Chapter **18**

New Technologies and Public Health in Developing Countries: The Cell PREVEN Project

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TELEHEALTH AND PUBLIC HEALTH

This chapter describes an application of telehealth using cell phones and the Internet to collect, transmit and monitor data in real-time from female sex workers (FSW) who are part of a large project in Peru to reduce sexually transmitted diseases (STD). According to a national survey conducted in Peru of 4479 FSW in 2002, the prevalence of STDs and bacterial vaginosis was 26% and 34% respectively (PREVEN, 2003). Early detection and treatment of STDs represents one major strategy for preventing transmission of STD, including infection with HIV (Sanchez, Campos, Courtois, Gutierrez, Carrillo, et al., 2003). New technologies and information systems can help public health in terms of prevention, surveillance, and management of public health data. Consider the following case.

> At 6 p.m. on a Friday night in a rural community in Piura, north of Peru, nurse Raquel Butron takes a taxi for the hour ride to the brothel. Raquel is part of a mobile team that screens female sex workers every 2 months as a sentinel surveillance. She provides medication for bacterial vaginosis, namely metronidazole. As part of her job, she carries three or more folders full of papers to track codes, medications, and adverse events such as nausea and vomiting that the participants might experience from the metronidazole they are receiving. This night, she is hoping that she won't be robbed like the week before. Although she recovered the folders and medications 3 days later, she is guarded about being robbed again.

Raquel and a peer-educator arrive early in order not to interrupt the women while they are working. They are well-received. Raquel starts screening "Paola," but Paola gets a call on her cell phone, so Raquel has to wait. Even among female sex workers who earn just 5 dollars a night, cell phones are a mainstay of life.

A year later, as Raquel heads to the brothel, she is going more discreetly. She is not carrying folders full of papers, just a cell phone. Helped with a hands-free device, she performs the interviews. Following a voice menu prompt on her cell phone, Raquel goes through a list of questions, pressing one and two on the phone's key pad for yes and no answers. She can also leave a voice message for a doctor in Lima at the end of the interview.

"A cell phone makes my job easier," she said. She doesn't worry as much about getting robbed because rather than sticking out, she appears like anyone else making a phone call. She also doesn't have to carry folders full of papers, or have to ship her reports every weekend to Lima. "I send the reports in real-time," she said.

Doctors in Lima, meanwhile, monitor in real-time the reactions female sex workers are having to medication and respond immediately if there is a strong reaction such as vomiting. Each time the system detects a serious adverse event, the system sends an alert to the cell phones of doctors in Lima. Using the Internet, the doctors can also monitor the activities of the health workers. After logging in, doctors can see the entire list of participants registered by the mobile team, day-by-day, or on a weekly basis. If Raquel leaves a voice message, the message is registered in the database as an audio file. Doctors in Lima can hear her message by accessing the database from the web. Doctors also have the capability to perform searches, and they can download the database for further analysis.

By using the cell phone, Rachel can enter the code for a female sex worker to get her past results from the lab. Because female sex workers do not stay in one place all the time, being able to tap into a database makes accessing records a world easier. "I don't have to wait weeks or months to share results with patients who may have traveled to another city".

CELL PREVEN: A MOBILE TELEHEALTH PROJECT

PREVEN (Prevencion comunitaria de enfermedades de transmision sexual; in English: Urban community randomized trial of STD prevention) is a collaborative effort between the Universidad Peruana Cayetano Heredia (Peru), Imperial College (London) and the University of Washington (Seattle). This project is a national urban community randomized trial in 20 Peruvian cities with populations more than or equal to 50,000 inhabitants. The cities were randomized into two groups: (1) 10 control sites with no intervention and (2) 10 intervention cities, with syndromic management of sexually transmitted diseases (STD), delivered primarily through pharmacies linked to referral networks of private physicians and health centers, and outreach to marginalized female sex workers (FSW). One of the primary scientific aims of the study is to determine the impact of the interventions on prevalence of gonococcal, chlamydial, trichomonal infection, syphilis and HIV seroreactivity in the general population of young adults through a population-based survey and in high-risk populations through sentinel surveillance of FSW and clients of FSW (PREVEN, 2003).

Workers in rural health care, who serve most of the population, are usually isolated from specialist support and up-to-date information because of poor roads and scarce access to information technologies. Many developing countries have a shortage of health care workers and most of the doctors, specialists and services are concentrated in the main cities (Fraser & McGrath, 2000).

Early detection and treatment of STDs represents one major strategy for preventing transmission of STD, including infection with HIV (Sanchez et al., 2003). Female sex workers (FSW), as other core groups, play a crucial role in STD transmission (Campos, Chiappe, Carcamo, Garcia, Buendia, et al., 2003). In a national survey conducted in 2002, the prevalence of STD and bacterial vaginosis in FSW in Peru was 26% and 34% respectively (PREVEN, 2003). Early detection of STD in FSWs, as well as promoting and providing condoms for commercial sex workers are needed to prevent HIV/STD in Peru, as in much of the developing world (Sanchez et al., 2003). New technologies and information systems can help programs and trials not only in STD/HIV, but in other fields of public health involving prevention, surveillance, and management of data.

Before the diffusion of new technologies among FSW in Peru, reports were collected on paper. Weeks or months could pass before public health workers, physicians, and team leaders learned of trends and patterns and were able to respond.

Using cell phone and the Internet technology, the aim of this project was to develop an interactive computer system for real-time collection and transmission of adverse events (e.g., vomiting, diarrhea) related with metronidazole administration as presumptive treatment for bacterial vaginosis in female sex workers. We developed a system that combines the phone and the Internet (Cell PREVEN). The idea was to design and implement a real-time surveillance system of adverse events as a component of the PREVEN Project. It also was a mean to optimize the data report efficiently, and improve time in sending the reports in order to have real-time decision-making.

We piloted the system in three cities of Peru: Chincha, Huanuco, and Piura. Data collection and transmission of AE information in the field began in early September, 2004. The system was incorporated in the mobile team activity of the PREVEN Project. The mobile team is composed mainly of nurses or obstetricians and a peer educator. They periodically screen female sex workers for STDs (gonococcal, chlamydial, trichomonal infection, and syphilis) and provide presumptive treatment of bacterial vaginosis. One week after they provide treatment, they return to the participants and ask for any adverse events. Six public health workers were trained to use the mobile phones and keep track of study participants. The report in the cell phone contained the same questions as on the paper form.

We developed an interactive voice response application for cell phones in Spanish, based on the infrastructure of Voxiva, a telecommunications company based in Peru (Voxiva, 2005). The architecture of the system has five elements: a central database and web server; remote access to the database from any Internet-connected computer; telephone audio computer-assisted personal interviewing; voice messages and short-message service (SMS)-based communications to and from the server via cell phones (Fig. 18.1).

Public health workers received an account number, personal identification number (PIN) and a plastic card with simple instructions and codes for all the symptoms they need to report (Fig. 18.2). By calling into a number in Lima using cell phones they could access the system and report adverse events from FSW systematically and in real time in urban and rural areas. Authorized users logged on and followed instructions on a wallet-sized card or a simple prompted menu and entered digital information about participants with adverse events. They could attach additional information in voice files.

Information was stored in an online database and could be immediately accessed worldwide and exported over a secure Internet connection. Safeguarding the privacy, confidentiality, and security of any public health informatics or e-health project is an important undertaking (O'Carroll, Yasnoff, Ward, Ripp, & Martin, 2002; see also Wallis & Rice, chap. 14, this volume). Our project does not collect the names on the database. The project works only with numbers. Each time that the health worker wants to make a report they have to enter a login, a password and the code number of the participant. If someone steals the cell phone, it could be easy to get access to the number that gets access to the system, but it is difficult to guess the login and the password and even more difficult to guess the code of the participants.

Team leaders (doctors) could receive the information immediately via the Internet, analyze the data, and use the system's communication and

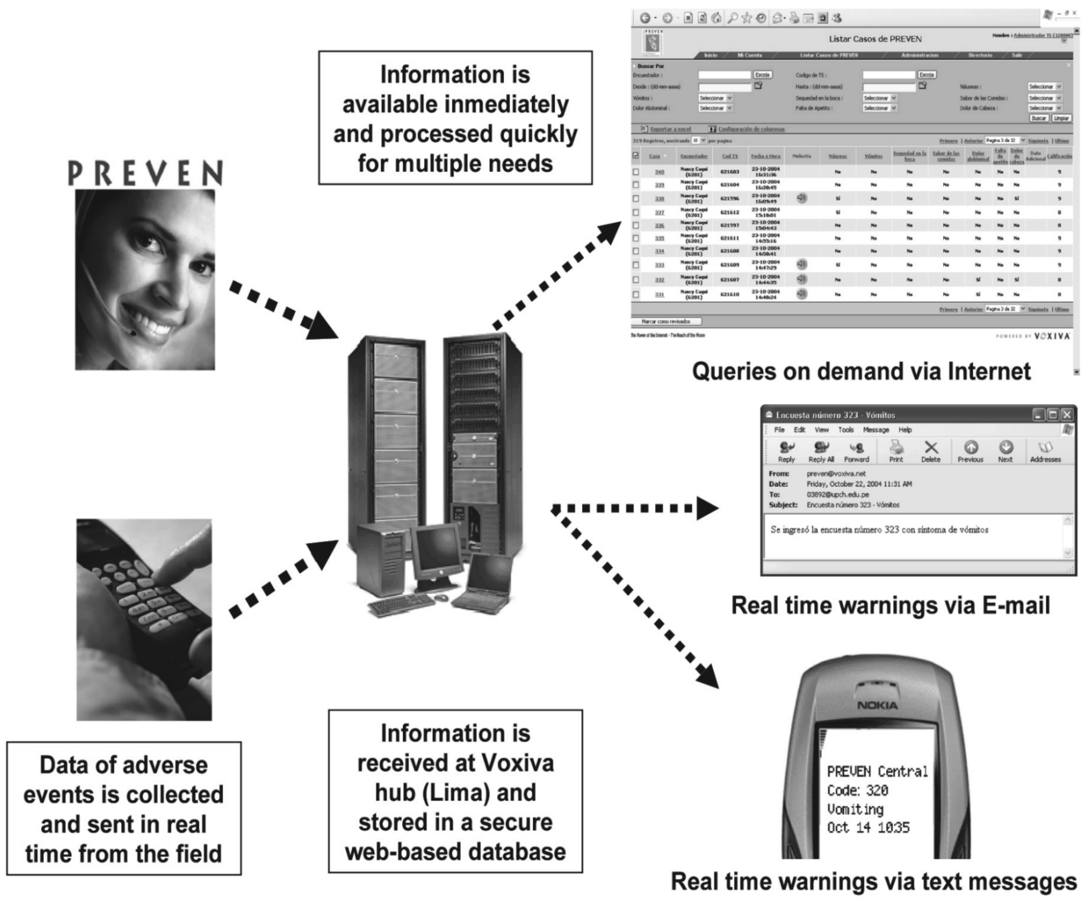

FIG. 18.1. Architecture of the system.

PREVEN

PREVENCIÓN COMUNITARIA DE ENFERMEDADES DE TRANSMISIÓN SEXUAL

Reporte de Eventos Adversos al Metronidazol

Numero Telefónico: 01 317-5941
Nombre: Walter Curioso
Código: 123456

1. Acceso al Sistema

Ingrese código de usuario, seguido marque #
Ingrese su clave secreta, seguido marque #

2. Registro de la Participante

Ingrese código de la participante, seguido marque #

3. Alguna Molestia?

Marque 1 para SI or 2 para NO
SI marcó 1, después de la señal grabe el síntoma y los días de ocurrencia, seguido marque #

4. Detalle de Síntomas

Para cada síntoma marque 1 para SI ó 2 para NO:

Náuseas	Cambio sabor comidas
Vómitos	Dolor abdominal
Sequedad en la boca	Falto de apetito
	Dolor de cabeza

4.1 Si marcó SI responda:

Cuando empezó? Ingrese el número de días, seguido marque #
Cuando terminó? Ingrese el número de días, seguido marque #
Tomó medicinas? Marque 1 (SI) ó 2 (NO)
Afectó su rutina? Marque 1 (SI) ó 2 (NO)
Volvería a tomar el medicamento?
1 (definitivamente si), 2 (no está segura),
3 (probablemente no), 4 (definitivamente no)

FIG. 18.2. Example of the instruction card.

messaging tools to respond. Team leaders could monitor incoming reports through a Web interface (Fig. 18.3). Individual adverse event reports arrived in real time with full-case details. Authorized users could also listen to voice files recorded by the remote health workers. Data were available immediately and team leaders could export it to various programs for analysis and presentation.

Designated users received automatic notification of selected symptoms via e-mail and SMS messages. Health officials could communicate with remote health professionals using voice mails as well as e-mails. For example, Dr. Pablo Campos, one of the team leaders in Peru received e-mail messages and text messages on his cell phone. He accessed the database for the project at his work at University Cayetano Heredia. I was consulting on the project through e-mail, chat and telephone from Seattle before heading to Peru. In Seattle, I could access the database from my computer. The system was operational 24 hours a day, 7 days a week. Because data was entered directly, data errors were reduced.

During September through December 2004, the system collected 800 reports of adverse events. A formal evaluation is currently under development. For updates please refer to the Web site of the cell phone project: http://www.prevenperu.org

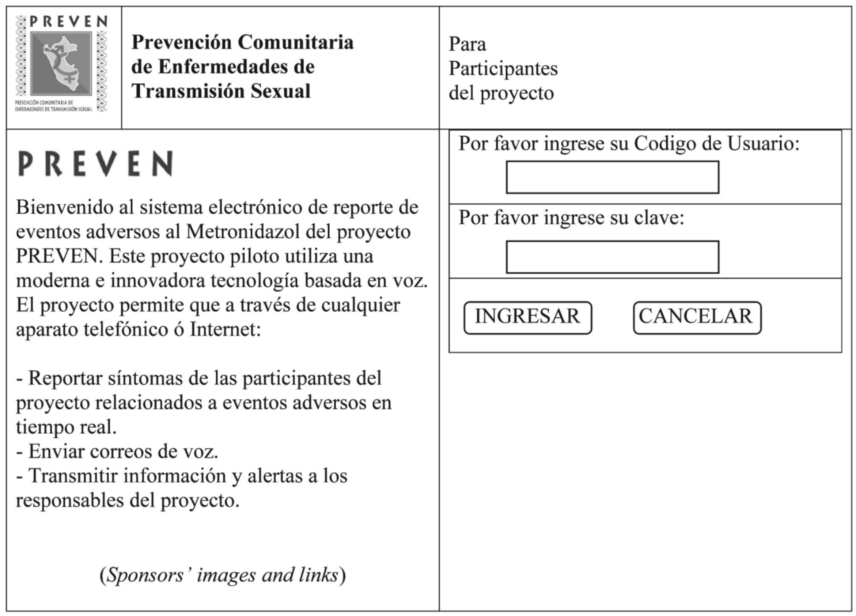

FIG. 18.3. Basic text and elements of the Web page (https://www.preven.alertaperu.net/).

CONTEXTUAL BARRIERS AND OPPORTUNITIES IN DEVELOPING COUNTRIES

Socioeconomic and Technology Infrastructure Factors

There are many factors that limit the dissemination of e-health applications in developing countries. Technology distribution and access deficiencies are two factors (Rodrigues & Risk, 2003). For example, there is a huge variation in terms of access to computer-based information technologies, usually measured in terms of teleaccessibility, personal computer ownership, and Internet connectivity available to people (Rodrigues, 2003).

Other factors that contribute to the digital divide include insufficient telecommunications infrastructure, limited markets for information technologies (IT), high telecommunication tariffs, inappropriate or weak policies, organizational inefficiency and lack of locally created content. Inequalities in the utilization of information technologies by the general population are also found in developed countries determined by income and level of education. In the health sector, the divide between developed and developing countries in technology access is wider than the gap observed in social and commercial sectors (Rodrigues & Risk, 2003).

Poor telecommunications infrastructure, limited number of Internet service providers, lack of access to international bandwidth, limited wireless networks and affordable Internet access costs continue to be major impediments to the diffusion of Internet applications to the point-of-care in developing countries.

Good connectivity is needed for reliable transactions. In developing countries, fast connectivity is still limited and usually only dial-up access is available. As an example, a study by Harte Hanks in 2001 across different industries showed that only about one-third of the connected organizations in selected lower and upper middle income Latin American countries had access to connection speeds higher than 56 Kilobits per second (Table 18.1).

However, the reform of telecommunications in many sectors of developing countries has been bringing considerable improvements in services. As a result of greater competition, expanding markets, and rapid trade liberalization, telecommunications prices are dropping and the infrastructure has been improving worldwide. One-fourth or 22 of the 89 major public telephone operators that were privatized throughout the world by the end of 1999 were in Latin America and the Caribbean (Rodrigues & Risk, 2003).

New Technologies in Developing Countries

By 2002, telephones had reached more than 6,000 communities in Peru, with Internet access reaching 900 (Prahalad, 2005). A high demand for cell phones is occurring in many developing countries, a demand that was lag-

TABLE 18.1
Connectivity Speed in Selected Countries of Latin America

Countries	*Organizations with Access > 56 kbps* (%)*
Mexico	42
Peru	39
Chile	37
Regional average	35
Brazil	33
Argentina	31
Colombia	31
Venezuela	27
Ecuador	22

Note. *Kilobits per second. Source: Harte-Hanks CI Technology Database (Harte-Hanks Market Intelligence, 2001), cited by Rodrigues and Risk (2003).

ging behind with the installation of conventional land-based communications equipment. Approximately 50% of refurbished cell phones are sold in Latin America, Africa, Russia, India, China and Pakistan (Bhuie, Ogunseitan, Saphores, & Shapiro, 2004). In Peru, the market for cell phones has been increasing since 1993, with major growth from about 200,000 in 1996 to 2.5 million cell phones by mid-2003 (ONGEI, 2003).

In some countries, one user may access the Internet in numerous ways including wireless, Internet cafes, kiosks, home, work and/or school accounts. Other single accounts may be shared by many users. Some users are heavy and others light; some started long ago while others started recently. Internet cafes are popular access points in many developing countries, such as Peru. By the year 2003 more than 3,600 "*cabinas publicas*" or Internet cafes were operating in Peru, up from 417 in 1999 (Yachay, 2003). Recent estimates reported that, by February 2005, there were 10,000 "*cabinas publicas*" in Peru and at least 6,000 were in Lima (Villalobos, 2005).

In Peru, doctors have limited access to the Internet in their workplace. They access mainly from home and Internet cafes. Meanwhile, 54 countries and territories in Africa have Internet access—at least in the capital cities (Jensen, 2002)—and many acquired the connection in recent years, indicating the rapid pace of change. The dramatic falling costs of computers suitable for Internet use should go some way to closing the gap between rich and poor. This price drop and accessibility to computers brings a unique opportunity for health care research.

Lack of Proficiency in Using Computers, and the Internet

Several other factors have been identified as contributing to the digital divide in developing countries, chief among them a lack of proficiency in using computers (Chandrasekhar & Ghosh, 2001). Other factors that have contributed to the digital divide include a gap in the actual use, measured as the amount of time spent utilizing information technologies; and a gap in the impact of use, measured by financial, economic and clinical returns. In other words, equipment alone is useless unless people are able to use it effectively and informed of the potential benefits of its use (Samuel et al., 2004).

Inadequate education in informatics skills is a constraint among medical students, doctors, nurses and many other health care professionals who have different levels of computer competence. In our study (1999), 40% of the sample composed by medical students in Peru' reported lack of proficiency on the use of Internet. We also found that the proficiency on the use of the Internet was not related with the year of medical school nor with age (Horna, Curioso, Guillen, Torres, & Kawano, 2002).

Similarly, in 2003, Samuel et al. reported that only 52% of medical students in Tanzania felt that they understood the basic terminology and concepts of computing. Only 23% of their sample had ever consulted an electronic journal, and 70% did not use any electronic resource. The authors concluded that the sample had a low level of ability (very basic) to use information technology facilities (Samuel et al., 2004). In Nigeria, Ajuwon reported that only 42.6% of the sample studied could use a computer. Another study conducted in Nigeria reported that 79% of students had little or no computer skills (Ajuwon, 2003), and a study conducted in Nigeria reported that 79% of students had little or no computer skills (Odusanya & Bamgbala, 2002).

Absent or Costly Committed Human Resources

People are central for the success of any application of e-health products and services. Employees' skills are the most expensive and least elastic resource, and an obstacle to technological development in developing countries. Systems professionals, technology products, services providers, and project team must have superior skill levels and experience in the particularities of the area being automated (Curioso, Saldias, & Zambrano, 2002).

Managing IT personnel and projects in both developing and developed countries is a challenging undertaking (O'Carroll et al., 2002). Successful IT projects depend greatly on a project head's ability to identify and select the right people to work on the project, to communicate with technical people, to hire consultants appropriately, and to organize technical teams. Selecting the most appropriate technology is important when developing an e-health project, but also important are good managing skills. It is important to recognize that the latest technology does not necessarily solve all the problems (O'Carroll et al., 2002).

Lack of Vision of Public Health Authorities Regarding IT

In developing countries, most public health organizations have a very limited use of IT applications in day-to-day practice. Some public health authorities believe that using IT is limited to creating a chart of the epidemiological weekly report or to produce statistical reports. Collecting and presenting data in a chart is not necessarily of interest to health care professionals and managers when it comes to surveillance systems.

Most of the information systems in developing countries are inadequate to the current models of health care, and many public health authorities are not aware of the potential of IT to support public health. Moreover, the public health sector is behind business, banks and other sectors in terms of effectively using information technologies. There can be many reasons for resistance to chance in developing countries. These can be classified as resistance to a particular change or resistance to the changer, for example, the individual initiating the change. There are several strategies that can be used to address these factors. One strategy, the five-stage model, includes assessment, feedback and options, strategy development, implementation and reassessment (O'Carroll et al., 2002).

On the other hand, private providers and managed care groups have been recognizing that a different type of information system and data elements are required to run their organizations and to survive in a competitive environment driven by increasing consumer demands and expectations for the delivery of personalized evidence-based services (Curioso, Montori, & Curioso, 2004).

CAN INEXPENSIVE TECHNOLOGIES BE USED EFFECTIVELY IN PUBLIC HEALTH IN DEVELOPING COUNTRIES?

New technology offers much better ways to collect data; for example, it can be collected more easily over much shorter periods of time (McCoy, 2002). Although the use of computers or PDAs are limited in developing countries because of their expense and requirement for additional equipment such relatively complex network connections, cell phones are proving a simple solution. Cell phones are ubiquitous and cheaper than most computers and PDAs. Cell phones are showing how easy it is to collect data electronically in developing countries even in remote settings.

Currently, one of the simplest solutions to collect data is to call a telephone number that links to the investigator's computer via the Internet. In our project, subjects accessed the system, and provided data using the push buttons on the telephone. Data was automatically inserted into the subjects' data files. The Internet provided the team leaders the possibility to access to all reports made by the field workers so doctors can monitor what is going in the field on a daily or weekly basis. The team leaders could perform searches of participants, and hear the voice files that the health workers recorded. Use of such technology depends on various factors—cost and availability, the socioeconomic status and education level of the subjects, and/or the amount of money available for the research. However, the cost of new technology tends to decrease over time, and it offers much improved methods for collecting more accurate data while involving less time and inconvenience for subjects and researchers alike (McCoy, 2002).

APPLICATIONS OF THE SYSTEM IN OTHER CONTEXTS

There are other applications of the system in both developing and developed countries. Alerta is a system that involves phone and the Internet for communications and disease surveillance in real-time in Peru. Health professionals, using available telephones and the Internet (whichever was available), submitted real-time, electronic reports of mandated diseases and disasters. Alerta required a substantially lower allocation of resources, lower operating costs, and resulted in a threefold increase in reporting coverage (Prahalad, 2005). Overall, the system required 40% lower costs of operations than the traditional paper system. The application was incorporated in health clinics and health centers of the Ministry of Health (Prahalad, 2005). The study also concluded that the use of voice mail for communication was 7.8 times less expensive than written communication.

Lescano et al. (2003) reported that the introduction of the application has led to early outbreak identification/response, timely case management, and increased review of clinical procedures within reporting units. The investment required by the system was small compared to alternative approaches to building disease surveillance capabilities, particularly in terms of infrastructure and maintenance expenses. The combination of scalable technology, accurate and close monitoring of performance, controlled growth, and effective mechanisms for information sharing, feedback and data-driven decision making has turned the application into a highly innovative, cost-effective, and replicable surveillance model (Lescano et al., 2003).

Applications Outside Peru

The U.S. Food and Drug Administration developed a Web-based system using Voxiva's platform for monitoring blood shortages in the United States. After discovering that 40 % of the nation's blood centers did not have ready access to the Internet, they used a system based on the use of the phone as well as the Internet to track blood shortages. The U.S. Department of Defense developed a disease surveillance system for Washington D.C., and San Diego County regarding a smallpox vaccination monitoring system (Voxiva, 2004).

In the developing world, similar systems have deployed health solutions in Latin America, Africa, Iraq, and India. For example, in Africa, they created a national HIV/AIDS information system for eight countries that among other things, monitors current data for national and global reporting requirement and manages the use of antiretrovirals to reduce the spread of viral resistance. In India, a surveillance system for Japanese encephalitis was created in a month (Prahalad, 2005).

OTHER TELEMEDICINE APPLICATIONS IN PERU

There is a great potential to improve health through the use of telecommunications and information technologies in developing countries. Installing more computers or connecting a computer to the Internet is not necessarily the answer to public health problems. One answer could be using cell phones, public phones or "*cabinas publicas*".

Other telemedicine projects have been developed in Peru. One of the most relevant is The Enlace Hispano Americano de Salud (EHAS; Hispanic American Health Link) (Martinez, Villarroel, Seoane, & del Pozo, 2004). EHAS has developed a system that facilitates the exchange of information between health centers and health workers in a rural area. The EHAS system uses radio (VHF, HF and WiFi) for voice and data communication. Information exchange is by e-mail, 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. EHAS demonstrated that: (1) voice and e-mail communication via VHF radio is technically and economically sustainable for rural telemedicine; (2) rural health workers, in many cases nursing technicians with no university education, are capable of learning to use computers for basic office tasks and e-mail, by attending training sessions of no more than 10 days' duration; (3) only through a scheme involving the active participation of all users can a sustainable service be achieved. Currently, EHAS is working in four Latin American countries as well as Spain (EHAS, 2002).

TeleMedMail (Fraser, Jazayeri, Bannach, Szolovits, & McGrath, 2001) is a software application to facilitate store-and-forward telemedicine by secure e-mail of images from digital cameras. TeleMedMail is written in Java and allows structured text entry, image processing, image and data compression, and data encryption. This web-based telemedicine system is currently under evaluation in South Africa and Peru and is available for free at http://www.sourceforge.net/projects/telemedmail/

Lastly, but not least, training in telemedicine is a key aspect. In Peru, for example, a collaboration between the University of Washington (UW) and the Universidad Peruana Cayetano Heredia, allows better training. The training includes a combination of short-term training for resource personnel in Peru, and bringing many of the information integration and organizational tools from ongoing information technology projects at the UW (Karras et al., 2001).

LESSONS LEARNED WITH CELL PREVEN IN A DEVELOPING COUNTRY

1. Even in a challenging social setting with limited infrastructure it is possible to develop an effective surveillance system. It is not necessary to have the latest Palm Pilot or Tablet PC to create a sophisticated public health surveillance system (Chin, 2005). It is possible to deploy a health information system much more quickly and cost-effectively than systems that require a lot of logistics and expensive network requirements and devices.

2. The system described in this chapter is applicable to a range of health problems—from reporting and monitoring adverse events during clinical trials or vaccination campaigns to reporting disease outbreaks. We can even apply the system to nonhealth settings like reporting crime or potentially tracking commercial orders and distribution.

3. Systems implementers need a clear idea of the problem. Many technologies failed because of lack of careful planning and evaluation of the necessities. Factors to consider include: scan assessment of barriers, technology, training, cost and sustainability. Even in 20 years this example could be still used by health professionals for different purposes. This system addresses three key ingredients of an effective surveillance system: (a) Real-time data collection, from health workers reporting an adverse event or a doctor reporting a disease outbreak, for example; (b) Rapid analyses of data to make opportune decisions and allocation of resources; and (c) Communications back to the field to coordinate response.

4. Two-way information systems are more than just collecting data. They provide feedback and support to health care workers in the field. Many times, only managers have information that allows them to monitor and evaluate data but these systems do not prove any aggregate value to health care workers in the field. A well-designed information system has to support and enhance the performance of all user levels in a secure environment.

5. Information systems should be carefully planned and integrated across different programs. Prahalad (2005) has reported that health workers in some developing countries spend as much as 40% of their time filling out forms, compiling and copying data from different pro-

grams (e.g., tuberculosis, malaria, HIV/AIDS, etc.). By choosing the most appropriate information technology, we can avoid duplication and deploy different devices—i.e., cell phones, Internet—to report from each public health program.

6. Partnership is key to overcome technology barriers. We can attract top-tier industry partners if we have a comprehensive public health initiative. Public private partnerships can increase developing country access to improved health technologies.

7. Installing programs and PCs in public health organizations does not mean that we are creating an integrated system. It is necessary to have a robust, scalable, integrated information system that connects health care professionals from the local to the national level and provide them with the most appropriate information and support they each need. To accomplish this, it may be necessary to have a different technology architecture and different approach for each demand.

8. Any new technology will fail if there is not support for management change by leaders or chief information officers. Many public health authorities in developing countries are not accustomed to real-time information. They have to understand that helping decision-making and response with information technologies is critical to the success of their mission. This change requires considerable teamwork, leadership with solid strategic planning, training, and capacity-building efforts that go together with the deployment of a robust information system.

9. We need to understand the culture and to select the most appropriate technology for a determined necessity.

FUTURE DEVELOPMENTS

Telecommunications and information technology breakthroughs hold great potential if properly harnessed. We must understand the rich array of information-based technologies that support public health goals, and which communications technologies are the most appropriate for a specific cause (intervention, prevention, etc.). We must also understand who needs to know about these new public health solutions and how to educate and training them.

Telemedicine holds the promise of improving access to health care, especially in areas where there are geographical barriers, and of reducing costs (Wootton, 2001). Telehealth in developing countries is a reality and offers tremendous opportunities that need to be explored more in the future. One of the problems with telehealth is that telecommunications companies often try to force a technical "solution" in public health services without understanding the problems in the field. Some new technologies may become more important in the future, as wireless access improves (for example, Wireless Application Protocol -WAP- phones) (Hung & Zhang, 2001, 2003). Karras et al. reported that a Java-enabled wireless phone could be potentially used in disaster response and public health informatics. They emphasized that the technology was inherently deployable, portable and that minimal orientation to new hardware was needed since everyone was comfortable with entering numbers on a phone keypad and pushing the send button (Karras, Huq, Bliss, & Lober, 2002). Any application that can run on a PC can potentially run on a portable phone using Java applets.

In teleconsultation, cell phones has been proven that is feasible to capture and transmit images using e-mail for care of chronic wounds (Braun et al., 2005). However, the main problem in telemedicine is not the lack of technology; rather, it is the organizational problem of knowing how to take advantage of the technology. For example, how communities may benefit from the right information technology application. In some countries, cell phones may be a better application than using Tablets PCs, smart cards, or satellite communications (Wootton, 2001).

A Web-based electronic medical record system has shown that effective information management is also possible in a poor community with no modern infrastructure. In Peru, Fraser et al. (2004) described a web-based medical record system to support the management of multidrug resistant tuberculosis. Web-based analyses have been developed to track drug sensitivity test results, patterns of sputum smear and culture results and time to conversion from positive to negative cultures (Fraser, Jazayeri, Mitnick, Mukherjee, & Bayona, 2002). Jazayeri et al. (2003) described a prototype Electronic Medical Record system the “HIV-EMR” to support treatment of HIV and tuberculosis in remote and impoverished areas in Haiti. The EMR allows physicians to order medicines and laboratory tests, and provides alerts based on clinical status and test results (see also Wallis & Rice, chap. 14, this volume).

Recently, we developed a web-based electronic report system for STD for the PREVEN project. Interviewers entered their data directly into a single database as they progress through the reports, thereby saving time and costs over having the data entry done after data is collected. The system collects new participants and generates alert reports defined by the number of missed treatment that must be provided by the health care interviewers. The system has the capability of searching so the interviewers can check past laboratory results and medications. The system allows real-time access of the database (only available for the team leaders) via the web. We believed that web-based data collection may provide better access to difficult-to-reach populations and cities considering the great popularity and cheap cost of Internet cafes or "*cabinas publicas*" in Peru (Curioso, Campos, Buendia, Butron, & Kimball, 2005). The unique popularity and low-cost of Internet cafes in some countries open new possibilities to developing future web-based systems to show that effective information management can be possible in poor communities with no modern infrastructure but widespread use of "*cabinas publicas*."

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