

Infraestructura y servicios de telemedicina rural en el Departamento del Cauca, Colombia¹

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ABSTRACT

The development of telemedicine programs for the public health network of the Department of Cauca¹⁰, Colombia, would make it possible to satisfy many identified necessities such as medical coordination, continuing education, epidemiological surveillance, patient referral and counter-referral, and an end to the feeling of isolation among professionals that work in rural health centers. Nevertheless, geographic, economic and social difficulties and the lack of a telecommunication infrastructure in areas with these characteristics present a challenge of such magnitude that the majority of existing telemedicine projects in Colombia have been centered in urban or other areas which present fewer difficulties. In the municipality of Silvia, the University of Cauca has established a prototype network using the "Hispano-American Health Link" (EHAS in Spanish) program technologies, which employs VHF (Very High Frequency) and WiFi (Wireless Fidelity, a set of standards for wireless local area networks) radio systems for the deployment of low cost voice and data networks; over this network information access and exchange services have been developed, which aspire to satisfy some of the aforementioned identified challenges. An initial, short-term evaluation has been completed. The objectives were to obtain information about the development of the project's activities and their possible impact. The project telecommunication network and information services, and the results and conclusions of the first evaluation are presented here.

INTRODUCTION

The Municipality of Silvia, in the Department of Cauca, Colombia, has identified many serious difficulties and unmet needs in its local public health care system. Telemedicine offers potential solutions, however the difficulties associated with the project setting itself are equally serious. Located in the Central Range of the Andes at altitudes that vary between 2,500 and 3,800 meters, the town of Silvia has an urban population of 6,600 inhabitants (18% of the total population) and 31,400 in the rural areas (82%). Six ethnic Paez and

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10 Department is the major political and territorial division of the country. The Department of Cauca is located on the Pacific coast in the southwest of the country.

Guambian Indian reservations, whose members comprise 80% of the population, are in this region. The remaining 20% are of Mestizo origin. The municipality suffers economically from high levels of unemployment, a once promising tourism industry now adversely affected by episodic confrontations between guerrilla, paramilitary and government forces, and there is limited access to markets for the sale of agricultural produce. In health care, only 35% of the population is affiliated with the national social security system through the contributive and subsidized regimens. The remaining 65% lacks direct protection and are covered by the local public health care system which is the responsibility of the mayor's office. Two local, level I hospitals provide services to the population: San Carlos Hospital, located in the town, dependent on Cauca Departmental Health Direction (DDSC), and Mama Dominga Hospital on the Guambian Indian Reservation, which is administered directly by that community. The absence of a telecommunication infrastructure imposes severe difficulties on the coordination of sanitary services and results in a feeling of social and professional isolation for many health care personnel. This is due to the state of violence in the country, the socioeconomic difficulties and the relatively austere geographic and communication conditions.

In Colombia, there are many telemedicine projects, but few are being developed in areas as complicated as the forest and jungle regions of the Pacific coast or the mountainous regions in the Department of Cauca. The technology used by the company Vision Technology Group (VTG), which specializes in teleradiology [1], allowed for more than 360,000 digitalized x-rays to be sent to and read by radiologists, but this occurred in urban areas in several cities in the Departments of Cundinamarca and Atlantic. The telemedicine project of the Colombia National University and the Electronic and Communications Technological Institute of Telecom (National Company of Colombian Telecommunications) attempted to reach jungle regions of Colombia (Department of Amazonia), but it was restricted to level I hospitals and did not link more remote primary care health centers [2]. The teleconsultation project of the University of Caldas, with regional presence, has created the "hospital network of the Department of Caldas", and has become one of the projects with a recognized projection in the country, within a relatively short period of time. Ecopetrol (Colombian petroleum company) provides teleconsultation and telediagnostic services, using a video-teleconferencing capability for its employees. None of these projects uses communications technology based on radios. It is believed that economic sustainability in areas where there is no fixed telecommunication network and economic resources are scarce, usage of radio may be ideal. Many telemedicine projects in developing countries have not turned out to be viable because of the excessive communication costs.

The University of Cauca, inspired by the technological developments and experience of the EHAS program [3], has developed a rural telemedicine pilot project in order to improve the efficiency of the local health care system in Silvia. Using appropriate and low cost technologies, a strategy of a mixed network for voice and data transmission over VHF and WiFi systems was developed. This platform permitted the development of information exchange and access services such as a computerized system of epidemiologic surveillance, distance education, patient referral and counter-referral and teleconsultations. The project objective was to provide the rural health care workers a tool for the collection, analysis and feedback of information that would improve coordination, avoid a feeling of social and professional isolation and maintain a system of continuing education, at a reasonable cost.

To achieve this objective, the expected results of this project were: 1) the creation of a high-speed network that permits the interconnection of the two local hospitals in the intervention area with the DDSC, as well as a low-speed voice and data network that interconnects each of the local hospitals with the rural health centers dependent on them; 2) to furnish each of these interconnected health care establishments with a computerized epidemiologic surveillance system, a program of continuing education at a distance, a controlled system to manage patient referral and counter-referral and the option of teleconsultation in case of difficult or uncertain diagnoses or treatment plans; and 3) carry out an evaluation of technical and economic viability, as well as a study of the project's impact on the primary care services and the health of the communities.

MATERIALS AND METHODS

Deployment of the telecommunication network

A high-speed trunk network at 2 Megabits per second (Mbps) was designed and installed. This link is illustrated by a continuous red line in Fig. 1. This network uses a repeater (on the same mountain peak as the Guambian radio station transmitter *Namuy Wuam*) for linking the two hospitals in Silvia and the University of Cauca in Popayán, the capital city of Cauca. Through this network, the University provides the hospitals an access to Internet services. Two more high-speed links were also designed, illustrated by discontinuous red lines in Fig. 1. These links provide Internet access to the Hospital of Jambaló (Fig. 4) at the north of Silvia, and to the municipalities of Guapi, Timbiquí and López de Micay in the forest and jungle areas of the pacific coast in the Department of Cauca. This WiFi network will utilize a repeater on Mt. Santana, located in the Western Andean Range, in order to connect the University of Cauca with the health care center in the indigenous community of Agua Clarita (in the jungle, 53 km from the repeater) and the Hospital Santa Bárbara in Timbiquí (on the coast, 88 km from the repeater). The latter will also serve as the repeater to link the Hospital San Francisco of Assisi in the city of Guapi, 33 km to the south, and the health care centers in Puerto Saija, 12 km away, and Nonanamito, 29 km to the north.

This high-speed network is the backbone for connecting the health care centers (HCC). Each HCC is connected to its hospital through a packet radio data transmission link over VHF (9600 bps) as illustrated with blue lines in Fig. 1. The set of HCC depending on a hospital makes up what we call a "VHF micro-network" (Fig. 2). There are nine HCC dependent on the San Carlos Hospital, seven dependent on the Mama Dominga Hospital, three dependent on the Santa Bárbara Hospital, and four dependent on the San Francisco of Assisi Hospital. Of these 26 HCC, four have been installed and are operated in the pilot project in Silvia, fifteen others are scheduled for installation in Jambaló and Silvia during May and June of 2004, and seven more are planned for installation at the end of 2004 on the Pacific coast.

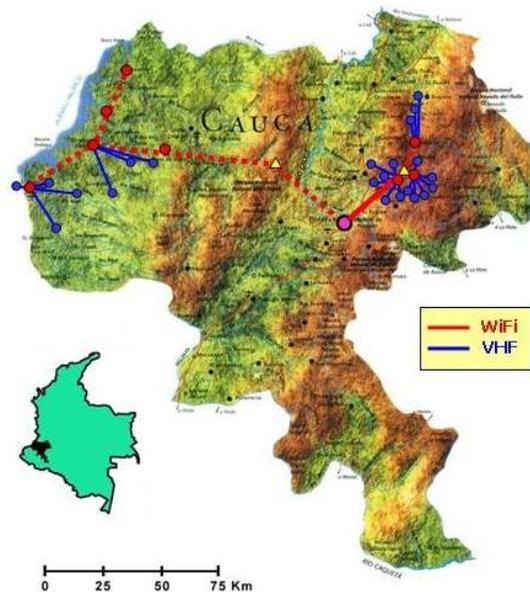


Fig. 1.- Health care establishment interconnections in the municipalities of Silvia, Jambaló, Guapi, Timbiquí y López de Micay.

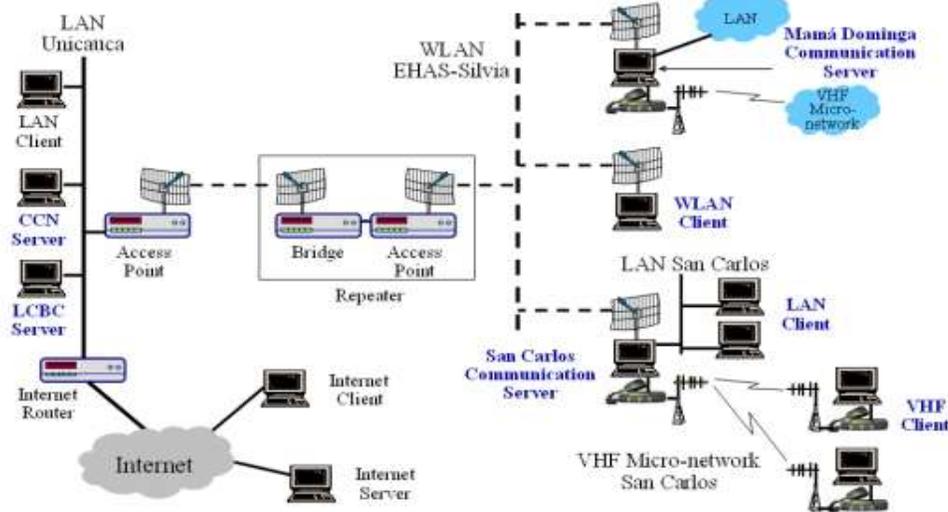


Fig. 2.- Topology of the WiFi-VHF mixed network of EHAS in the Department of Cauca.



Fig.3.- La Campana Health Care Center on the Guambian Indian Reservation (Silvia)



Fig.4.- Jambaló Municipal Hospital

Each HCC is outfitted with a personal computer, a point matrix printer, a Tigertronics (Grants Pass, Oregon, USA) BP96-A radio-modem and a Motorola (Schaumburg, Illinois, USA) PRO 3100 VHF radio. All the computers have installed Linux Debian Woody (<http://www.debian.org>), the KDE 3.1.4 graphical desktop environment (<http://www.kde.org>), OpenOffice 1.10 utilities (<http://www.openoffice.org>), the Mozilla 1.0 browser (<http://www.mozilla.org>) and the software support for the AX.25 packet radio protocol.

A communications server is installed in the hospitals and some of the health centers. This system consists of a PC equipped with an 11 Mbps WLAN (Wireless Local Area Network) card for the WiFi link, a radio-modem and a VHF radio for the VHF micro-network connection, and a network card for the local intranet. The computer has Linux Debian Woody installed and enhanced for AX.25 and WiFi, Sendmail for the management of electronic mail, and BIND (Berkeley Internet Name Domain) as a name server (a system that stores information about host names and domain names on Internet). Each establishment also has a computer client in its intranet, configured with Linux Debian, KDE, OpenOffice and Mozilla.

Parallel to the equipment installations in the pilot project, research and development tasks for WiFi use with the intention of optimizing the technologies utilized in future network installations was conducted. EHAS had experience in the deployment of wide-band links with IEEE 802.11b technology to a distance of 40 kms. The links now planned on the Pacific coast are up to 90 kms. It is not possible to mount shorter spans due to the characteristics of the terrain. This represents a big challenge because the authors are not aware of any place in the world where permanent installations employ this technology at such great distances. Its application here would mean bringing voice and data with a wide-band and at a low cost to a region that lacks

telecommunication access. A new routing ad-hoc wireless system with an autonomous solar power generator and Quality of Service (QoS) are being investigated and developed. These systems will permit the rapid and easy deployment of wide-band networks in order to switch data and voice without affecting vocal communications in situations of heavy network traffic transferring data. Additionally, by incorporating self-configuration and remote administration mechanisms which will enable less-skilled personnel to deploy networks and carry out routine maintenance, which we hope improves quality, reduces long term costs and thereby increases the chances of sustainability.

Services of exchange and access to information

According to studies carried out by EHAS in several Latin-American countries [4], rural health care personnel need the following information access and exchange services:

1. **Epidemiological surveillance:** There are many difficulties associated with the collection, transmission, processing, visualization and feedback of epidemiological information. Frequently, epidemiological information does not get transmitted, arrives late or with erroneous data, which, in many cases, makes it very difficult or impossible to make informed decisions or mobilize rapid interventions.

The Department of Telematics of the University of Cauca has developed a centralized information system for the distribution of forms (based on the Extensible Markup Language, XML) through the EHAS network. These forms are sent to HCC so health care personnel is able to fill them out in order to satisfy the requirements of the national system of epidemiological surveillance (Sistema de Vigilancia en Salud Pública, SIVIGILA) as well as the vertical programs¹¹ (maternal-child health, tuberculosis, hypertension, etc.). The electronically collected data is transmitted through the wireless links to the hospitals, where automatic processing and visualization of the information is performed. The information will be fed back to the rural HCC in monthly bulletins.

2. **Continued Education:** The Polytechnic University of Madrid and the Carlos III University of Madrid are developing a distance education system with four major components: course editor, course transformers, virtual learning environment and unplugged client. This system complies with the requirements of intermittent connection of rural HCC in the EHAS network. HCC don't have permanent Internet connections so data transfer is only possible by electronic mail.

The XML based course editor has a highly useable interface. Courses can incorporate text, static and dynamic images, tables, self-evaluations, references and examinations. The transformers allow course conversion from XML to the format required for diverse distribution ways. Hyper-Text Markup Language (HTML) is used for electronic mail distribution divided into lessons. Portable Document Format (PDF) is used for printed distribution as a book. Both formats can be used for conveying the course to a web server or a CD.

The virtual learning environment offers tools for online learning and student activity tracking, such as forums, access to learning resources, etc. At HCC, the unplugged client is periodically synchronized with this environment by using electronic mail. In this way, the physician, nurse or other health care worker at HCC make use of a learning environment as complete as those on-line, even though he/she finds himself in an isolated health care establishment, with the sole connection being electronic mail by radio.

3. **Patient referral and counter-referral:** The remission of patients from rural health centers to hospitals in the capital city is always somewhat complicated, for the physician as well as the patient. The introduction of a referral system for patients with appointments (obtained by e-mail), and the prior mailing of a summary of their clinical histories, would facilitate the effectiveness of care by specialists. Patient follow-up would improve markedly with counter-referral support, that is, if the rural physician received by e-mail the specialists' reports of lab tests, procedures, therapies, recommendations, etc.
4. **Consultations:** The possibility of obtaining an informed opinion from a specialist in cases difficult to diagnose or manage, help to reduce the number of elective and emergency referrals, as well as costs and

11 Health programs devoted to deal with specific problems.

inconveniences to patients and their families, as was demonstrated in a pilot study in Peru [5]. In the case of emergency referrals, the availability of voice communication systems (VHF radio or voice over IP in WiFi links) connecting the health care establishments at different levels, allows for a more rapid and efficient use of available transportation in rural areas, reducing considerably the delay time for patient transfer.

Short-term study of feasibility and impact

The intervention presented here is governed by a basic principle— a consideration of the interests and needs of the affected populations. This is a requisite for working with indigenous communities in Cauca, which have achieved significant levels of administrative organization and strategies for the defense of their ancestral culture. For this reason, all the decisions, from the telecommunication network design to the information services content definition, were made with the participation of the community’s health care personnel, designated representatives or tribal authorities.

In agreement with this basic principle, the project’s methodology for working with rural health care personnel and communities is Participatory Action Research (PAR) [6]. One of the fundamental characteristics of PAR is the high degree of participation by the project beneficiaries in all the phases of execution. They join the project personnel to form a single working team in order to decide on which actions to pursue, be made aware of project results and help elaborate the conclusions reached. This results in a continuous evaluation and adjustment of project development, at that same time that it establishes the bases for achieving one of the key objectives of the intervention and its sustainability, the integration of the EHAS services with the procedures and programs of the public health system.

The PAR methodology has been employed to develop a community wide epidemiological surveillance system, which focuses on the social and cultural determinants of disease prevalence. Furthermore, workshops, follow-up meetings and other mechanisms used by PAR provide valuable qualitative information for the conduction and evaluation of the project.

Besides that, the EHAS program applies surveys in order to evaluate the evolution and impact of actions in different moments of its development. A first short term evaluation has been carried out (at four months of functioning) in the six health care establishments of the pilot project: three in the municipality of Silvia (San Carlos, Usenda and Pitayó) and three on the Guambian Indian Reservation (Mama Dominga, Cacique and La Campana). Table 1 gives information about the survey participants.

TABLE 1. PARTICIPANTS ON THE SHORT TERM EVALUATION SURVEY

<i>Establishment</i>	<i>Network connection</i>	<i>Worker degree</i>	<i>Worker function</i>
Municipality of Silvia (3 participants)			
Hospital San Carlos	WiFi	Administrative assistant	Technical support
HCC Usenda	VHF	Health care technician	HCC head
HCC Pitayó	VHF	Health care technician	HCC head
Guambian Indian Reservation (5 participants)			
Hospital Mama Dominga	WiFi	Administrative assistant	Technical support
HCC Cacique	VHF	Nursing assistant	HCC head
		Health care technician	Health programs execution
HCC La Campana	VHF	Nursing assistant	HCC head
		Health care technician	Health programs execution

In a first attempt, electronic (HTML) questionnaires were sent by e-mail using the installed communication infrastructure but there was no response from the recipients. In a second attempt, questionnaires were printed

and hand carried to the health care personnel to be filled out in person. Information about the technical viability and utilization of the installed equipment and applications, and the usefulness of the information services was obtained.

RESULTS

The telecommunication equipment has been installed in the six health care establishments of the pilot project cited above. The information services provided to these establishments are continued education and consultations by e-mail, radio and chat. The epidemiological surveillance system is not fully operative but a first epidemiological bulletin has been sent. The implementation of the patient referral and counter-referral support procedures has been postponed until the other services are consolidated.

Due to the relatively short period of system deployment (4 months), the short-term evaluation survey was applied more as an instrument of project control and follow-up than as an indicator of impact. The survey sample had a small size; therefore, the evaluation data obtained by quantitative methods was complimented with interviews in order to support the validity of the results. Five questionnaire responses were obtained from the eight health care workers participating in the pilot project.

Appraisal about the computer and radio availability was diverse, but 60% of respondents declare that e-mail worked "few times". Even so, all of the respondents reported that they had used the system at least twice a week. Eighty percent requested more training in the use of e-mail and office programs, and all respondents requested more training in equipment operation and care. There was unanimity in the appreciation about the computer and e-mail usefulness for supporting their work related tasks, but 60% prefer the radio to communicate locally (only one respondent prefers e-mail). Sixty percent of the responders report that queries about the functioning of their equipment were directed to project personnel and only 20% directed questions to their colleagues working in other health centers in the network. Nevertheless, in spite of these initial difficulties, 60% agree with increasing project services and coverage (the other 40% did not respond to the question) and all respondents consider that the information that they receive thru the system is useful for their work.

With respect to PAR mechanisms, six workshops have been performed to train community members and health care workers in the methods to be utilized in developing the surveillance system. Maternal-child health has been the theme used for teaching the methodology. Interestingly, the participants have concluded, by consensus, that the continual loss of traditional cultural values is the principal factor associated with adverse events affecting maternal-child health. We have also begun the first continuing education course, titled Health and Disease. Its objective is to elaborate on the multiple and varied concepts of health, illness and disease in the ethnically diverse population of Silvia. Two course modules have been sent, and one forum and an evaluation exercise have been completed. Almost all of the system users participated in the forum and evaluation; however, it was necessary to provide them with constant reminders, encouragement and prodding by radio. Consequently, the few course activities to date have taken a great deal longer than originally planned. We also have sent an epidemiological bulletin reviewing an epidemic of Yellow Fever, which occurred earlier in 2004 on the Colombian Atlantic coast.

Perhaps the major achievement of the project until now is having reached an inflection point in the trajectory of project acceptance on the part of the rural health care workers and administrative personnel. In the initial phase all of the initiative for developing the project was taken by project personnel themselves. Now the initiative is being shared with the health care personnel, and they now make suggestions and propose new activities. They have begun to appreciate the benefits of the EHAS services and realize that they need more training in order to take full advantage of them. On their part, the hospital administrators, who initially had assumed an expectant attitude, have now adopted a more active role. Now, they show a great deal of interest in articulating the continuing education courses and other project services and activities with the programs and activities of the hospitals and their HCC. At the same time, the hospital technicians, after having received a training course in equipment maintenance and trouble-shooting, have gradually begun to be more aware of and pay more attention to adverse events which occur in the network. It is also important to point

out the utilization of the system in situations that were not foreseen, such as the use of chats to communicate with the providers of the hospital billing system in order to obtain on-line technical assistance.

Another indication of the pertinence of the project is the fact that hospital administrators in the towns of Rosas, Corinto and Santander de Quilichao, also located in the Department of Cauca, have requested the installation of the EHAS systems and services in their municipalities. Furthermore, the use of the WiFi-VHF network for interventions in other sectors such as education (project E-LANE financed by the European @LIS Program) and agricultural production (Agroindustrial Community Telecenter financed by Colciencias), has also been requested.

DISCUSSION

The telecommunication network has not been very stable as a consequence of various factors, among which it is worth mentioning equipment configuration problems due to the lack of user practical experience and damages caused by electrical discharges. The up time of the system has been adversely affected because hospital technical personnel have not assumed their new responsibilities for the maintenance and trouble shooting of the equipment. We are hopeful that with the expansion of the network, hospital administrators will designate specific time for the labor required for system maintenance.

One of the most serious difficulties that we have faced is the lack of experience and knowledge in the use of information and communication technologies on the part of the health care workers themselves. This had been foreseen, and one of the first project activities was training of the health care personnel in the use of EHAS equipment and services. However, acquiring confidence and skill in the management of the equipment and applications, and incorporating them into daily work routines, is a process that requires a great deal of time, dedication and patience. Personnel have still not become accustomed to using e-mail and have limited themselves to activities related to distance courses and bulletins. On the other hand, the radio has been used with much more regularity, mainly due to the fact that the majority has previously had first-hand experience with it. However, communication with project personnel has been limited to the coordination of programmed activities and the use of equipment rather than medical queries. This may be due to the hierarchical structure of the local health care system. Health care technicians and nursing assistants can make medical decisions only if they are authorized by physicians at the local hospital.

We know that a short term evaluation is not able to measure the impact of the project on processes related to changes in the health status of the populations in its area of influence. Nevertheless, we consider it to be a valuable instrument for measuring tendencies related to the acceptance and pertinence of the technologies and services that are being developed. As was to be expected, the assimilation of these new technologies and services into the daily work routine of rural health care workers has been a slow process, but we believe the evaluation indicates that the methodologies we are employing are correct.

The first course of continued education, Health and Disease, provides an extensive and in depth study of the topic in six modules, but the expected time of completion of each module, which includes practical exercises and discussion forums, was greatly underestimated. There were many difficulties related to the stability of the network, the system utilization capabilities of the participants and the time available to them to dedicate to the course readings and exercises. Consequently, we have changed the courses structure, opting for fewer and shorter modules, with a total course duration of three weeks and topics proposed by the health care workers themselves. In a recent meeting with them they suggested the next two topics for courses— arthritis and VIH/AIDS.

FUTURE PLANS

With the installation of equipment in 28 additional health care establishments, which will result in five municipal, health micro-networks (Silvia, Jambaló, Guapi, Timbiquí, and López de Micay) it will be possible to evaluate various aspects of the impact of the project, difficult to measure at the present time with only six equipped health centers. The decision to go with low-cost wireless technologies is showing positive results in

Colombia as well as in other countries with similar, ongoing EHAS projects. We believe it is the most appropriate alternative from the point of view of project sustainability.

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