.*³⁵ sort telehealth according to its purpose, such as clinical, educational, or administrative; its health care discipline area; the environmental setting; the type of communication infrastructure used; and the delivery modality. However, application of telehealth should be designed to motivate programs that will be cost-effective in VL control. The role of telehealth in VL control might offer advantages with improved medical care to remote rural areas; including many other activities like public awareness, changing personal behavior, early diagnosis and complete treatment, integrated vector management and vector surveillance; social mobilization and building partnerships. There is a limited research on the effectiveness of telehealth in vector borne disease control and its application in the health sector. Satellite remote sensing technique and GIS enable surveillance of environmental conditions for vector development and disease transmission thus providing information on epidemiology of a region namely, favorable ecological conditions, habitat types sustaining breeding sites, prevailing disease pattern, history of epidemics, and environmental and socio-economic barriers associated with the disease. Such applications in the VL elimination program also have the potential to lessen geographical disparities and to simplify access to resources, diagnosis, and the knowledge of scarce specialists, through linkages with health centers at different levels of the system. The issue is whether the telehealth system can synergistically integrate multifaceted intervention, prevention, assessment, and treatment to achieve improved personnel as well as local, national, and international community health (Fig. 1).

Current Scenario of Telehealth in India

At present, India is not capable in providing even total primary medical care in the rural areas. Secondary and tertiary medical cares are not consistently available even in suburban and urban areas.³⁶ The Apollo group of hospitals was a pioneer in starting a pilot project at a secondary level hospital in a village called Aragonda 16 km from Chittoor in Andhra Pradesh. Starting from simple web cameras and integrated services digital network telephone lines, today the village hospital has a state-of-the-art video conferencing system and a very small aperture terminal (VSAT) satellite installed by ISRO.³⁷ ISRO has already established telemedicine through geostationary satellite-based network connecting 22 super specialty hospitals with 78 rural and remote hospitals across the country.³⁸ Some of the successful telemedicine pilot projects implemented by the Department of Information and Technology in various states are the telemedicine network in West Bengal for diagnosis and monitoring of tropical disease, oncology networks

in Kerala and Tamilnadu, the network for specialty health care access in rural areas of Punjab, Maharashtra, the hilly state of Himachal Pradesh and the North Eastern region (www.isro.org/recent_events.htm).

The ISRO satellite-based telemedicine network through Indian Satellite System, which started in 2001 under the GRAMSAT program, now includes 315 hospitals, 271 remote/rural hospitals/health centers connected to 44 super specialty hospitals located in major cities. With a focus on the application of space technology for health care, ISRO has launched a series of socially relevant programs under the training and development communications project. It also plans to introduce SATCOM-based telemedicine technology in remote areas.³⁹ This connectivity between patients at remote end and specialist doctors in urban centers has been effectively established. Mobile telemedicine units in tele-ophthalmology and community health have also been established. ISRO also took the initiative of continuing medical education efforts that provide doctors at rural health care centers a chance to upgrade their medical knowledge and skills through interactions with experts at the specialty hospitals through satellite-based tele-link. The Recent Telemedicine Users' meet organized by the ISRO in Ahmedabad during May 2007 has published some data on the hospital-wise super specialty teleconsultations. According to the data, there were 30 612 super specialty consultations made during the last 5 years.⁴⁰ The country overcame the challenges of technophobia and fears, and eventually became a super power in the field of knowledge and information technology.⁴¹

Mobile Telehealth — A Positive Proposition

Mobile data capture is an emerging information technology with potential for incorporation into data management system/decision support system.⁴² It has been patented with the coming of faster, cheaper, low power processors and more robust wireless data transmission technologies. The technical limits of mobile devices are constantly changing and mobile Internet access is now achieved in most rural areas.

There is a strong interest in using mobile data capture in public health including other vector borne disease surveillance. Recent studies have evaluated the use of personal digital assistant for data collection during household surveys on malaria or bed net use^{43,44} and collection of data for supporting dengue patients in clinical studies in Nicaragua.⁴⁵ The potential for use of cell phones as mobile data capturing devices was evaluated for infectious disease surveillance in Peru⁴⁶ and for malaria surveillance and surveying in Thailand.⁴⁷ In India, the Government has launched

Figure 1 Application of telehealth in kala-azar control in India.

mobile clinics in the rural areas of some states namely Andhra Pradesh, Maharashtra, Gujrat (<http://www.ehealthonline.or/news/newsdetails.asp?catid=&ewsid=13421>). However, no studies have yet been developed on the use of this technology in leishmaniasis.

Today the Indian mobile market is the fastest growing and the most competitive in the world. India has around 720 million phones connections as on 2009–2010 (source: <http://www.assocam.org/arb/study-on-mobile.payments.pdf>). Airtel is one brand which has been successful in building up a vast subscriber base for itself. It has established its own ‘mediphone’ services, targeting the entire population of India. ‘Mediphone’ provides health care services to customers and is staffed by accredited doctors and nurses for reliable quality health care advice on their mobile phones anytime, anywhere. Hence, this technology can be useful for VL elimination program by increasing communication between local stakeholders and by obtaining, transmitting, and analyzing

human health information that can be used for early detection of disease outbreaks.

Telehealth — VL Preparedness and Alerts

Telehealth is by far the most suitable information for the alert and preparedness phase as it makes it possible to predict the outbreak threat based on remote sensing and GIS platforms, and to spread the information quickly to ‘those who need to know’, so decisions can be made and action can be taken at the early response level.⁴⁸ One of the major telehealth applications in kala-azar epidemiology would have contributed to ‘monitoring of well being’ based on two important areas, namely disease management (including use of vital signs monitor — notably for uses with long term conditions) through peer information exchange and emotional support and health and fitness (including use of telephone and video consultation and dialogue about lifestyles, health and motivational coaching of public health workers).⁴⁸ The technology also aids in

Figure 2 Application of telehealth in surveillance.

kala-azar preparedness *via* public awareness, rehabilitation services in kala-azar affected areas and improving communications between health providers separated by distance. Telehealth can also play a pivotal role in anticipating epidemics by distinguishing and describing the risk reasons in the population and real-time monitoring of kala-azar incidence (Fig. 2.).

In general, both surveillance and outbreak prevention and control benefit greatly from telehealth applications and are perfectly suited to the networking idea. The effectiveness of outbreak control of VL depends mainly on the performance of the system in the early alert phase which is also linked to telehealth facilities. Telehealth provides epidemiological information, in particular, the findings of the investigation shed lights on risk factors (seasonal changes and sandfly abundance etc.), and transmission routes. It can relay information to individuals as well as to the population as a whole which can provide an easy access to those living in remote/rural areas. Moreover, it promotes self-care and domiciliary care practices. Many of those living in remote areas can be benefited from self-management of health problems which will supplement existing health care services.⁴⁹

Telehealth — A Health Solution for a Neglected Disease (VL)

For inhabitants of rural areas, especially in developing countries access to medical specialists is a problematic issue,⁵⁰ since it needs travel to urban centers where the doctors are present. Such travel is often costly and sometimes tricky for rural people. For these places telehealth initiative may be a significant opportunity for specialized care and diagnosis of VL for rural populations and for the evaluation and monitoring of healthcare services.

However, telehealth network may provide a good opportunity for the patients to have access to remote hospitals for real time evaluation by specialists, via either video or audio, using Doppler's and webcams. ISRO is the service provider of satellite network for telemedicine application in India. The satellite network has a hub and VSATs based on Internet protocol technology. The connectivity is to be provided through demand assigned multiple access pool, which has a network monitoring system.⁵¹ This network will operate Ku-band against the existing network that is extended C-band. It will also separate in a star configuration to provide a low cost solution;

Figure 3 Application of telehealth in education.

Ku-band system is expected to reduce the size of VSAT antenna,⁵¹ to provide multi-node connectivity with low-cost electronics.⁵² As such, web-based telehealth software may be developed to create and store the electronic medical record of the patients.⁵³ This software can be installed in kala-azar research centers, district hospitals, and remote public health centers. Using this software, the physicians can quickly add notes on the patients' progress, create reports, give advice to the rural health workers and patients gain the line of treatment from the specialists, and so on. In this way, various medical specialists can provide high quality medical attention to large areas in which public health centers are highly dispersed and in which human and technological resources are in scarce supply.

Telehealth and Integrated Vector Management

Vector control can be a useful approach to reduce the incidence of VL. The diversity of Sandfly biology is such that there is no one method of control either applications or attainable in the different foci throughout the world. The principle methods used in sandfly control, supported by WHO/TDR, have been the application of insecticides, sometimes with environmental management, but there has been little emphasis on methods for protection of individuals.⁵⁴⁻⁵⁶ The breeding sites of the sandfly are not known which therefore limits control to attacking of adults. However, they are not necessarily presented in order of importance. Telehealth may help to co-ordinate the strategies to bridge the gap between the people and programmer by tele-education and tele-training

(Fig. 3). Video conferencing is the most common form of transferring the information to a caregiver.

This technology may help rural people take protection at home, insecticide diffuser and coils, personal protection through insecticide treated bed nets, repellents, etc. to reduce the man vector contact. Alternatively, the technology may also offer environmental education and protection to rural people which may aid in destroying sand fly habitats. It might also help in understanding the difficulties of scientific thinking to shape everyday life to march the risk factor related to sand fly habitat at household level.

Telehealth in Treatment and Diagnosis

An untreated kala-azar and post kala-azar dermal leishmaniasis patient makes up the major reservoir for continuing transmission of VL.^{57,58} Therefore, timely, effective diagnosis and drug treatment are essential not only to cure the individual patients, but also to decrease the time from onset of illness to diagnosis. Telehealth through satellites can play a role in the diagnosis and treatment of urgent patients in the field.^{59,60} However, in VL treatment, telehealth may simplify the health decision-making process or communication between healthcare providers and individuals on prevention, diagnosis, or management of a health condition (Fig. 4). To seek the opinion of a specialist using tele-communication, doctors can connect to the specialist's personnel computer from within the telehealth software. The rapid access to a wider range of specialists and medical procedures, to manage overall medical systems and patients care through seamless delivery of service by satellites can

Figure 4 Application of telehealth in diagnosis and treatment.

provide chances for both patients and medical staff to various urgent medical care treatments.

Patients affected by kala-azar were inadequately followed up for reasons ranging from a lack of local medical expertise to poor social and economic conditions. After receiving the drug, the patients can live at home depending upon active collaboration of the local health centers who keep an eye on their health status. On the other hand, the medical data transmission centers set up that could transmit information on fever, weight, blood pressure, blood sugar, etc. This information could be transmitted routinely, e.g. daily, or urgently when needed. This follow-up will prevent or diagnose a flare-up of the disease or drug side effects without a need for hospitalization when it is not necessary. It also helps locally available health workers use standardized protocols for diagnosis, management, and compliance of disease.

Telehealth – Saved Health Care Cost of VL-affected People

Diagnosis and treatment of kala-azar are problematic because the treatment is lengthy and relatively costly (<http://nvbdcp.gov.in/Doc/Guidelines-Diagnosis-Treatment-KA.pdf>). Those affected by kala-azar are extremely poor and live in thatched dwellings with mud floors. The families depend on unreliable sources of income such as casual labor (www.oneworldhealth.org). On an average, the household spends \$134 on the treatment of family member suffering from kala-azar. This represents more than 50% of what is spent on a family member in an entire year.⁶ The telehealth originally emerged to serve rural population or anyone who is geographically dispersed, where time and cost of travel make it difficult to receive the best medical care.

The patients in rural areas have to expend a lot of money in the hand of quacks before going for actual treatment. Most of these patients are illiterate hence it more time is required to inform them and explain the course of the treatment. Telehealth seems to be a promising patient management approach which may reduce the financial burden of health care costs. Telehealth has the potential to dramatically reduce unnecessary costs improving quality of care associated with transport and protection, improved access of medical specialists, and improved patient outcomes.

Telehealth and Epidemic Prediction

Public health and epidemiology in particular has become a hot topic recently. The disease, VL is spread through female infected sand fly and it is now accepted that on top of seasonal changes, climate and therefore climate change play a crucial role in carrying the disease.^{61,62} Advances in satellite-based remote sensing, global positioning system, GIS, and computer processing have now made it easier to integrate ecological, environmental and other data, to develop predictive models that can be used in disease surveillance and control activities.^{63–65} Telehealth may now plan new insights into the geographical distribution and gradients of kala-azar prevalence, as well as on population health assessment, by providing valuable information about different populations at risk, based on risk factor profiles. This information complements the decision support system data to introduce spatial-temporal fluctuations of temperature, humidity, precipitation, land use/land cover, vegetation characteristics, etc. Remote sensing techniques have been recently used in this field. Hence, the different data sets can be used for geo-statistical

modeling, mapping, and geographical and epidemiological analysis. Seamlessly, telehealth system will produce longitudinal data and analysis on advancing health information, social reforms, social policies, and practice which will contribute to government, NGO, private, and community health system.

Conclusion

Telehealth is a relatively recent and complex technology, which explains why it has not been used to its full potential, especially in the control of VL, where it is extremely promising. We are now at the point where possibilities are clearly seen. Telehealth can be a tool of prime importance to rural health care deliverers and in the surveillance and control of VL or kala-azar in India. Though, telehealth is not a magical solution to all the difficulties about information on health care, but it is a powerful tool capable of transforming the way with which information is dealt with. It can reduce the number of emergency visits of poor people to the hospitals. At the same time, it will promote the early intervention for the successful control of disease. The technology may also aid to the remote rural people to reduce the density of kala-azar vector through video conferencing system. Thus, by using of telehealth service, not only doctors, but also other professionals, researchers, and decision maker can work to reduce the glooms of kala-azar patients. Thus our main interest is the interplay between telehealth system and the strengthening rural health system in the context of disease (especially kala-azar) control.

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