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MEDNET: Telemedicine via Satellite Combining Improved Access to Health-Care Services with Enhanced Social Cohesion in Rural Peru

Dimitrios Panopoulos, Ilias Sachpazidis, Despoina Rizou, Wayne Menary, Jose Cardenas and John Psarras

Abstract

Peru, officially classified as a middle-income country, has benefited from sustained economic growth in recent years. However, the benefits have not been seen by the vast majority of the population, particularly Peru's rural population. Virtually all of the nation's rural health-care centres are cut off from the rest of the country, so access to care for most people is not only difficult but also costly. MEDNET attempts to redress this issue by developing a medical health network with the help of the collaboration medical application based on TeleConsult & @HOME medical database for vital signs. The expected benefits include improved support for medics in the field, reduction of patient referrals, reduction in number of emergency interventions and improved times for medical diagnosis. An important caveat is the emphasis on exploiting the proposed infrastructure for education and social enterprise initiatives. The project has the full support of regional political and health authorities and, importantly, full local community support.

Keywords Telemedicine · TeleConsult · Rural health care · Medical care network

1. Introduction: Clinical and Technical Requirements

Peru is officially classified as a middle-income country. Strong economic growth over nine consecutive years (9% in 2007; 10% in Jan 2008 alone), low inflation and a budget surplus coupled with the growth in reserves have resulted in Fitch Ratings raising Peru's foreign currency debt rating to the investment grade level of BBB in April 2008 [1]. However, despite surging economic growth, large sections of the population remain marginalized with distinct inequalities between those living in urban and rural areas.

The aim of the project MEDNET is to develop a medical health network in Peru targeting these very locations which have been virtually abandoned by the state.

The sites chosen for inclusion in MEDNET are Chongos Alto, Comas, Pariahuanca, Puerto Ocopa, Mazamari, Rio Negro, S.M. de Pangoa (Fig. 98.1).

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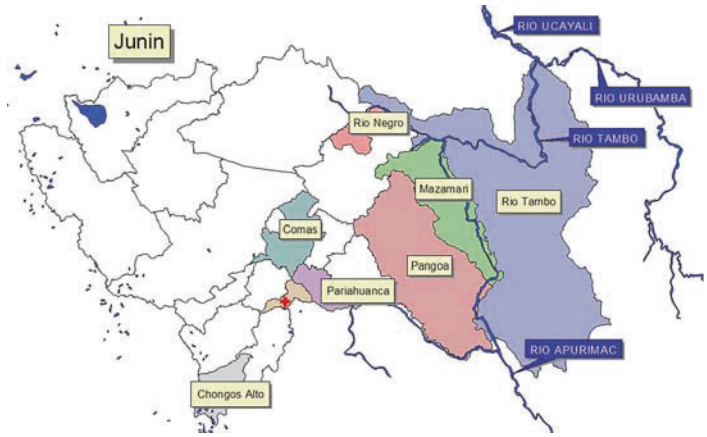

Figure 98.1. Map outline of the sites selected in Junín, Peru, for inclusion in MEDNET.

1.1. Medical Situation

Currently, patients travel long distances just to arrive at the rural health centres chosen for inclusion in MEDNET. Unfortunately, there is a dearth of medical equipment at these health facilities. If the physician is uncertain and decides to refer the patient for further consultation and/or examination, only approximately 5% of patients can afford to attend. Large sections of the community in these regions are effectively disenfranchised from the health service as a result of long distances, high costs associated with travel and lodging, cultural obstacles and endemic poverty. The isolated nature of these sites also impact upon the medical staff with medics feeling isolated and vulnerable with no access to expert second opinion, severe lack of health resources and poor communication between health outposts and the regional health authority – DIRESA Junín.

1.2. Doctors Needs

After studying for the career of medicine in Peru, medical students have to complete a period of time practising medicine in a rural environment (SERUM – abbreviation of medical student undertaking Rural Medical Service). Competition for these posts is very high since, without this experience, a medic is unable to apply for employment at any public hospital in Peru. In addition each rural health care centre has a named medic who is responsible for the site. DIRESA Junín can therefore ensure appropriate cover for the health outposts. However, the SERUM working at any particular site often find themselves working alone and unable to seek a second opinion. This was witnessed first hand in Puerto Ocopa where the medical director was absent and the SERUM was working alone. The danger is that if the SERUM makes a mistake that is not corrected, this particular practise could become embedded throughout their medical career. *The overriding need is therefore to facilitate continual professional development*.

At many of the sites, the medics expressed the fact that many patients were transferred to Huancayo needlessly because of the decision to *err on the side of caution*. This implies a cost which is unacceptable to many patients: both economic and cultural. Patients simply do not have the money to pay travel and lodging costs associated with transfers from the health centres to the main hospitals in Huancayo. Costs average around s/.200 (46) for these transfers and considering daily wages are approximately s/.10 (2.3) per day, many patients find themselves effectively disenfranchised from the national health service (M. Gonzales, 2008, *The average salary is considerably less in satipo*, personal communication).

Additionally, many people, particularly in the jungle region of Rio Negro, Pangoa, Mazamari and Rio Tambo, are native peoples and do not want to travel to the urban regions for cultural reasons. *The*

overriding need for the medic here is to be able to provide basic medical diagnosis avoiding the need for urgent patient transfers (e.g. provision of pre-natal U/S controls) and receive expert second opinions.

The lack of reliable and fast communications in all of the MEDNET establishments in Peru has a direct impact on administrative efficiency. Inefficient communications directly impact upon the resources available to the medics at each site. For example, at Puerto Ocopa, DIRESA Junín had no idea that the health centre was unable to access a fund to purchase fuel which is available to support rural outposts with access to vehicles and/or boats. DIRESA Junín also has no way to directly contact these health outposts and vice versa. This can result in delays in receiving basic provisions (syringes, etc.) as well as a failure to accurately record and update vital health statistics. *The overriding need here is to improve communications between rural isolated outposts and other health centres and the main health authority (DIRESA Junín).*

1.3. Health-Care Infrastructure Needs

The main health-care requirement at each establishment is basic diagnostic equipment. Where sites do have microscopes or ultrasound (U/S) machines (microscopes available at Chongos Alto, Puerto Ocopa, Mazamari and S.M. de Pangoa: U/S available at S.M. de Pangoa) they are either not currently functioning (e.g. the U/S at S.M. de Pangoa and the microscopes at Puerto Ocopa) or are not DICOM compatible.

Unstable electrical supplies jeopardize the refrigeration of patient samples and basic reagents whilst many of the sites do not have earthing and/or lightning systems. With high frequency of thunder and lightning activity it will be a basic requirement to implement earthing systems in order to provide appropriate protection to equipment.

None of the sites have access to any kind of Internet access. Where Internet access is available in the local community, it is extremely slow.

Mazamari, Pangoa and Rio Negro are the only sites with a fixed telephone landline. Chongos Alto, Puerto Ocopa, Pariahuanca and Comas can be contacted through a satellite community telephone. Mobile phone coverage is sporadic but CLARO (part of the telecom group América Móvil) provides better coverage, on average, to most of the MEDNET sites in Peru compared to MOVISTAR (owned by Telefónica Móviles).

Radio plays a major part in communications in the more isolated sites, particularly in the jungle region of Satipo.

2. Architecture and Major Components of the System

The network participant will communicate with the help of the collaboration medical application based on TeleConsult & @HOME medical database for vital signs, which has been developed by Fraunhofer IGD and MedCom GmbH, with partial financing of the European Commission.

2.1. TeleConsult

TeleConsult is a stand-alone application running on Windows 2000/XP. The application is able to acquire medical images from any ultrasound device through a video grabber attached to the computer [2]. Furthermore, DICOM-based agents would store medical images from any DICOM-compliant device (DICOM is a worldwide standard for the representation of medical imaging data). TeleConsult application is a combination of a 2D/3D DICOM Viewer, an image grabbing software, medical annotation tools and a medical telecommunication tool [3]. Fig. 98.2 illustrates the user interface of TeleConsult.

The largest part of the user interface is used for the display of the images. On the left side of the software all images, currently loaded into TeleConsult, are listed [4]. In the centre of the user interface, there is place for showing the details of one or more images. All operations, a user of the software can operate, can be assigned to the following eight modules:

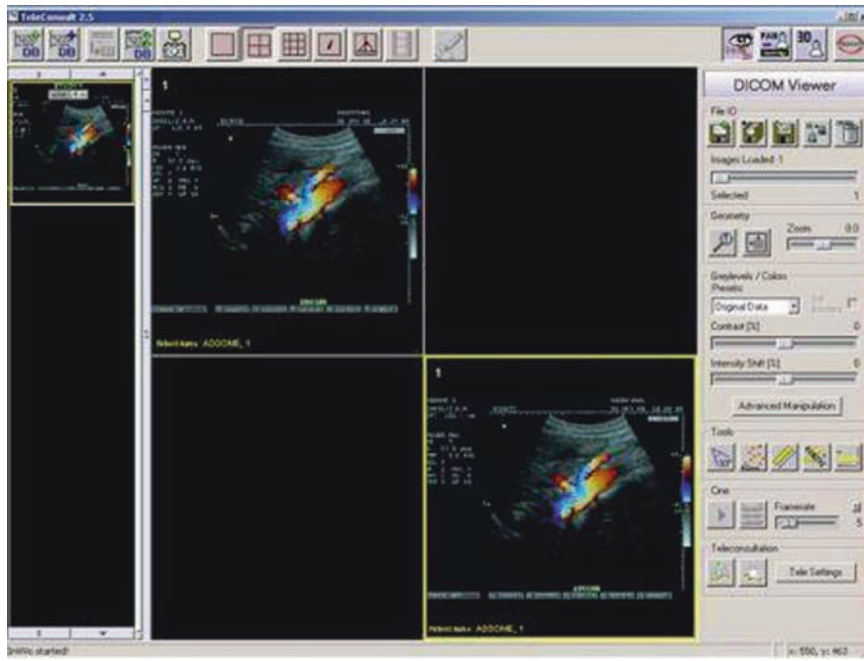

Figure 98.2. TeleConsult user interface.

- The Database Interface menu
- The Image View menu
- The File I/O menu
- The Geometry menu
- The Greylevels/Colors menu
- The Tools menu
- The Cine menu
- The Teleconsultation menu

TeleConsult is currently used in several European locations and provides an excellent, proven communication tool for telemedicine systems. The system also provides easy localization options for Spanish and Portuguese.

2.2. Medical Database/Health-Care Records

There are alternative ways to manage clinical information using paper cards and charts, but for clinical trials, monitoring and analysis of population data and telemedicine, computerization of some sort is generally required. A key challenge is to create sustainable systems that are able to be used widely and can support several of the above tasks, rather than using multiple "stove pipe" applications.

Problem issues with ICTs and Electronic Medical Records:

- Data collection and entry (including data completeness and quality)
- Data standards (common data models and open standards)
- Difficulties in reuse of technology and avoiding re-invention of systems
- Tensions between standard approaches and local requirements
- Safety, security and confidentiality of medical data
- Language and cultural differences
- Short-term quick solutions that do not scale up, especially spreadsheets

Our medical imaging application offers a patient management database with the following possible operations:

- Creation, modification and deletion of patients
- Creation, modification and deletion of studies
- Storing of images, configurations, videos and other (additional) files assigned to a patient and study
- Swapping out data (images) to other storage medias, whereby the purpose is to prohibit the local hard disk of getting full
- Export and import of patients/studies and images to external files, whereby the purpose is the exchange of data between several databases
- Loading of images, configurations and videos into TeleConsult
- Importing of DICOM images into the database
- Sending and receiving of messages, together with patient, study and image information from and to other TeleConsult workstations (offline messaging)
- Importing/exporting of vital signals (ECG, BP, SPO2, Glucose) into the database

The database is based on *open*EHR; the definition of the "electronic health record" corresponds to the "Integrated Care EHR" as defined in ISO/DTR 20514: The Integrated Care EHR is defined as a repository of information regarding the health of a subject of care in computer processable form, stored and transmitted securely and accessible by multiple authorized users. It has a commonly agreed logical information model which is independent of EHR systems. Its primary purpose is the support of continuing, efficient and quality integrated health care and it contains information which is retrospective, concurrent and prospective [5].

The EHR has the following characteristics:

- Patient-centred: one EHR relates to one subject of care, not to an episode of care at an institution.
- Longitudinal: it is a long-term record of care, possibly birth to death.
- Comprehensive: it includes a record of care events from all types of carers and provider institutions tending to a patient, not just one speciality; in other words there are no important care events of any kind not in the HER.
- Prospective: not only are previous events recorded, so is decisional and prospective information such as plans, goals, orders and evaluations.

2.3. Satellite Communication/AmerHis

The selected regions in Amazon have no access to broadband communications. Therefore, AmerHis system is going to be utilized. AmerHis makes use of DVB-RCS bi-direction European standard. Thales Alenia Space España is leading the AMERHIS project within the Hispasat Amazonas satellite. AmerHis is an advanced communication system, supported and co-funded by ESA and the industry to deploy an advanced communications system based on a regenerative payload on board the *Amazonas* satellite [6].

The AMERHIS system integrates a broadcasting multimedia network with an interaction network by combining two standards, the DVB-S and DVB-RCS, into one unique regenerative and multi-spot satellite system. In this manner, the users calling for broadband and interactive services will be able to utilize standard stations (RCSTs) at both transmitting and receiving sides. Next figure illustrates the concept.

In this system, the DVB-RCS return channel standard is applied by all users to access through a standard uplink to the satellite. On board, the regenerative payload (OBP) is in charge of multiplexing that information from diverse sources into one or more DVB-S data streams capable of being received by any standard IRD equipment. The onboard repeater is capable of not only multiplexing signals coming from the same uplink but also cross-connecting and/or broadcasting channels coming from separate uplink coverage areas to different downlink coverage areas.

3. Community Engagement

Through the convocation of medical staff and local community representatives, we managed to obtain a good impression of the needs of not only the health-care establishment but also the wider community.

The recurring themes from the seven sites chosen were the need for (1) basic medical diagnostic equipment (such as u/s: there were no [functioning] ultrasounds or working microscopes at any of the rural health centres); (2) improved communications – for the wider local community and also for essential medical information; (3) expert second opinion; (4) improved institutional efficiency; (5) capacity building programmes and (6) stable electrical supply.

At each site in Peru chosen for inclusion in MEDNET, the local municipality has offered their full support. The actual support provided will depend on the clinical and technical requirements of each site, and also to a certain degree, the funds available at each municipality – though even municipalities with limited funds offered assistance "in-kind". *The question of stable electricity supply will therefore be resolved by the municipalities*.

The additional services the project consortium members plan to provide at each site in an attempt to exploit the MEDNET infrastructure (e.g. Internet, VoIP) are also of particular interest to each municipality and the services could easily be divided between municipality and health-care centre, particularly in Chongos Alto, Mazamari, Rio Negro, Comas and S.M. de Pangoa due to the proximity of both.

In order to assess user needs for the sites chosen in Peru, a clinical requirements audit was undertaken at each site. Additionally, at each site, the local mayor, or their deputy, along with representatives of the local community together and the medical staff responsible for the site were invited to attend a meeting in which an outline of the MEDNET project was presented. Sustainability is a primary objective of MEDNET and involvement of the local community is crucial if sustainability is to be achieved. In total, roundtable meetings were held with in excess of 56 top-level stakeholder representatives from the seven sites and the two referral hospitals in Huancayo.

4. Expected Impacts

Regional workshops involving both public and private institutions delivering health services identified the most urgent health needs as viewed by the population. Based upon these locally perceived priority health concerns, together with statistics and epidemiological results from DIRESA Junín, the following were characterized as priority regional health problems:

- Basic hygiene
- High prevalence of infant malnutrition
- Female health problems: teenage pregnancy; maternal mortality
- High incidence of infectious/contagious diseases
- Family violence

Many of these priority health concerns are highly communicable and can be addressed both clinically and through the design of public health programmes in MEDNET.

Additionally, the Conditional Cash Transfer programme "Juntos" is an antipoverty initiative launched by the Peruvian government in 2005. Eligibility depends on several factors, e.g. a family must have children under the age of 14 and live in a community where at least two basic needs – running water, electricity, schools, health services – are unmet. Families receiving the cash in Peru must enrol their children in schools and ensure that they are vaccinated. Pregnant mothers must take part in pre-natal care programmes and post-natal controls. In addition, the adults must have national identification cards and make sure that their children have birth certificates.

This pilot project proposal in Peru aims to identify opportunities and synergies for co-operation and integration with current health sector reforms and the "Juntos" programme, particularly

- Helping the health services and education operators become involved in a more effective way
- Facilitating capacity building programmes aimed at improving service quality
- Providing a platform that can be exploited to deliver improved standards in education and promote social enterprise in order to alleviate poverty

General benefits accruing from the application of MEDNET in Peru are improved quality of health service to approximately 102,000 located in the pilot project locations; a reduction in the level of inequitable access to medical services; provides scientific and technological assistance to professional health workers – e.g. continuing professional development; facilitates an integrated level of patient attention; optimizes administrative process embedding efficiency within the health system; augments health awareness amongst the general population.

5. Conclusions – Future Work

Health service coverage in rural and isolated communities in Latin America is extremely low. Although the states deliver services, the level of medical attention is characterized by limited infrastructure and resources, in both equipment and professional personnel. With this lack of infrastructure it is difficult to effectively confront the health problems faced by the population. Also, the population of these regions suffer from extreme poverty. The poorest fail to access the health service – for economic reasons. The costs involved, transport and lodging, coupled with cultural barriers, deter approximately 95% of patients from undertaking this referral – patients in rural Peru are therefore essentially disenfranchised from the nation's health-care service. Finally, geographical barrier is another mitigating factor resulting in social exclusion. Often patients have to walk and travel in boat many hours just to reach these health-care outposts only to find that they are referred to more urban centres due to a lack of medical equipment and/or the need of attending medics for expert second opinion.

Today, ICTs permit greater access to health information and thereby allow patients, potential patients and families to learn more about health problems, care options, and prevention strategies. However, for those without computers or even telephones, as is the case for the regions being targeted, access to these information resources is more a promise than a reality. Community clinics may be able to provide some with access to information resources, but funding for such services and for the clinics themselves is vulnerable to retrenchment in public services and budgets. Deficits in literacy and language skills may create further difficulties for disadvantaged populations. The gap in access may actually widen if information services improve only for the more affluent and educated.

MEDNET will develop a medical network that addresses the problems of delivering health care to rural and isolated communities in Latin America. The medical network will be supported by expert physicians located at referral hospitals within urban centres, where the majority of health-care resources are often located. The medical applications will vary from gynaecology, paediatrics, cardiology to typical infectious diseases for the region such as malaria and tuberculosis.

The telemedicine network will enable patients to access ultrasound examination, ECG test, blood test and blood test imaging for automation diagnosis locally, reducing the need to travel long distances.

The project will empower medical doctors to constantly and remotely keep track of their patients with minimum effort, assisted by an intelligent automated infrastructure. A sophisticated Collaboration Model will manage the whole service and will be aware of each patient's medical record, providing an information channel between the medical staff, the patients and their carers (family, friends, etc.).

Electronic health records of each patient, extracted from the examinations, will be stored in a health-care database. Patient's demographic information along with haematological and imaging examinations, ultrasound examinations, electrocardiogram and dermatological images will be stored into the database along with the prescribed medication.

According to predefined limits, the system will be able to alert patients and physicians about increases in risk of patients' condition based on medical data stored into the medical database. Moreover, physicians

will be able to share information and request medical advice from expert physicians, thus facilitating rapid and informed patient treatment in these isolated areas, e.g. in Amazonia.

The locations selected for inclusion in MEDNET will be connected over satellite communication based on DVB-RCS protocol via the European AmerHis system which can provide concurrently up to 4/8 Mbits in the upload and download links, respectively. In addition, the medical platform is based on the results of previous European Union-funded telemedicine projects – TeleInViVo, T@LEMED, @HOME project (IST-2000-26083).

The clinical impact and added value of MEDNET will be the following:

- To enable the efficient and cost-effective use of high-level and high-quality medical resources available in large cities for improvement of health services for residents in remote and rural underserved regions
- To help reduce morbidity and mortality in underserved regions by providing a means for early detection and treatment of contagious diseases, such as malaria and tuberculoses, by the use of telematics and e-health technologies
- To improve primary health-care through the use of telematic ultrasound systems transferring expert's "know-how" in large cities to more remote areas
- To contribute to the advancement of medical research, diagnosis and treatment methods, through the efficient collection and sharing of data on treatment outcomes and patient demographics

MEDNET will also offer the possibility to compare two different access technologies (transparent and regenerative satellites) in order to assess the benefits of the mesh connectivity offered by AmerHis and to compare the cost of operation of both alternatives.

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