FOSS for improving public primary health-care systems in developing countries: A case study of the EHAS Foundation

Abstract: Public health care systems in these areas face many problems like isolation, scarce of communication infrastructures or lack of personnel with adequate training that may be solved through the use of appropriate ICTs. This chapter presents a case study of the more than ten years of EHAS (Enlace Hispano Americano de Salud - Hispano American Health Link) Foundation activities trying to solve this problem. The work of EHAS is based on providing connectivity, and designing software and hardware in order to improve public primary health-care systems in rural and isolated areas of the world. Implications of FOSS are not only discussed in the context of the technology itself, but they are also examined through the glens of open knowledge philosophy it brings along. This view will show how FOSS is key to the long term sustainability and the positive impact on health achieved by the telemedicine networks deployed by the EHAS Foundation. The experience of EHAS will also provide a starting point to analyse the role that FOSS can play in ICT4D projects in the next future.

Keywords: Telemedicine, sustainable development, FOSS, rural areas, developing countries, Health Information Systems.

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1. Introduction

Providing care in rural areas of developing countries is a very challenging task since they are inhabited for the most vulnerable and most impoverished sectors of the population, those who suffer the most acute diseases. In addition, in these countries a high proportion of the medical expertise is located in urban areas preventing the most needed, those living in rural and isolated areas, from access to a quality health care-system.

Many initiatives have tried to improve public primary health-care systems in rural and isolated areas by using ICTs to connect rural health-centres with urban hospitals to address this issue and foster the development of rural communities (Wooton et al., 2009). The isolation and lack of infrastructure (roads, energy) of these regions make them less economically attractive for telecommunication operators to invest in deploying information and communication networks in these areas. This leaves only two solutions for connecting health-care facilities. Either they make use of satellite connections or they build out the networks themselves.

The first option is the most common (Bagayoko et al., 2006; Kopec et al.; 2002; Sachpazidis et al., 2006), however, the high operating cost of these connections has made most of these initiatives fail to become sustainable (Rey, 2010, Bebea-González et al., 2011b). Other stakeholders have chosen to build up their own communication infrastructure incurring in a high capital expenditure, but reducing to a minimum the operational expenditure (CAICBO, 2007; Macha Works, 2011; Pun et al., 2006; Surana et al., 2008, Simó et al., 2006). To do so, most of them use FOSS for adapting their communication solutions to the environment where they operate.

Once health-care centers are connected, through the aforementioned means or by traditional networks, many other institutions work for improving health-care provision through the design of software and hardware solutions to address the communication needs faced by their staff (Seebrægts et al., 2009; Braa et al., 2007; Martinez et al., 2005).

This chapter presents a case study of the more than ten years of EHAS (Enlace Hispano Americano de Salud - Hispano American Health Link) Foundation activities. EHAS is one of the few examples that not only uses FOSS for providing connectivity, but also uses FOSS to design software and hardware to improve public primary health-care systems in rural and isolated areas of the world. This allows analysing lessons learnt from both activities. Concretely, this chapter introduces the model EHAS follows regarding FOSS, and the role the later has played in the sustainability of its actions.

2. Background

2.1 Structure of the primary health care system in rural areas of developing countries

Public health care systems in Latin American countries use a multi-tiered system that includes national and regional reference hospitals, but primary care institutions can be grouped into two categories: Health Centres (HC) and Health Posts (HP) (Martinez, 2004). An HP (Figure 1) is an access point to the health care system for a rural population that does not have a physician but is staffed by at least one medical technician. HPs are typically located in towns with less than 1,000 inhabitants that have no telephone lines and very limited transport infrastructure.
An HC (Figure 2) is usually located in a provincial or district capital and has telephone lines installed. HCs are always under the direction of a physician and are equipped to make some more advanced diagnostic tests than HPs.

Several HPs depend on a single HC and together they comprise a health ‘micronetwork’ of basic primary care. The micro-networks are under the direction of the physician responsible for the HC, who coordinates the activities of the HPs. Most medical technicians at HPs need better ways to communicate with the physician for consultation, conveying epidemiological surveillance reports, ordering medical supplies and relaying information concerning acute epidemic outbreaks, medical emergencies and natural disasters. Without technology to assist in this communication and the exchange of information, health-care workers have to travel from one facility to another, which can take hours or even days.
2.2 Communication and access to information needs in primary health care in rural areas of developing countries

Results from many studies (Martínez et al., 2005a; Dorsch, 2000; Wootton, 2008) show that primary health systems in rural areas of developing countries are very inefficient due to various reasons including difficulties in the information sharing. A more detailed analysis shows the following:

- Epidemiological surveillance systems, those in charge of gathering and analysing data about diseases to assess whether an epidemic outbreak is to come, are not very efficient for three main reasons: (a) information arrives late, (b) information contains frequent errors, and (c) information is not useful for taking timely corrective action. Traditional surveillance systems are expensive because they are labour intensive and highly dependent on significant travel costs. Information arrives late (a) because HPs are far away from the hospital, communication infrastructure is scarce, and information is processed manually at all the HPs and most of the HCs. Data errors are frequent (b) for at least two reasons: the same data is introduced several times by hand in different locations; and once an error is detected, it is not possible to correct it by asking the person who introduced the original data. In the most isolated rural areas, it is difficult to take timely corrective action (c) because diagnostic or referral information from the higher-resourced hospital simply arrives too late.

- There are always difficulties correctly diagnosing and treating cases at the primary health-care sites because of three main reasons: (a) rural personnel have inadequate training; (b) there are difficulties consulting other, perhaps more experienced professionals; and (c) stocks of medicines are low due to the inefficiency of the drug delivery system. Inadequately trained staff (a) results from inadequate access to medical information and the inefficiency of continuous training programs. Furthermore, qualified personnel (physicians, obstetricians, and nurses) usually move to large cities, preferring the numerous personal and professional opportunities to isolation and insufficient on-going professional training. The consultation process is quite complicated (b) because of the large distances between centres that lack even basic telecommunication capabilities. The inefficient drug delivery system (c) demands significant time for sending the orders and receiving the drugs, causing the perpetual absence of important medicines or medical consumables.

- Management of emergency cases in rural areas is complicated for two reasons. The first reason is the difficulty of coordinating patient transfers. It is hardly easy to predict when a transferred patient is going to arrive to the referral centre and to know in advance patient clinical history. This creates a delay in the care a patient receives once the patient arrives at the health-care centre. The second reason is unavailability of transport to transfer patients. This is worsened by lack of communication, which makes sharing ambulances between neighbouring establishments impossible. Another challenge is that ensuring every health-care site has unique access to transport is costly. The transport challenges means that many patients are delayed or never reach the referral facility.

Using ICTs to address these problems is commonly known as telemedicine.

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1 According to the American Telemedicine Association, Telemedicine is “the use of medical information exchanged from one site to another via electronic communications to improve patients’ health status. Closely associated with telemedicine is the term “telehealth,” which is often used to encompass a broader definition of remote healthcare that does not always involve clinical services. Videoconferencing, transmission of still images, e-health including patient portals, remote monitoring of vital signs, continuing medical education and nursing call centers are all considered part of telemedicine and telehealth.”

2.3 Background to EHAS

The EHAS Foundation is a non-profit institution which aims at improving public health care systems in remote areas through the application of appropriate information and communication technologies (ICTs). EHAS started its activities in 1999 as result of the collaboration between the Polytechnic University of Madrid and Engineers Without Borders, and since then it has interconnected more than 200 health-care facilities (both health posts and centres) with their reference hospitals in Peru, Colombia, Ecuador and Cuba. Along this time the group of collaborators has broadened and nowadays the EHAS Board of Directors includes also representatives from Rey Juan Carlos University, Catholic University of Peru and Cauca University in Colombia.

EHAS works specifically with the primary care facilities of the public health systems in developing countries. In rural instances, EHAS operates in the relatively well-equipped and well-staffed health centres, as well as remote and less-resourced rural health posts located in areas with no roads or fixed or mobile phone systems and with very limited medical capabilities. EHAS strives to create more effective communications systems between health centres and posts, specifically focusing on connecting medical staff in the most isolated health posts with their better-resourced counterparts in health centres to achieve four main results:

a. improved the epidemiological surveillance system, given that the previous system relied on late or erroneous reports;

b. increased diagnostic and treatment capacity in the most isolated health posts, allowing for a quick and costless consultation with a proper doctor and better coordination of essential medicinal stocks;

c. reduced need for trips by patients and medical personnel and thereby reduced costs (river travels are expensive) that offset the costs of deploying the infrastructure; and

d. reduced average time for the emergency transfer of patients in cases where the transfer is necessary.

In order to achieve this results EHAS supports the design, execution and maintenance of telecommunications infrastructure appropriate for each deployment context, that use to be an unfriendly one like a forest or a mountains range. These telecommunications networks are based on alternative radio technologies, like HF (High Frequency), VHF (Very High Frequency) or WiLD (WiFi over Long Distances) and adapted with FOSS to the requirements of each health ‘micro-network’. Thanks to this solution EHAS has extended voice and data connectivity to the most isolated environments. Access to the Internet and PSTN (Public Switched Telephone Network) is achieved by distributing satellite or land-line connections available in cities located in a range up to 300Km. Along the whole process EHAS works closely with local partners in each focus country, like the Rural Telecommunication Group of Catholic University of Peru or the Telematic Department of Cauca University in Colombia. Besides providing voice and data communications between health care centres, EHAS is working recently on designing telemedicine services for remote consultations.

Once the network is properly functioning, EHAS transfers network control to the local and regional health-care authorities, which implies training users of the systems and preparing all constituents for the transfer of network. EHAS Foundation experience exhibits that using FOSS and open knowledge throughout the process of designing, constructing and maintaining telemedicine networks allows such regional health authorities to leverage their limited budgets and make the networks sustainable. FOSS also allows network administrators to avoid problems with viruses and licenses, and focus on the many other kinds of hardware-network problems like protecting communication devices in areas where lightning storms are frequent and the humidity level is very high.
3. The EHAS model for the improvement public health-care systems in developing countries through the use of FOSS

As shown in the previous sections, the challenges affecting primary health-care provision in the developing world involve a wide variety of constituents. This section describes how the EHAS model is pivotal for these various stakeholders to achieve a common goal; a sustainable improvement of health-care provision in rural areas of developing countries.

Stakeholders involved and their respective roles are presented as the model core in Figure 3 and are grouped as follows:

- **Universities** - research institutions in both the global south and north that partner with EHAS and are responsible for furthering shared research and development of FOSS-based ICT solutions for application in isolated rural areas with low-income population;
- **Local government and health authorities** - beneficiaries of EHAS projects that receive and own technology and retain the commitment to administer and maintain ICT deployments.
- **Health staff** - another category of beneficiaries of EHAS projects as they use technology in their workplace thus helping reduce their professional isolation, improve management of health reports, build capacity through increased telemedical diagnosis and information sharing.
- **Patients** - the primary target population of EHAS projects who benefit from better health-care services in their rural villages.

![Figure 3. EHAS Model for a sustainable improvement of public health-care services.](image)
Figure 3 shows the process for a targeted improvement of rural health-care processes and which of the aforementioned stakeholders is involved in each step of the process:

- **Step 1.** The starting point of any project is a case analysis of health-care, informational and communications needs of the rural primary care providers of the public health-care system.
- **Step 2.** This understanding of needs provides inputs to researchers who seek solutions through R&D.
- **Step 3.** These solutions are then proved in controlled testbed scenarios.
- **Step 4.** Once these solutions are stable in controlled scenarios are ready for real project implementation in rural and isolated areas of developing countries.
- **Step 5.** Feedback provided by active users of real networks provides new insights and poses new problems to be addressed for the R & D group.
- **Step 6.** Operation & Maintenance of the networks also raises new issues to be improved.
- **Step 7.** Once context related challenges have been addressed, the network is ready for real technology adoption and appropriate everyday usage.
- **Step 8.** This real usage can lead to improved health processes such as increased tele-medical consultations, punctual and accurate epidemiological surveillance and improved emergency transport coordination.
- **Step 9.** The main challenge is to improve this initial situation and achieve positive impact on health by improving effectiveness of health-care processes.
- **Step 10.** Results and lessons learnt through each of these steps is share openly and widely through academic research and FOSS, so solutions can be further used and adapted anywhere by any individual or institution because they are FOSS-based.

FOSS is crucial for this model. Sustainability of ICTs applied to development is only feasible if academic and governmental institutions have the tools and know-how to adapt the ICTs to achieve the change (Bebea et al., 2011a). The key is that all processes and roles described above are part of the machinery of open knowledge and open technology, built above the pillar of FOSS. Here, knowledge and technology are not only shared among EHAS partners but also replicable by other institutions. As an example, SIR network in Bolivia has been deployed for the rural health facilities in Riberalta using EHAS technology adapted to the specific context (SIR, n.d.), and ISF Mozambican multi-sectoral approach to improve rural health-care services combines EHAS model with micro-finance maintenance entrepreneurs (ISF-ApD, n.d.).

The model used and described in the next sections is based on three principles: adaptation of technologies to local context (Steps 2-7), impact evaluation of the proposed solutions (Steps 8 -9) and replication of these life saving technologies through the open sharing of knowledge (Step 10). Each of these principles will be presented in the chapter, justifying the steps taken, showing the results obtained and highlighting the lessons learned during the more than ten years of experience of the EHAS Foundation.

### 3.1 Adaptation of technologies

As mentioned before, FOSS is used in almost every aspect of every project carried out within the EHAS Foundation, from the network design to its final deployment and performance analysis. It is used in the user terminals, the routers that relay information to the closest Internet gateway and the servers that provide intranet services to the health care facilities. The developments made, the software used and the lessons learned regarding the
use of FOSS throughout the process of building up and maintaining the telecommunications network will be presented in this section.

3.1.1 Telecommunication network for voice and data connectivity

The main aim of an EHAS network is to connect isolated HPs to each other and to the referral HC. This connectivity facilitates communication and relevant information sharing throughout the health care system. Appropriate technical solutions to do so are different for each place, depending on their characteristics: geography, climate, isolation, population, needs and resources. However, several characteristics intrinsic to an appropriate communication technology for an isolated rural area have been identified: robustness, low-cost, low-power consumption and ease of maintenance. In order to provide access to the scattered populations described above at a reasonable cost, only wireless technologies seem viable (Brewer et al., 2005).

The most important communication service is local telephony, as it permits the staff at rural health facilities to interact in a well-known way with administrative and clinical staff at hospitals. However, data communications have also demonstrated their importance. Access to information systems, exchange of epidemiological information, access to e-learning platforms for capacity building, and even access to the Internet for general purposes have also been observed as important communication needs. Hence, any communication technology deployed should guarantee local telephony, but also it should provide the site with data communication services.

Combining these two features proved difficult with existing technologies back in 1999 when the EHAS Foundation started. The technology needed to be adapted to the local context in which they were deployed and to the communication needs they were trying to solve. Both technology and the FOSS community have evolved wildly in the last ten years and the solutions existing in the market today address many of the same challenges existing back in 1999. In this scenario, some of the past developments may seem outdated. However, as seen below, every step was taken in order to improve public health-care systems through the use of ICT at the lowest possible cost making use of the most appropriate technologies available at each instance.

Adaptation of narrowband technologies for the provision of data services

When the EHAS Foundation started its activities, the wireless technologies available in the market that were most appropriate for such development context were HF and VHF radios and satellite transceivers. HF and VHF radios were designed to provide primarily voice, and in some cases, also offered low-speed data communications that used proprietary solutions with high cost. Satellite transceivers allowed voice and data communications but high operational costs also hindered the sustainability of such initiatives.

In this context, the first approach made use of FOSS to develop a solution of transmitting low-rate data over HF and VHF voice-only radios (Figure 4) much less expensive than the voice and data able radios. This occurred by using a computer and an appropriate interface. In order to connect a radio to a computer, a radio modem was needed. As a way to reduce costs and increase flexibility, software modems were used. Software modems can run in any modern workstation, including the users’ stations. However, a cheap, low-consumption embedded computer was used instead as a separate platform for interfacing the computer and the radio, which let the user choose freely the operating system for his workstation.

In order to build the software modem, the solution relies on the availability of a sound modem package for GNU/Linux (Sailer, 2000) which implements different modems, each optimised for its use in a specific band. Although the package was developed for data
transmissions, some modifications were necessary to optimise the modems for an environment where propagation conditions were difficult: including the creation of a completely new AX.25 control packet mechanism in the Linux Kernel, and the adaptation of UUCP (Unix-to-Unix Copy Protocol) for providing TCP-like services, like email, on top of this data link layer (Martínez et al., 2007).

With the technical solution achieved, several telemedicine networks were deployed in Colombia and Peru, using the HF/VHF bands the governments had granted to the health authorities, allowing health-care centres to use voice and low-speed data services (Rendon et al., 2005 and Martínez et al., 2004). However, this solution proved far too complex and it was very difficult to train local technicians to maintain the data services. As a result, medical technicians did not adapt to services they never used before, and networks functioned exclusively as voice-only.

**Adaptation of WiFi for long distance links**

Technology evolved over time and other technologies appeared in the market that could offer improved solutions. One such technology was WiFi, which operated in the non-licensed spectrum and allowed voice and data communications in a wireless local area network with very low-cost devices. The low cost devices and open frequency band encouraged the search to use WiFi beyond the local area networks only. It was found that there were no physical constraints for wide area networks but that performance was not optimal for long distances due to protocol issues. Two parameters - slottime and acktimeout - needed to be adapted to achieve an optimal and predictable performance for long distance links (Simó et al., 2010). Both parameters can be easily set up on some wireless cards, especially those based on Atheros chipsets, which include the FOSS MadWifi driver (Madwifi, n.d.). Finally, for WiFi based networks, a solar-powered wireless router was developed (Figure 5). It used an embedded computer similar to the one used as communication processor for VHF/HF networks. With this device, along with a Debian based GNU/Linux operating system, it was possible to set up, not only WiFi fine tuning and routing, but a bunch of functions like Quality of Service (QoS) support, Voice over IP (VoIP) using Asterisk package (Asterisk, n.d.) and a Network Management System (Simó
et al, 2008). With this solution many WiFi routers were deployed and many other health care facilities were provided with IP broadband services (Rendon et al., 2005 and Simo et al 2006) including videoconferencing and VoIP with quality of service (QoS) to prioritise among them.

Figure 5. WiFi router of EHAS.

Today, long-range broadband wireless technologies have come to age and several manufacturers such as MikroTik (MikroTik, n.d.) or Ubiquiti (Ubiquiti, n.d.) offer proprietary WiFi-like solutions that outperform several times the standard solution developed. The EHAS Foundation has always advocated for the use of standard communication technologies that facilitate interoperability among different manufacturers and the use of FOSS for adapting them to the context in which they were going to be deployed. But, for a small organisation like EHAS, maintaining a stable solution throughout the years by installing all the security updates of the packages and their dependencies was too tough and time consuming a task.

To solve this dilemma, a Spanish company was approached to maintain the solution in exchange for complete access to all of its R&D. Unfortunately, this arrangement proved infeasible. Now, each time a network is going to be deployed, new tests need to be done with the solar-powered router for assuring the compatibility of the latest packages available. Now that cost-effective solutions have emerged, it is time for EHAS to reconsider if the resource compromised for developing and maintaining FOSS communication solutions is compensate with the performance obtained. This potential change of strategy will go against the principles EHAS has been applying over the last ten years.

The use of FOSS for designing, simulation and management of the network

FOSS has been considered in the stages of design, simulation and monitoring of the network, with different results. The design of networks is strongly based on free but not-open software called RadioMobile. This is because the FOSS alternatives are by far lower performing and EHAS lacks the resources to develop such tools. Other supplementary tools of great value for network design and simulation are network simulators like NS-2 and NS-3. EHAS has developed a solution that integrates RadioMobile and NS-3 for cross-layer network design. However, if NS-2 was almost abandoned because of the many limitations of a complex FOSS that is at the end of its life cycle, NS-3 is at the beginning of its life cycle and cannot be entirely trusted for the moment. It has to be recognised that, in this case, the use of FOSS is very much conditioned by the extremely high price of proprietary
network simulators like QualNet or OPNET. However, there are also technical reasons related to the need of modifying internal parameters that are not accessible in those proprietary solutions.

A similar choice drove EHAS to use FOSS solutions for network operation and maintenance. Guaranteeing availability of connectivity and other services is not an easy task in the context of rural areas of developing countries. However, licensed professional solutions for Network Management Systems (NMS) are extremely expensive and not flexible, so solutions starting on FOSS products such as Zabbix and Nagios Core (Maya Ortiz et al., 2009, Nagios) have been developed. The flexibility of FOSS permitted EHAS, in this case, to develop and extend management agents and management GNU/Linux scripts. In this effort, EHAS developed an extension of the IEEE 802.11 Management Information Base (based in RFC 1213) to include specific parameters for Long Distance WiFi links. As Figure 6 shows, this system allows clear visibility into of the activities of the network, which leads to easier management of problems when they occur (Bebea et al., 2011a).

![Figure 6. Management Framework for operation & maintenance of rural e-Healthcare, including human resources assignment.](image)

Also FOSS has been used to adapt the NMS to obtain a solution ideally suited to the project’s needs. A gateway from Nagios to FOSS Request Tracker for Incident Response (RTIR) was developed to record NMS alarms and incidents reported by users, as well as time-to-response and recovery-time in EHAS networks (Bebea et al., 2011a). Figure 7 shows this solution.
Regarding the operating system used in user desktops, context-related situations have also obliged the use of proprietary technologies in some occasions. Although FOSS is always the first option, EHAS must accept that its preferences as project proponents cannot be imposed when the reality of the network users contains restrictions that make the adoption of FOSS impractical.

3.1.2 The teleservices offered by the EHAS Foundation

No matter what technology is chosen to interconnect the health-care facilities, broadband is granted in the intranet. In this sense, other telemedicine services can be implemented for medical technicians at the HP to not only talk with the doctors at the HC and the hospital but also send images, videos or sounds for the doctor to have better information of the disease the technician is facing. Most of the telemedicine software and hardware to acquire and send this data are proprietary and cost-forbidden in the contexts these networks are installed. In this context, the EHAS Foundation has used FOSS for developing alternative tools to do so, as it will be explained in the next sections.

Diagnostic support tools

In recent years, EHAS has also worked on the development of appropriate diagnostic tools to address the aforementioned problems in remote locations. This is a collaborative effort with various Spanish hospitals (Caceres and Fuenlabrada) and an Argentinian Foundation (Fundatel) that is focused on ways to better diagnose and combat common infant diseases (such as respiratory conditions and diarrhoea) and improve maternal health.

One example of this FOSS effort is the real-time wireless stethoscope for use in health posts where there is no physician (Figure 8). This instrument allows a doctor (usually the reference physician) to remotely listen to the respiratory and cardiac sounds of a patient while visualizing him and guiding the medical technician in the correct positioning of the stethoscope. To do so, the PulseAudio networked sound server (GPLv2) and the softphone Ekiga (GPLv2), to support video-conferencing, has been used. In addition, both the
software and the hardware, specifically developed for the stethoscope, are open source (GPLv3) and open hardware respectively.

![Figure 8. EHAS tele-stethoscope.](image)

Another system has been developed for transferring microscopy (to help with diarrhoeal diseases diagnosis) and ultrasound (for foetal control) images. In these cases Java-based open-architecture ImageJ has been used for the acquisition, analysis and image processing, and the iPath server, written in PHP, to provide a free and open web platform to support diagnosing the cases online. A third example is a specially-designed electrocardiograph (EKG) adapted for use in these difficult rural circumstances. Again its software, necessary for system control, has been developed under django web platform (BSD license), and Arduino has been used for the hardware design.

Validation tests that are currently being carried out in Spanish hospitals and forthcoming field test are planned in a pilot project in the Napo River in Peru. After these steps, further implications of the design of open hardware and open software solutions will be learnt. In addition, once validated all these teleservice systems will be left free, thus providing a cheaper and more flexible alternative to proprietary solutions to those interested in improving primary health attention in rural areas of developing countries.

Health Information Systems

As discussed in previous sections, improving efficiency in health information exchange related to epidemiological reports, telemedicine diagnosis, and improved patient referral are one of the biggest opportunities for EHAS to improve health outcomes. A Health Information System (HIS) is both a software architecture and a discipline at the intersection of information science and health care. It deals with the resources, devices, and methods required to optimize the acquisition, storage, retrieval, statistical calculation, and use of information in health and medicine.

In this area, the EHAS Foundation is involved, together with its local partners, in the design of a software prototype to manage health information related to most common epidemic and clinical outbreaks in the target countries. OpenMRS, a Java-based, web-based electronic medical record is being used in order to adapt the technology to the needs of the different health facilities and their clinical staff. Its basic functionality is to be a generic medical record system to support the clinical history of patients, gathering observations,
encounters, notes, and finally rendering those in summaries, reports, and data views that would improve the effectiveness of health workers using the system.

3.2 Evaluation of the EHAS interventions

Significant positive results have been achieved and verified in the EHAS interventions using the methodology defined by Martinez (2001): from 93% of healthcare workers who previously said it was impossible to obtain a consultation to 95% who now say it is easy and fast to obtain such a consultation in cases where there was doubt (this is reflected in a 700% increase in the number of consultations made); a 75% reduction in the number of trips required for the delivery of reports; a 60% reduction in the average time for transferring emergency patients; and significant reduction in the maternal and newborn child morbidity and mortality rates in the project areas (Martinez et al. 2004).

These positive quantitative impacts have been furthered, and nowadays EHAS counts with a signed commitment of the health care and regional authorities in the Loreto region of Peru to keep the network alive through budgeting for the maintenance of EHAS networks, guaranteeing that way its sustainability. Furthermore, EHAS also had lasting qualitative impacts like, for instance, the growth of EHAS local partners. In Peru and Colombia, these partners have grown to develop several projects of their own and are now financially independent and self-sustaining.

FOSS has played an important role in achieving all these positive impacts. As it has been shown, it has helped achieve sustainable development with the initiatives previously described not only through the entire process of building local capacity, but also through research, development, testing and adaptation of communication technologies and services specifically tailored for the communications needs of the project’s beneficiaries (Bebea et al., 2010).

EHAS also acknowledges some mistakes committed during these years; mistakes which have served to educate the institution and help adapt solutions to the ever changing world of technology, as shown in the previous section.

The EHAS Foundation considers it important to share freely all knowledge generated in order to let others benefiting from the steps taken to obtain positive impact and to avoid those leading to negative impact. External actors benefiting from it will on return expand both the base of knowledge and the positive impact of ICT interventions. The steps taken and the lesson learnt will be described in the next section.

3.3. Open Knowledge

As said, one of the main objectives of the EHAS Foundation is to broadly and promptly disseminate all knowledge gained during the research, development or adaptation of software and hardware solutions. This implies the use of GPL license for every software solution proposed, but also to make available the documentation related to developments, as well as the academic work related to them. Everything that has been learnt during these years is in its website (www.ehas.org) for everybody to use: graduate and post-graduate thesis, articles, conference presentations, posters, wiki discussion, training materials, etc. Furthermore, in a step to put together in a single and neat document all the knowledge and experience achieved, a book in Spanish was edited (Camacho & Rey-Moreno, 2008), that was later updated and reviewed by the local partners in Peru (Carbajal et al, 2010). Creative Commons licensing was used to allow broader access to the contents of the book, which was also made available on-line.

As a way to further disseminate knowledge, the EHAS Foundation also participates in a Master Program offered at Universidad Rey Juan Carlos de Madrid in Spain (TSC-
URJC, n.d.). It started in 2008 and has since had an average amount of 25 engineers per year from all Latin American countries learn from the experience obtained through all these years of FOSS oriented networks. The idea is to create a critical mass of professionals and researchers in Latin American universities who are able to advocate FOSS as a technology of choice and improve further sustainable development of ICT initiatives.

Quantifying the impact of these initiatives on open knowledge is a very difficult task. Although some feedback on the use of EHAS solutions has been received, it is believed that more could be done to further disseminate the knowledge gained. EHAS has no budget to market its website so visibility of EHAS repository is limited to those who have Internet access and know it is there. Furthermore, it is claimed that all the solutions are open source, but some of them are not hosted in a public repository for the broader open source community to engage with the project, so they cannot be considered completely free and open. As highlighted in the previous sections the institution is constrained by a limited number of human resources and the small budget it works under. With such a limited staff, it is difficult to produce, maintain and disseminate all the knowledge gained. This is a problem yet to be solved.

4. Future Trends

In the specific field of ICT for development (ICT4D), software developers use to face problems that are somehow specific to undeserved areas. The community of developers involved in projects in this field is usually very small because the problems faced are too specific. Financial resources for software development are usually scarce and of short duration. Those are extra handicaps that must be taken into account before adopting a FOSS approach. While FOSS is always desirable, its cost must be effectively measured not only for development but also for maintenance and long-term support of the solutions to be developed.

A lot of people that develop and promote the use of FOSS tend to give a high priority to the fact that software and information must be open due to ideological reasons, as it has been many times the ace of the EHAS Foundation. The obvious advantages of open software and open information are magnified in those cases, while the development costs, the difficulties for achieving stable products and other obstacles for sustainability are neglected for the same reason. This is especially frequent in the domain of ICT for development. However, as actors gain experience, more accurate analysis permits to recognise the power and the limits of FOSS in a more realistic manner.

The questions that arise for future ICT4D projects are: when FOSS must be adopted and when it presents too many disadvantages and must not be imposed. From the experiences presented in the previous sections, the following strategies derive:

- Whenever a new product or service must be developed for the first time, FOSS is the best choice. If there are software modules that can be used as a starting point, it fosters the development. But even if the development must start from scratch, the possibility of collaborating with others and obtain their support may be a key to succeed. Sometimes this is the starting point, but the industry proposes later packaged products that are cheaper, more robust and with higher performance than the previous FOSS solutions. That was the case for EHAS with long-distance WiFi communication systems. Developers must recognise that situation and identify the moment when their efforts are better invested in other projects.

- When a product exists in the market under the form of commercial non-FOSS products, and FOSS alternatives do not exist or do not meet the specifications, there are two options that must be evaluated: developing a complete FOSS product, or use
and evaluate a commercial alternative first. In the first case, it must be well understood that user needs will be met only after the whole development cycle and, only in case of success, a continuous effort will be required to guarantee long-term sustainability. In the second case, a FOSS project may still be initiated once the utility has been proved and the specifications are well derived from real user needs. This way, the FOSS development does not impact the beneficiaries in a negative way in the short-term, and in case of successful development may become an interesting alternative in the future.

- And, of course, when a good FOSS solution already exists, that is the solution to adopt.

In particular, broadband communications systems tend to be non-FOSS solutions because good low-cost products are available in the markets under different standards that make any infrastructure much more stable than any solution based on embedded computers with FOSS. Telemedicine devices follow the same trends: FOSS has been useful for prototyping, but user needs seem only to be met through the apparition of low-cost commercial products in the market. Manufacturers have a high resistance to develop a commercial strategy based on free software and efforts must be made to promote FOSS-based industrial products in which manufacturers may obtain the help of a wider community for lowering the development costs.

Regarding services that are specific to the health sector, it would be specially important to promote the adoption of FOSS in health information systems. While immediate solutions may or may not be FOSS-based, it would be extremely interesting in the long term to count on solid and well supported FOSS solutions for this. Examples from other sectors, such as tele-education, show that a FOSS solution may become the best, and the advantages would be enormous in the case of the health domain for adaptation and integration purposes.

General services like IP telephony, mail, web, etc. may be easily based on FOSS already, as there are very solid options whose adoption is straightforward.

5. Concluding Remarks

The EHAS Foundation has always worked on the basis of the profound conviction that knowledge and software must be free and open for fostering human development. FOSS maximises both outreach and impact. As explained throughout this chapter, this commitment to sharing of information has marked most of its technological choices, all its R&D, documentation and academic activity. However, also based on the experience, FOSS cannot always be adopted when real impact is a must. EHAS aims to improve the lives of poor people in disadvantaged regions. Then, impact on their livelihoods is on top of any technological choice. These are the main reasons that have in reality limited a complete adoption of a FOSS and open knowledge paradigm:

- FOSS does not mean that one can modify the software for free. The cost of modifying, stabilising and testing complex software packages, as has been the case for EHAS in an e-learning platform, network simulators and software modems, may be very high in terms of the time and human resources required.
- FOSS is only meaningful when it happens in collaboration with a wide community that shares the effort and the responsibility along the development process, but creating such a community is also a costly task.
- The interaction with beneficiaries that have already adopted non-FOSS solutions that sometimes further limits the adoption of FOSS proposals. That was the case for the adoption of GNU/Linux as the operating system of end-users in some health
networks where several applications required the use of MS Windows. One can always think that software emulators may solve the problem, but that is not always the case.

Even with these restrictions, most of the development activities and final products developed by the EHAS Foundation have been FOSS based, and immense benefits have been experienced from this approach. FOSS inspires collaboration, openness, distribution of resources and business models based on the effort and not on withholding information for specific organisational gain. FOSS is, in general terms and in EHAS humble opinion, is the best possible philosophy to make R&D, innovation and human development compatible. However, one must always remember that information and software are means and not goals in most real projects, and the openness must be seen as a very desirable tendency in which exceptions are sometimes necessary to provide people with real solutions to their problems.

References


