Best Paper Selection for: JMIA Yearbook of Medical Informatics 2006: Assessing Information Technologies for Health.
Haux R, Kulikowski C, editors. Methods Inf Med 2006; 45 Suppl 1:19.
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Original article

A study of a rural telemedicine system in the Amazon region of Peru

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Summary

Voice and data communication facilities (email via VHF radio) were installed in 39 previously isolated health facilities in the province of Alto Amazonas in Peru. A baseline study was carried out in January 2001 and a follow-up evaluation in May 2002, after nine months of operation. We measured the reliability of the technology and the effect the system had on staff access to medical training and information. We also measured the indirect effects on the general population of access to better health-care. The experimental data were collected from 35 of the 39 sites in face-to-face questionnaire interviews. Before installation of the system, the mean consultation rate was 3 per month per facility (95% CI 1.5 to 4.5). At the end of the study, the mean consultation rate was 23 per month per facility (95% CI 14.7 to 31.5). There were 205 emergency transfers from the 39 health facilities. The system was employed in all these cases to alert the referral centre. The mean time required for evacuation was reduced from 8.6 h to 5.2 h. Health-care personnel reported that in 58 of the emergency cases (28%) the use of the system saved the life of the patient. The study shows that the use of communication technologies appropriate to local needs solves many problems in rural primary care, and that voice and email communication via VHF radio are feasible and useful for rural telemedicine.

Introduction

Telemedicine has been used to deliver health services to isolated regions of industrialized countries. It can also be used to provide medical care in disadvantaged areas of developing nations, where there is little infrastructure[1,2]. There is great potential to improve health through the use of telecommunications and information technologies. However, the availability of telephony services and the use of computers remain limited in many developing countries, particularly in the health sector[3,4]. Before telemedicine can be introduced, problems such as the lack of electricity in many rural areas and the absence of an adequate infrastructure[5] must be addressed. This suggests that the introduction of telemedicine in these countries requires careful planning and appropriate evaluation[6].

In both industrialized and developing countries, there are significant differences between the health-care provided in urban areas and that available in rural or sparsely populated regions[7]. These differences are accentuated in poor countries, and strategies to minimize or avoid them have been the subject of several studies in recent years[8–10].

Health-care in the Amazon region

Primary care institutions in Latin America can be grouped into two categories: health centres and health posts. A health post is a point of access to the health-care system for a rural population. Health posts are typically located in towns of no more than 1000 inhabitants that have no telephone line and poor transport. A health centre is usually located in a provincial or district capital and has telephone lines installed. Health centres are always under the direction of a physician and are equipped to make select

Accepted 29 April 2004
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diagnostic tests. They can also hospitalize some patients.

Several health posts depend on a single health centre, which together comprise a health 'micro-network'—a basic primary care unit. The micro-networks are under the direction of the physician responsible for the health centre, who coordinates the activities of the health posts. Most health posts need better ways of communicating with the physician for consultation, conveying epidemiological surveillance reports, ordering medical supplies and relaying information concerning acute epidemic outbreaks, medical emergencies or natural disasters. Normally, communication and the exchange of information require health-care workers to travel from one facility to another, which can take hours or even days. The Enlace Hispano Americano de Salud (EHAS; Hispanic American Health Link) has developed a system that facilitates the exchange of information between health centres and health posts in a rural area of Peru.

The EHAS system

The EHAS system uses radio (VHF, HF and WiFi) for voice and data communication (Fig 1). Information exchange is by email, and is focused on distance training, the exchange of epidemiological reports and patient transfer.

The system was installed in the province of Alto Amazonas in Peru (Fig 2). The area is large (twice the area of Belgium) and lacks roads: 95% of the health-care facilities are accessible only by river. It has little in the way of telecommunications infrastructure; for example, only 2 of the province's 93 health-care facilities have telephone lines. The 93 health-care facilities are organized into two health networks, the Marañón network and the Huallaga network. The Huallaga network contains seven micro-networks (Balsapuerto, Lagunas, Sta Cruz, Shucushyacu, Pampahermosa, Jeberos and Yurimaguas). Each of these has a single supervising health centre and several health posts. The administrative centre is at Yurimaguas Hospital, where the provincial health authority is based.

The Marañón network covers the Saramiriza and San Lorenzo health centres but the EHAS system had not been installed in their respective health posts and so it was not included in the evaluation study. In order to allow us to measure the effect of the EHAS system, facilities were preferentially selected from the Huallaga network, so that the Marañón network could serve as a comparator. In that selection, priority was given to the most isolated facilities (i.e. those farthest from their referral centre) and those in 'silent zones' (i.e. those areas for which it was not possible to obtain reliable information about their health-care activity or problems). There also had to be the appropriate technical conditions for radio transmission, as well as proximity (less than 40 km) to a telephone, to allow efficient voice and data communication.

In cooperation with the Catholic University of Peru (PUCP), equipment was installed in the provincial hospital, seven health centres and 31 health posts during 2000 and 2001. In the health centres, email servers were mounted on a wall rack to facilitate their maintenance (Fig 3). In addition, each health centre received a PC connected to the server via an Ethernet cable, four batteries, a recharger to take advantage of the 4 h of electricity delivered to the health centre, a tower (30 m tall) with an antenna and a system for protection against lightning strikes.

In the health posts (Figs 4 and 5), laptop computers, a VHF transceiver with a radio-based modem, a matrix printer, batteries, two lights and a regulator were

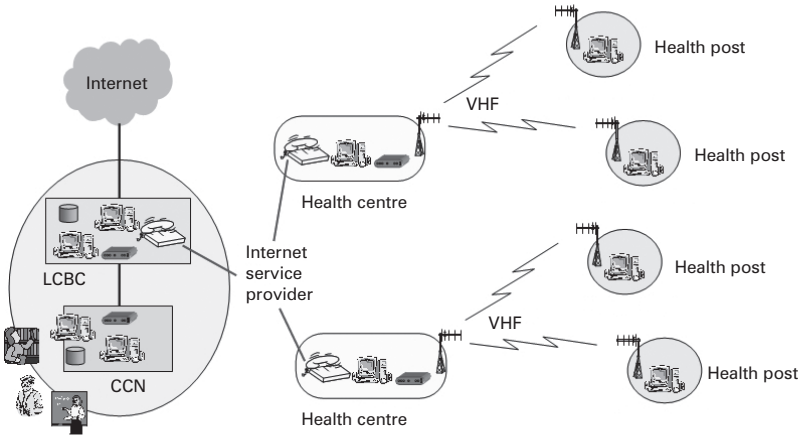

Fig 1 The EHAS system network. The LCBC (low-cost communications laboratory) hosts the central server. The CCN (national coordination centre) is the EHAS services provider, located at the Cayetano Heredia University.

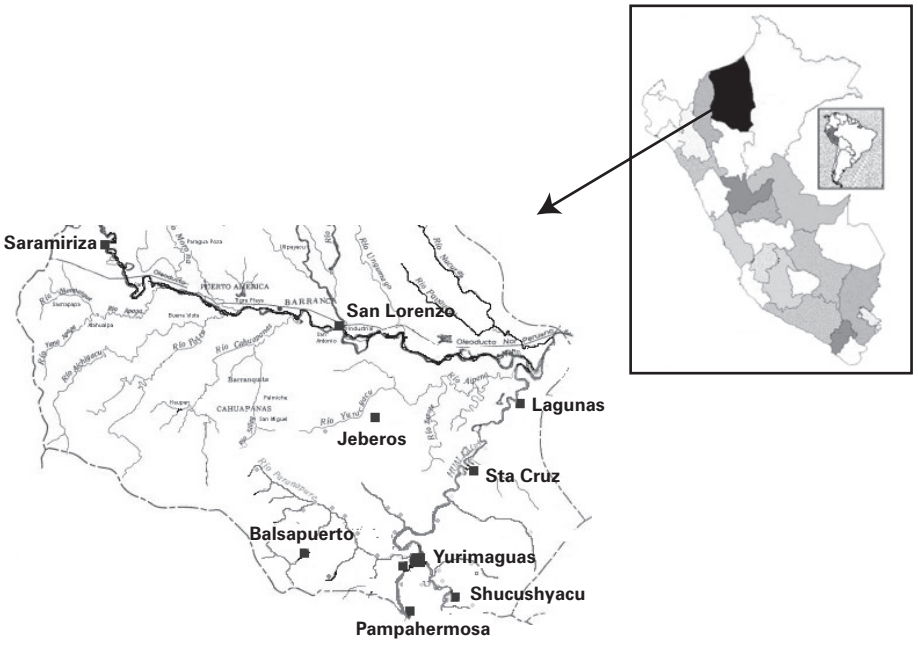

Fig 2 Locations of the health centres in the two health networks in the province of Alto Amazonas (shaded area of inset map). Note that the Saramiriza and San Lorenzo health centres in the Marañón network were not included in the present evaluation study.

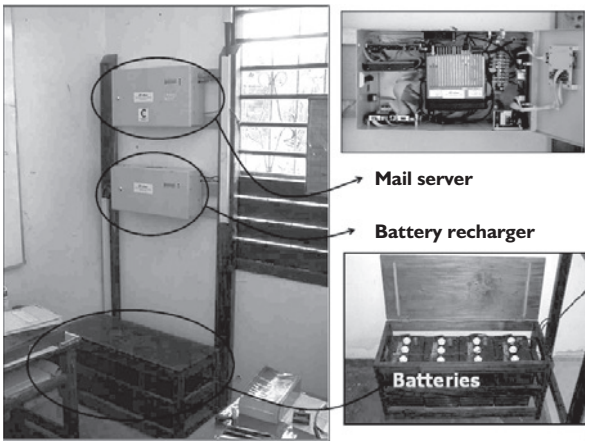

Fig 3 Server and battery system in a health centre.

Fig 4 Infirmary technician using the VHF system for voice communication.

installed, along with two 80 W solar panels, a tower 15–30 m tall to support the antenna and an electricity protection system.

The main server for the project was located in Lima. It was the only machine in the entire project that was connected to the Internet 24 h a day. This server stored all the messages received for all the accounts involved in the EHAS project in Peru and routed all those sent to the Internet from the rural system sites.

With the radio transceiver installed in the health post, the health-care staff could transmit voice messages (for urgent medical cases) and, via the modem that linked the radio to the laptop, could receive and transmit email. The health centre server managed all the local messages in its micro-network via radio (80% of all communications occurred within the micro-network). The government of Peru supported the project by installing telephone lines in every health centre. The servers at the health centre could therefore make a telephone call every 3 h to send to and receive from the Internet all the mail of the micro-network. Thus, the cost of communication was reduced as the expense of the telephone was shared among all the facilities of each micro-network.

The following information services were deployed over the network:

Fig 5 Infirmary technician using the VHF system for data (email) communication.

(1) voice and email messages (useful for emergency care and the coordination of health-care activities);
(2) distance training via email (carried out by the Cayetano Heredia University) — four health-related courses were offered via email, on malaria, dengue, breastfeeding and first aid;
(3) exchange of epidemiological vigilance reports;
(4) electronic publications with local health news (to reduce professional isolation).

The purpose of the present study was to evaluate the effect of the EHAS system on the working conditions of rural health-care workers.

Methods

A baseline study was carried out in January 2001. The telemedicine system was then evaluated in May 2002, after nine months of operation. We measured the reliability of the technology, and the effect that the system had on staff access to medical training and information. We also measured the indirect effects on the general population of access to better health-care.

The experimental data were collected in face-to-face questionnaire interviews. The person in charge of each medical facility was interviewed. The questionnaire covered 295 variables, which corresponded to 81 indicators and 39 sub-hypotheses. For example, the ease with which consultations could be made was rated from 1 to 20, with higher scores indicating greater ease, and the distance training courses were scored from 0 (bad) to 20 (excellent).

Results

Data were collected from 35 of the 39 sites. Twenty-seven sites were included in both surveys (Table 1).

Effectiveness

In the baseline survey, the majority of those interviewed said it was impossible or very bothersome to carry out consultations. At the second survey, this was reversed (Table 2). The score for the ease with which consultations could be made had increased significantly ($P<0.05$).

Before installing the EHAS system, the mean consultation rate was 3 per month per facility (95% CI 1.5

Table 1 Sites studied

Type	Both surveys	First survey only	Second survey only
Health posts	Cotoyacu Puerto Perú Progreso Nuevo Arica Panan Vista Alegre Centroamérica Nueva Vida Varadero Jeberillos Providencia San Pedro de Zapote Munichis Puerto Victoria Huancayo Pucacuro Charupa Achual Tipishca Naranjal Islandia Libertad Cuipari	Nueva Era Nuevo Mundo Gloria	Varaderillo Tupac Amaru Unión Campesina Parianari
Subtotal	*22*	*3*	*4*
Health centres	Pampahermosa Balsapuerto Jeberos Santa Cruz Shucushyacu	Lagunas	
Subtotal	*5*	*1*	*0*
Total	*27*	*4*	*4*

Table 2 Selected survey results

	First survey (baseline)	Second survey (after 9 months)
It is easy to consult with other personnel when there is a doubt: proportion (%) of respondents agreeing (total no. of respondents)	6 (31)	93 (31)
Mean score (0=very difficult, 20=very easy) for the ease of conducting a consultation (total no. of respondents)	8.7 (31)	16.3 (30)
Mean proportion (%) of emergency evacuations preceded by warning of the existence of an emergency (total no. of respondents)	40 (31)	100 (29)

to 4.5). At the end of the study, the mean consultation rate was 23 per month per facility (95% CI 14.7 to 31.5).

The system was effective for distance education of rural health-care workers: the mean score was 16.9 (n=19). Twenty of the 21 students surveyed (95%) considered the system adequate for the continuing education of health-care personnel in rural areas of Peru. Moreover, it served to reduce by nearly half the number of students attending class in person and provided access to all the continuing education courses offered for personnel at 93% of the sites (26 of 28), compared with 36% previously (11 of 31).

Email was used for epidemiological reporting in the Balsapuerto micro-network (one of the more geographically isolated health centres). The number of trips needed to convey reports was reduced to one-quarter of those made previously. Eighteen of 30 health posts (60%) used a computer to prepare reports, which produced a significant reduction in the time spent writing them (from 20 to 13 h a month) ($P<0.05$).

In nine months there were 205 emergency transfers from the 39 health facilities. The EHAS system was employed in all of these cases to alert the referral centre. In 131 of the transfers (64%), vehicles from other facilities were used, and this reduced the mean time required for the evacuation from 8.6 h to 5.2 h. Health-care personnel reported that in 58 cases (28%) use of the system had saved the life of the patient.

Reliability

During the nine-month study period, 34 problems with the equipment were detected. Twenty-five of these (74%) were solved locally. The voice system was found to have a rate of reliability of 97%, while the rate for email was 90%. One problem was the mean length of time required to resolve problems with the email system, which was about 24 days.

Usability

Only two courses, each lasting five days, were provided to teach basic maintenance and use of the voice and email systems and of the computer. All those interviewed had attended the training sessions offered by EHAS. Only 4 of the 31 interviewees (13%) stated that they had had previous experience of computer use and only one (3%) was familiar with email. At interview, 93% (25 of 27) considered the use of email easy or very easy and 77% (23 of 30) said the same about the use of the computer to write and print documents.

The rate of use of the radio equipment for voice communications was very high, with an average of 11.8 calls per day (95% CI 8.6 to 15.0). Only two respondents of 26 (8%) complained that they could not accustom themselves to using email and had problems with it. The rest reported that they sent and received about 10 messages per week (95% CI 6.8 to 12.4). The computer was employed daily by 81% of those interviewed and 70% (21 of 30) said that they had no difficulties with its use.

Institutional sustainability

All of those responsible for the micro-networks (five people) and unit directors (10 people) at the Alto Amazonas provincial health authority agreed or strongly agreed that EHAS improved communication and access to information for rural health-care workers. Ninety per cent considered that the system was effective and useful, that it functioned as expected and that it solved the problems mentioned above. None considered that the investment was disproportionate or that the money should have been used in some other way. Eighty per cent reported that the communication network improved the health of the residents of Alto Amazonas and only 20% believed that the provincial health authority would be unable to guarantee the sustainability of the communication network in the future (of the remaining 80%, half believed it would be able to do so and the other half were not sure).

Costs and savings

The maintenance and repair of the 39 systems installed, plus the telephone bill, amounted to US$704 per month (US$1 is €0.8).

There were direct savings from the reduced number of trips made by the health-care workers, amounting to

US$1728 per month. There were much greater savings from the reduction in emergency evacuations: 0.6 transfers were avoided per month at each site, or 23 per month across the network, which represents a saving of US$4266 per month. However, only 17% of these costs were borne by the Ministry, so the saving to the Ministry was $725 per month.

Effect on the clinical process

Both the physicians responsible for the health-care micro-networks and the unit directors in the provincial authority stated that, since the system was installed, the diagnostic and therapeutic capacity of the health posts had increased. However, only 7 of 18 people interviewed (39%) said that the EHAS distance education courses had helped them with a specific patient.

There were 645 clinical consultations over the nine months of the study, carried out to address doubts concerning diagnosis (a mean of 10 per facility) or treatment (a mean of 6.6 per facility). The problems were solved satisfactorily in 98% of cases. The consultations were usually carried out in realtime via radio while the patient was at the facility.

Moreover, 19 of the 31 people interviewed (61%) affirmed that the EHAS system enabled them rapidly to procure some medication that they lacked to treat a given patient. In addition, as indicated above (see 'Effectiveness'), the radio was used in medical emergencies to provide information about the evacuation, which reduced the transfer time by 3.4 h and allowed the appropriate preparations to be made.

Effect on patient health and welfare

From the point of view of the health centre physicians and the unit directors at Yurimaguas Hospital, obstetric emergencies, followed by cases of complicated malaria, were the two medical problems for which the EHAS communication system had the greatest benefit. In fact, the time to detection of cases of malaria was reduced by half, which, over the long term, will affect the morbidity and mortality associated with this disease. Cases of severe trauma, snake bites and all the diseases for which notification is obligatory were also mentioned. Moreover, 26 of the 30 people interviewed (87%) reported that, in at least one of their emergency transfers, the use of the system had saved the life of the patient. The majority of these emergencies (58 in total — see 'Effectiveness', above) concerned pregnant women (cases involving Caesarean section, retained placenta, fetal death, eclampsia); there were also cases of bullet and machete wounds, severe trauma, snake bite and complicated malaria.

Effect on professional isolation

Feelings of professional isolation on the part of rural health-care personnel were slightly reduced. The trips of these workers were reduced by 42% ($P<0.01$), which was beneficial as staff worried if they left the facility unattended for too long — the rate of which fell from 55% (17 of 31) to 27% (8 of 31) of those interviewed. The feeling of not being wholly able to perform their work also diminished slightly. The staff at health posts were nearly unanimous (97%) (29 of 30) in saying they felt surer of themselves in their work because they could consult with their referral physician. Practically all those interviewed also agreed that, since the communication system had been installed, they had more opportunities to carry out joint activities and exchange experience and knowledge with their colleagues, in addition to learning and doing new things in their work.

The system, especially the radio, was frequently used for personal communications unrelated to work (15 radio communications and 4 email messages per month during the study period, versus 2 personal communications per month previously).

Discussion

We believe that the results of the EHAS trial in Alto Amazonas are applicable to regions with similar health-care conditions and facilities, and thus to most other rural areas in Latin American countries.

Based on the results of the present study, we believe that:

(1) the use of communication technologies appropriate to local needs solves many problems in rural primary care;
(2) voice and email communication via VHF radio is technically and economically sustainable for rural telemedicine;
(3) the personnel of rural health posts, in many cases nursing technicians with no university education, are capable of learning to use computers for basic office tasks and email, by attending training sessions of no more than 10 days' duration;
(4) only through a scheme involving the active participation of all users can a sustainable service be achieved.

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