

Analysis of Information and Communication Needs in Rural Primary Health Care in Developing Countries

A. Martínez, V. Villarroel, J. Seoane, and F. del Pozo, *Senior Member, IEEE*

Abstract—This article presents three studies dealing with information and communication needs in rural primary health care from Peru and Nicaragua. Results show that primary health-care systems in rural areas of developing countries are very inefficient. Among the main reasons we found factors related to communication infrastructure, information sharing, and continuous training of health professionals. We conclude that telemedicine systems can improve this situation, but the lack of infrastructures, low income levels, and other conditions, impose strong limits to the introduction of new technologies. The main conclusion is that differences in needs and conditions between developing countries and industrialized ones force to use different solutions and approaches. This article presents some proposals on technology requirements and how to deal with the use of telemedicine in rural areas of developing countries. These proposals can be useful to all kind of actors (national public administrations, multilateral institutions, industry, academy, civil society, etc.) in order to promote really relevant and sustainable proposals in telemedicine for rural regions of developing countries.

Index Terms—Developing countries, information needs, rural telemedicine.

I. INTRODUCTION

THE ORIGINS of telemedicine are associated with the search for communication-based solutions to allow isolated or scattered population access to remote health services [1]. Moreover, telemedicine was always considered the only feasible way to approach modern medicine services and systems in many underserved scenarios, notably those of the rural areas of developing countries.

However, reality has gone in a very different direction. The already extensive experimentation with telemedicine systems in the developing world has not demonstrated yet that telemedicine could provide sustainable options if applied in developing countries. This latter assumption is due to some adverse conditions we encounter in the rural areas of those countries such as lack of infrastructure, poor purchasing capacity, difficulties in the access to maintenance and repair, etc. However, it has been demonstrated that most telemedicine services and technology platforms, developed to fulfil the needs

of industrialized countries [2]–[4] health-care models, are not appropriate for developing countries. There are several studies on information needs of health staff in rural regions of industrialized countries [5]–[9] and on their training needs [10], but few studies have focused their attention on developing countries [11]–[13] and less on Latin America [14]. As a consequence, when we analyze telemedicine solutions for developing countries, first we should recognize which are the health-care-related needs of rural areas of developing countries, what is the social and economic context, and what kind of communication-based solutions of telemedicine has to be designed and installed.

The objective of this paper is an empirical analysis dealing with consultation, information, and training needs of health staff in rural areas of developing countries in order to identify those needs that can be improved by accessible communication networks.

The empirical analysis presented here is based on three field studies carried out from 1998 to 2002. The first one covered three of the five Peruvian Initial Application Provinces (IAP), where health sector reform in Peru began. A second study was carried out in the Chinandega region in Nicaragua, and the last one in Alto Amazonas province, in the Loreto region of Peru.

II. MATERIALS AND METHODS

Primary health-care systems in Peru and Nicaragua are based on two kinds of establishments: health centers (HCs) and health posts (HPs). HCs are usually located in towns with access to telephone networks. They are always headed by physicians, have some infrastructure, equipment for diagnostic tests, and, in some cases, allow hospitalization. HPs are under HCs in the establishment's hierarchy. They are in small towns (no more than 1000 inhabitants), have no telephone lines, and are badly endowed with road infrastructures. The set of various HPs depending on one HCs configures what is called a "health micronet," which is the basic unit in primary health-care systems.

Peru is a large South American country and was chosen as representative of the Latin American region and of the countries with medium Human Development Index (according to the United Nation Development Program ranking). Nicaragua is a small Central American country and has medium to low Human Development Index. In terms of health, both countries are in a similar situation. Rural areas of both countries have worse health conditions than urban ones and suffer the same kind of health problems (transmissible diseases, respiratory infections, and diarrhoeal diseases [16], [17]), with children and pregnant women the most vulnerable groups. In terms of Information and Communication Technologies (ICT) Peru and Nicaragua have

Manuscript received March 24, 2004; revised July 26, 2004 and October 6, 2004.

A. Martínez was with the Biomedical Engineering and Telemedicine Group, Technical University of Madrid, Madrid 28040, Spain. He is now with the Department of Signal and Communication Theory, Carlos III University, Madrid 28911, Spain (e-mail: andresmf@ehas.org).

V. Villarroel and F. del Pozo are with the Biomedical Engineering and Telemedicine Group, Technical University of Madrid, Madrid 28040, Spain (e-mail: valentin@ehas.org; fpozo@gbt.tfo.upm.es).

J. Seoane is with the Department of Telematic Engineering, Technical University of Madrid, Madrid 28040, Spain (e-mail: joaquin@dit.upm.es).

Digital Object Identifier 10.1109/TITB.2004.842411

TABLE I
SELECTED ESTABLISHMENT IN THE THREE STUDIES

		Total HC	Total HP	selected HC	selected HP
1 st study	Morropón	6	46	4	14
	Moyobamba	6	37	5	8
	Islay	4	9	3	7
2 nd study	Chinandega	16	78	8	9
3 rd study	Alto Amazonas	11	81	7	34

similar conditions, despite the fact that Peru has better indicators [15], [18].

The first study was carried out in the Peruvian provinces of Morropón (Piura region), Moyobamba (San Martín), and Islay (Arequipa). The fieldwork was done in November and December 1998. The second study was carried out in the Chinandega Region, Nicaragua. The fieldwork was done in November and December 1999. The third and last study was carried out in the Peruvian province of Alto Amazonas. Fieldwork was done in December 2000 and January 2001. Table I shows the selected establishments in each study.

At each site all staff was interviewed. Sites were chosen according to the following:

- a balance in the number of HC and HP;
- including establishments with different access difficulties;
- including establishments with and without communication system.

The results from the first and the last studies in Peru can be seen, respectively, as representative of the upper and lower extremes of the general conditions in Peru. The three Peruvian provinces analyzed in the first study stand out as the provinces with better health-care system in the whole country. Nevertheless, Alto Amazonas is one of the most isolated Peruvian provinces and has very low health indicators. Chinandega can be considered representative of the best of the Nicaraguan health system.

The technique used for data collection was a personal interview guided by a questionnaire.

Qualitative analysis was used to design the questionnaires. The techniques used were depth interviews, focus groups, and participant observation. A total of 16 depth interviews (that were trying to understand and compare both the management class vision and the intermediate people in charge, the rural health-care personnel, too) were done: six of high level (one in Lima to the director of the Program of Reinforcement of the Health Systems, and to three regional health directors, to two provincial health directors); and ten of low level in Alto Amazonas (to the hospital director; persons in charge of epidemiology, training, pharmacy, statistics, and radio-communication; physicians in charge of three health micronets and infirmary technicians from the hospital departments of statistic, environment health, and malaria), and seven meetings (that were seeking the debate dealing with the most conflictual or contradictory issues) were also done with the following four focus groups: managing committee of the hospital, all the personnel from two health micronets, and all the rural physicians in the province. After this, we could design a 92-question survey, which was

used in both countries (only with minor local language adaptations), previously validated on the field.

To get a quantitative description and characterization of the above, we identified the following targets to be analyzed and statistically described:

- profile of health personnel (profession, age, and experience);
- profile of the health-care establishments (buildings, transport vehicles, medical equipment, and computer and telecommunication infrastructure);
- features of the administrative and health information systems (sufficiency, precision, and usefulness of information; acceptance, satisfaction, and ease of use of actual systems; and time and cost to prepare and send reports);
- drug acquisition systems (orders, travels, and costs);
- travels out of the town of work (for training, coordination, and consultation);
- training needs;
- access to health publications;
- work conditions (isolation feeling, possibilities of promotion, and motivation);
- perceptions on using telecommunication systems at work (communication flows, costs, priorities, and acceptance).

Internal reports from the regional and provincial offices of Ministry of Health have been used in the three studies. Also, internal reports from the regional and provincial government have been used in the case of Alto Amazonas.

III. RESULTS

Results from the three studies (IAP, Chinandega, and Alto Amazonas) are organized in the following eight areas: 1) profile of health staff; 2) profile of the HCs; 3) administrative and health information systems; 4) drug distribution systems; 5) travels out of the town of work; 6) training needs and access to health publications; 7) work conditions; and 8) perception about the use of ICT at work.

A. Profile of Health Staff

Health staff in rural areas is young, has little work experience, and shows high job rotation. In many cases, HPs are headed by infirmary technicians, who are barely trained, and must take care of several villages. Physicians tend to leave the rural area looking for large cities arguing professional isolation. They do not have much experience working with computers and electronic mail. Results are shown in Table II.

B. Profile of Establishments

Access to rural health establishments is always difficult. Alto Amazonas province has only one road, which is not asphalted, that links the capital with the rest of the country. All other transport within the province has to be made by fluvial boats. Only 8 out of the 93 health establishments in the province are accessible by road. In Alto Amazonas, travelling from an HP to its reference HC takes 11 h on average. In case of urgent patient transfer, the average is 8.6 h (with a highest value of 72 h). There are few establishments with telecommunication systems

TABLE II
PROFILE OF HEALTH PERSONNEL INTERVIEWED

	IAP	Chinandega	Alto Amazonas
Average age	32 years	32 years	31,5 years
Years of experience working on health	5 years	8 years	5 years
HP headed by infirmiry technicians	78,6%	61,5%	100%
Staff who never used computer	46,3%	70,6%	64,9%
Staff who never used e-mail	73,2%	70,6%	89,2%

TABLE III
INFRASTRUCTURE OF THE ESTABLISHMENTS

	IAP	Chinandega	Alto Amazonas
Average time for travel to reference establishment	1,1 hours	1,3 hours	11 hours
Establishments with some telecommunication system	34,1%	41 %	29,4%
HP with some telecommunication system	20%	20%	18%
Establishments with telephone line	22%	11%	2,9%
Establishments with radio equipment	20%	35%	26,4%
Establishments with public telephone in the village	56%	23,5%	23,5%
Establishments with computer	17,1%	23,5%	11,7%
Establishments with some transport vehicle	22%	41,2%	48,6%

(less than 20% of the HP): the latter is usually a radio equipment. Telephone lines are very scarce (in Alto Amazonas, only two establishments out of 98 have telephones, the hospital and one HC). There are not many computers (nearly 25% of the establishments have a computer). Patient transfer has to be done stretching up to the nearest road in order to catch a van (or a boat in the rain forest). There are not enough vehicles for patient transfers, particularly in HPs: in IAP and Chinandega, none of the HP has an appropriate vehicle for patient transfer, whereas in Alto Amazonas, 30.7% of them have one. Results are shown in Table III.

C. Administrative and Health Information Systems

Current health information systems are based on paper. Forms are filled in and sent to the reference establishment (from HP to HC and from HC to the health provincial office). Epidemiological surveillance reports are sent once a week and health program reports (about 12) and other forms (medical insurance, administrative reports, financial ones, chemists, etc.) are sent once a month. The volume of interchanged information is very high. In Peru, HPs monthly send 100 pages on average to their reference HC, while HCs send about 300 pages to their provincial office. In Nicaragua, HPs send 32 pages to HCs and HCs send 250 pages to the provincial office. People interviewed consider the time devoted to fill in and to send reports to be excessive. Table IV collects the time spent to fill in and to send reports, as well as the costs to send reports.

The cost to send reports in Alto Amazonas represents 55% of the average income to an HP and the 23% to an HC. If there is not enough money in an establishment, the health staff has two options: to pay it by themselves (which is the common

TABLE IV
TIMES AND COSTS TO FILL IN AND TO SEND REPORTS

	IAP	Chinandega	Alto Amazonas
Monthly time devoted to fill in reports	41 hours	65,3 hours	23,3 hours
Monthly time devoted to send reports	14 hours	20 hours	27,9 hours
Monthly cost to send reports	\$ 20	\$ 12	\$ 22

TABLE V
FEEDBACK INFORMATION

	IAP	Chinandega	Alto Amazonas
It arrives always or almost always	25,6%	35,3%	8,8%
Average time of delay	1 month	3 months	2 months

choice) or not to send the report (which can cause problems to the worker).

The health staff is not very satisfied with the actual information systems: only 22.2% were satisfied in the IAP and 47% in Chinandega. Personnel consider information to be very useful but they recognize that information usually arrives late, it is not always complete, and some times it is not clear and/or precise. Health personnel denounced a very common problem: There is nearly total absence of feedback information to the HP (especially important in epidemiological surveillance).

As for filling in reports, the main complaint is that staff is forced to duplicate information in different forms. Forms are usually sent personally. Sixty-five percent of people interviewed in Alto Amazonas recognize reports were lost in some occasions. Losses used to happen when reports were carried by a resident external to the health-care system. Filling in reports is one of the most unpleasant tasks for health staff. Health staff agreed that feedback information (processed information sent back to the rural area) is very useful for their daily work. Unfortunately, feedback information does not generally arrive; furthermore, when feedback information comes, it is usually late. Table V shows the results.

There is an important subregistration and a deficient quality control, too. Lack of communication systems makes it difficult to confirm data when a possible error is suspected.

D. Drug Acquisition Systems

All rural health establishments deliver drugs. According to the common practice, the HC usually supplies its micronet with drugs. The person in charge of the chemistry unit prepares the order and travels personally to the reference establishment to supply the drug stock. In some cases, traveling has to be done directly to the provincial hospital. In most of the cases, drugs are ordered once a month. Drug acquisition systems are slow: The whole process (round-trip to get the drugs) takes in Alto Amazonas an average time of 4.3 days. Much of the travels are done without knowing if there is enough stock in destiny, causing a lot of useless travels.

E. Travels Out of the Town of Work

Only one person heads most of the rural HPs. In all these cases, travels out of the establishment forces them to suspend

TABLE VI
AVERAGE TRAVEL COSTS BY MONTH

	HC	HP
Total costs	\$446,31	\$153,56
Cost paid by health system	\$267,3	\$95,98
Cost paid by health establishment	\$197,48	\$58,13

health-care service, sometimes for more than one day. Personnel's travels are not only planned to transfer patients, to send reports, and to acquire drugs, but also to coordinate meetings, training courses, and consultation with other professionals. Health staff usually travels to the reference establishment, or to the provincial hospital, four or five times a month (for coordination, training, and doubt consultation). Another reason to suspend health-care service is to attend patients at their homes or in near villages (usually about two travels per month).

Health personnel from Alto Amazonas takes an average of 8 h each month to travel for delivering reports. Commonly, health staff does not find substitutes when they have to travel for coordination or consultation, thus leaving the health-care posts without assistance service (this is recognized by 75.7% of personnel interviewed in Alto Amazonas). Those interviewed consider that this percentage could be reduced if the establishments would have some telecommunication system to coordinate travels. Consultations with other professionals are continuously demanded especially by infirmity technicians, who need to communicate frequently with their reference physician because of their scarce training. Because of transport limitations and time required for travel, health personnel do not make all the consultations they would. Nevertheless, when health staff can have consultations, they usually can exchange information with delay (in Alto Amazonas 59.5% of people recognize they do consultations too late). Infirmity technicians at HP can solve their doubts at the HC, so they do not need to consult with the hospital. However, physicians and nurses from HC need to solve their doubts at other HC or at the hospital.

Travel costs in Alto Amazonas are \$225 monthly per establishment, including emergency evacuations, accommodation, and food expenses when travels take more than one day. In case of an HC having a patient transfer to the hospital, cost is shared among the patient, the local council, and the health establishment. The HP does not pay when the costs of the emergency evacuation are shared out among the patient and the local council. Training courses take place at the hospital and travel costs are paid by MINSA (Ministry of Health). Taking into account these various premises, travel costs can be divided as shown in Table VI.

Travel costs in HP are higher than incomes. In many cases, health personnel have to pay part of these expenditures themselves (on average 17% of his/her salary).

The use of electronic mail could avoid several travels, as it can be seen in Table VII. In Alto Amazonas, 73.5% of the people interviewed think patient transfers would be reduced with a telecommunication system in the establishment.

According to the data in Table VII, within the health system, savings would be \$312 every year per rural worker in the IAP and \$192 in Chinandega. Detailed results are shown in Table VIII. We have taken into account only the savings related

TABLE VII
PERCENTAGE OF STAFF WHO THINKS E-MAIL
COULD REDUCE TRAVELS ON 50% OR MORE

	IAP	Chinandega	Alto Amazonas
Travels for co-ordination	94,6%	81,3%	-
Travels for training	52,8%	50%	-
Travels for consultations	90%	-	-

TABLE VIII
ANNUAL SAVED ESTIMATED PER WORKER BY
AVOIDING MEETINGS THANKS TO E-MAIL

	IAP	Chinandega	Alto Amazonas
Co-ordination Meetings	\$190	\$130	-
Training meetings	\$68	\$62	-
Doubt consultation meetings	\$54	-	-

to travel expenses, accommodation, and food. In this study, we did not consider other intangible costs as the opportunity cost of having health staff travelling instead of attending patients. The estimated saving gives an idea of cost reduction for the health system in case of having a telecommunication system.

F. Training Needs and Access to Health Publications

Health personnel consider the number of received training courses to be insufficient (97% of people interviewed in Alto Amazonas). Not receiving or receiving the notice of the course too late is one of the main reasons why people do not attend to training meetings (59% in Alto Amazonas). Almost everybody said that they would like to assist to more courses. The most demanded training deals with items related to more common diseases in the area: maternal and child health, diarrhoeic diseases, respiratory diseases, and general transmissible diseases, computer use and health administration or management, too.

G. Working Conditions

Of rural sanitary personnel, 73.2% in the IAP, and 73.2% in Chinandega, recognized sometimes having a feeling of professional isolation. This feeling is due to geographical isolation, scarce communication infrastructures, and difficult access to any kind of information. According to health workers, the main consequences of isolation are problems with patient transfers, lack of updating in health topics, deficiencies of health equipment, problems with information sharing, and cultural barriers with the local communities. Having voice and data communication systems would improve the professional situation much or very much for 100% of people interviewed in the IAP and 94.1% in Chinandega, while the personal situation would improve much or very much for 87.2% in the IAP and 78.6% in Chinandega. Rural health personnel are satisfied with their job, although they consider that their work is not always recognized by the Ministry of Health.

H. Perception About the Use of ICT at Work

In Alto Amazonas, health staff identifies priorities (where there is no telecommunication system in the establishment) in the following order: communication system (42.9%), improvement of the buildings (28.6%), increasing staff (19%), and transportation vehicle (9.5%). A very valuable result is that health

staff considers that 80% of their communication needs are limited to the local health micronet and only 20% of them have to be made at a provincial or national level.

If health workers had to choose between a voice communication system and a data one, in the three studies, the majority preferred data communication systems (63.4% in the IAP and 81.3% in Chinandega), especially if that systems would avoid travel for information delivery. They considered that the use of e-mail to send forms would avoid the loss of them.

One hundred percent of the people interviewed in the IAP and in Chinandega considered that access to e-mail would help much or very much to improve the current information system. The personnel of Alto Amazonas agree or totally agree with the idea that e-mail can improve the service they provide (94.6%), the epidemiological surveillance system (94.6%), their training on health topics (91.9%), and the sharing of transport vehicles (91.7%), and 88.9% thinks it is positive to reduce the number of travels.

IV. DISCUSSION

Results from the three studies show that primary health systems in rural areas of developing countries are very inefficient due, among other things, to difficulties in the sharing of information.

We found some general telecommunication infrastructure constraints as follows:

- there is no electricity access in most rural villages;
- these areas have scarce or no public telecommunication infrastructure;
- rural health establishments have a limited purchasing power;
- maintenance costs are very high due to the great distances and the lack of a maintenance culture;
- there are few well-trained people for management, maintenance, and repair of ICT systems;

A more detailed analysis shows the following:

- 1) Epidemiological surveillance systems are expensive and not very efficient for three main reasons: information arrives late, contains frequent errors, and is not useful for taking correctives actions on time. The surveillance systems are expensive because of travel costs for sending reports and time used by personnel to fill in and send reports. Information arrives late because HPs are far away from the hospital, communication infrastructures are scarce, and information is processed by hand at all the HPs and most of the HCs. Data errors are frequent at least for two reasons: First, the same data is introduced several times by hand in different locations. Second, once a data error is detected, it is not possible to correct it by asking to the person who introduced the original data. Finally, in rural areas, it is difficult to take corrective measures on time because it is not possible to send back in time the feedback information from the hospital.

- 2) There are always difficulties for doing a correct diagnosis and treatment at the care sites because of three main reasons, such as: rural personnel low profile training; difficulties to make consultations to other professional; and inefficiency of the drug delivery system. As for the first reason, we recognized that the actual continuous training programs are very inefficient, thus making impossible access to medical information. Furthermore, qualified personnel (physicians, obstetricians, and nurses) usually move to large cities, arguing isolation and insufficient professional updating. As for the second reason, consultation process stands out quite complicated because of the large distances between centers and lack of telecommunication networks. As for the third reason, the drug delivery system is inefficient, because it demands a long time for sending the orders and receiving the drugs, arriving in many cases too late.
- 3) Management of emergencies in rural areas is complicated for two reasons. The first one deals with difficulties of coordinating patient transfers: It is hardly easy to predict when a transfer is going to arrive to the health-care referring establishment and to know in advance patient clinical history. The second reason deals with vehicle availability to transfer patients: There is no possibility to share vehicles for patient transportation between neighbor referring establishments. Furthermore, because of the lack of financial resources, each health site hardly can afford a vehicle of its own.
- 4) Continuous medical education is mandatory for all the agents of this primary health-care system. As for the rural areas we analyzed, implementation of continuous education courses is constrained by the high travel costs due to a very poor transportation infrastructure. Even so, attending a course or a seminar implies abandoning the HP for several days. Furthermore, distant-based training is not possible for the lack of communication and post services.

V. CONCLUSION

Taking into account the general analysis we outlined, a computer-based system (completed with voice system) in rural health-care systems of developing countries could improve the epidemiological surveillance system, emergency management, doubt consultation, and could be used for distance training. However, any telemedicine system in rural areas of the developing world has to be sustainable. As a consequence, it is mandatory to fulfil the following conditions:

- be highly robust to reduce travels for maintenance;
- any technological platform must demand low infrastructure, maintenance, and, specially, operation costs;
- the needs identified here can be achieved by services based on electronic mail, so low-speed systems can be used;
- low consumption is mandatory, because photovoltaic systems have to be used for power supply;
- a radio-based system is a good option;

- remote maintenance systems should be extensively installed, wherever possible;
- Giving priority to open technologies (hardware and software) to allow easier maintenance and reduce acquisition, development, and adaptation costs;
- developing a training plan for technical personnel on system management, maintenance, and repair;
- including only appropriate telemedicine services, focused on the real needs of rural staff;
- most of the information and communication needs can be satisfied by simple and asynchronous (off-line) systems (as electronic mail).

The Biomedical Engineering and Telemedicine Group of the Madrid Technical University and the Ingeniería Sin Fronteras, Engineering Without Borders (NGO ISF) have developed, according to these ideas, a telemedicine platform that has been installed at several pilot sites on rural areas of Latin American countries [19] (Peru, Colombia, and Cuba) and initial results are available [20].

ACKNOWLEDGMENT

The authors want to acknowledge the many people who work for the EHAS Program from the partner institutions: NGO Engineering Without Borders, Catholic University, and Cayetano University from Peru. They also appreciate the cooperation of many workers and managers of the Peruvian Ministry of Health in Lima and Alto Amazonas, as well as, their colleagues of the Nicaraguan Ministry of Health in Managua and Chinandega, personnel from the Peruvian Ministry of Communication, and institutions that support the activities of the program: CICYT, AECE, CYTED, UPM, OSIPTEL.

REFERENCES

- [1] M. J. Field, *A Guide to Assessing Telecommunications in Health Care*. Washington, DC: National Academy Press, 1996. Telemedicine.
- [2] R. J. Rodrigues, C. Crawford, S. Koss, and M. McDonald, *Telecommunications in Health and Healthcare for the Latin America and the Caribbean: Preliminary Report on an Expert Consultation Meeting*. Washington, DC: Health Services Inform. Syst. Program, 1998. PAHO.
- [3] R. Wootton, "The possible use of telemedicine in developing countries," *J. Telemed. Telecare*, vol. 3, pp. 23–26, 1997.
- [4] D. Wright, "Telemedicine and developing countries: A report of study group 2 of the ITU development sector," *J. Telemed. Telecare*, vol. 4, pp. 1–85, 1998. Suppl. 2.
- [5] J. L. Dorsch, "Information needs of rural health professionals: A review of the literature," *Bull. Med. Library Assoc.*, vol. 88, no. 4, pp. 346–354, Oct. 2000.
- [6] K. M. McCloskey, "Library outreach: Addressing Utah's "digital divide"," *Bull. Med. Library Assoc.*, vol. 88, no. 4, pp. 367–373, Oct. 2000.
- [7] D. C. McDuffee, "AHEC library services: From circuit rider to virtual librarian," *Bull. Med. Library Assoc.*, vol. 88, no. 4, pp. 362–366, Oct. 2000.
- [8] J. L. Dorsch and V. Pifalo, "Information needs of rural health professionals: A retrospective use study," *Bull. Med. Library Assoc.*, vol. 85, no. 4, pp. 341–347, Oct. 1997.

- [9] K. J. Muus, T. D. Stratton, and K. A. Ahmed, "Medical information needs of rural health professionals," *J. Rural Health*, 1st Quarter 10–15, 1993.
- [10] J. A. Parham, "Multidisciplinary work and education and training in rural health service delivery-rhetoric or reality?," in *4th Nat. Rural Health Conf.*, Australia, Feb. 9, 1997.
- [11] F. A. Ehihamenor and B. Apalayine, "Information needs and sources of primary health care workers in the upper East region of Ghana," *J. Inf. Sci.*, vol. 22, no. 5, pp. 367–373, 1996.
- [12] R. Vincent, "Beyond circles in square boxes: Lessons learned from health communication impact evaluations," in *Proc. Impact Evaluation Services Projects Sem.*, London, U.K., Jun. 6, 2001.
- [13] I. Carter, (1998) *Meeting the Information Needs of Third World Farmers*. London, U.K.: INASP, Nov. 1998. INASP Newsletter.
- [14] "Setting up Healthcare Services Information Systems: A Guide for Requirement Analysis, Application Specification, and Procurement," Panamerican Health Organization (PAHO), PAHO, Essential Drugs and Technology Program, Division of Health Systems and Services Development, Washington, DC, 1999.
- [15] "Programa de las Naciones Unidas para el Desarrollo (PNUD)," Informe sobre desarrollo humano 2001, Ediciones Mundi-Prensa, Madrid, España, 2001.
- [16] (1998, Mar.) Peru, perfil del sistema de servicios de salud. Organización Panamericana de la Salud (OPS), Organización Panamericana de la Salud, [Consultation: 13th Nov. 2001]. [Online]. Available: <http://www.americas.health-sector-reform.org/spanish/clhmperpr.htm>
- [17] (1998, Mar.) Nicaragua, perfil del sistema de servicios de salud. Organización Panamericana de la Salud (OPS) [en línea], Organización Panamericana de la Salud, [Consultation: 13th Nov. 2001]. [Online]. Available: <http://www.americas.health-sector-reform.org/spanish/clhmicpr.htm>
- [18] "Informe sobre desarrollo humano 2000," Programa de las Naciones Unidas para el Desarrollo (PNUD), 2000, Ediciones Mundi-Prensa, Madrid, Spain, 2000.
- [19] A. Martínez, V. Villarroel, J. Seoane, and F. del Pozo, "EHAS program: Rural telemedicine systems for primary healthcare in developing countries," *IEEE Technol. Soc. Mag.*, vol. 23, no. 2, pp. 13–22, Summer 2004.
- [20] A. Martínez, V. Villarroel, J. Seoane, and F. del Pozo, "A study of a rural telemedicine system in the Amazon region of Peru," *J. Telemed. Telecare*, vol. 10, no. 4, pp. 219–26, 2004.



A. Martínez was born in 1970. He received the Telecomm. Eng. and the Ph.D. degrees from the Universidad Politécnica, Madrid, Spain, in 1994 and 2003, respectively.

He is currently an Associate Professor in the Department of Theory of Signals and Communications, Universidad Carlos III, Madrid. He is Director of the EHAS Foundation, Hispanic American Health Link, and Founding Member of the Latin American Network of Telemedicine and Medical Informatics of CYTED.



V. Villarroel was born in 1968. He received the Telecomm. Eng. degree from the Universidad Politécnica de Madrid (Technical University of Madrid), Spain.

He is a Researcher in evaluation and sustainability of rural telemedicine systems in developing countries at the Bioengineering and Telemedicine Group, Universidad Politécnica de Madrid, Subdirector of project execution at the EHAS Foundation, Hispanic American Health Link, and Coordinator of ICT projects at the NGO Ingeniería Sin Fronteras (Engineering Without Frontiers - Spain).



J. Seoane was born in 1953. He received the Telecomm. Eng. degree in 1976 and the Ph.D. degree in 1989.

He is currently an Associate Professor at the Telecommunication Engineering School, Technical University of Madrid, Spain. His current interests are distributed systems administration, internationalization and localization, SGML- and XML-based teaching tools, free software, and low-cost telematic systems for less developed regions. From 2000 to 2004, he was the Technical Director of the EHAS

Foundation.



F. del Pozo (SM'04) was born in Madrid, Spain, in 1945. He received the Telecomm. Eng. and Ph.D. degrees from the Universidad Politécnica of Madrid, Spain, in 1969 and 1979.

Since 1986, he has been a Full Professor at the Universidad Politécnica de Madrid. He is the Founder (1985) and Director of the Bioengineering and Telemedicina Department of the Universidad Politécnica de Madrid. He is a Board Member of the *International Journal of Healthcare Technology and Management* and the *Journal of Telemedicine and Telecare*. He has published more than 350 scientific papers and has directed 20 Ph.D. theses. He was the main Researcher of more than 40 European Union funded research projects and 28 contracts with industrial companies.

Dr. del Pozo is President of the Sociedad Española de Telemedicina (SET) and Vice-President of the Sociedad Española de Ingeniería Biomédica.