Telemedicine in Western Africa (RAFT project)

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Abstract— **Objectives: the evaluation of the feasibility, potential, problems and risks of an Internet-based telemedicine network in developing countries of Western Africa.**

Methods: a project for the development of a national telemedicine network in Mali was initiated in 2001, in Mauritania in 2002, Morocco in 2003 using Internet-based technologies for distance learning and teleconsultations. Several other countries are currently in the process of joining this network.

Results: the telemedicine network has been in productive use for over 18 months and has enabled various collaboration channels, including North-South, South-South, and South-North distance learning and teleconsultations. It has also unveiled a set of potential problems: a) the limited importance of North-South collaborations when there are major differences in the available resources or the socio-cultural contexts between the collaborating parties; b) the risk of an induced digital divide if the periphery of the health system is not involved in the development of the network, and c) the need for the development of local medical content management skills.

Conclusions: the identified risks have to be taken into account when designing large-scale telemedicine projects in developing countries and can be mitigated by the fostering of South-South collaboration channels, the use of satellite-based Internet connectivity in remote areas, and the appreciation of local knowledge and its publication on-line.

Index Terms—**telemedicine, developing countries, teleteaching**

I.Introduction

Telemedicine tools enable the communication and sharing of medical information in electronic form, and thus facilitate access to remote expertise. A physician located far from a reference center can consult his colleagues remotely in order to solve a difficult case, follow a continuing education course over the Internet, or access medical information from digital libraries. These same tools can also be used to facilitate the exchange between centers of medical expertise, at a national or international level [2,3,8,11].

The potential of these tools is particularly significant in countries where specialists are rare and where distances and the quality of the transportation infrastructure hinder the movement of physicians and/or patients. Many of the French-speaking African countries are confronted with these problems. In particular large and scarcely populated countries such as Mali (twice the size of France, 11 million inhabitants) and Mauritania (twice the size of France, 3 million inhabitants) are concerned by this problem.

The usefulness and risks of these new communication and collaboration channels have to be assessed before large-scale programs can be launched. Prior experiences in the field include ISDN-based video conferencing for tele-cardiology and tele-neurology between Dakar and Saint-Louis in Senegal, a demonstration project (FISSA) of the use of satellite-based prenatal tele-ultrasound imaging between Dakar and the Tambacounda region in Senegal, and tele-radiology experiences in Mozambique. However, there is little published material on the use of low-bandwidth, Internet-based telemedicine applications, although there is a significant investment in these technologies in developing countries.

The development of the national network for telemedicine in Mali was used as a pilot case in order to get a better insight into these aspects.

Other research projects on telemedicine have worked on the financial aspects and implications as well as [9]. Most of the published literature is actually on rather high-technology telemedicine, most on teleradiology [13]. Other articles in the fields include [12].

II.THE RAFT PROJECT

A.History of the Pilot Project

The pilot project in Mali, named «Keneya Blown» (the "health vestibule" in Bambara language), was initiated in 2001 by the Mali University Medical School in Bamako, and financed by the Geneva government and the Geneva University Hospitals. Several goals were set: a) the development and use of Internet-based connections between the national and regional health care institutions, b) the implementation of basic services such as e-mail and a medical Web portal to train users, c) the implementation of a low-bandwidth, Internet-based distance learning system, and d) the evaluation of the feasibility for long distance collaborations for continuing medical education and tele-consultations.

The national network infrastructure is based on an IEEE 802.11b wireless metropolitan area network in Bamako, and on the numeric telephony network to reach regional hospitals that are outside of the capital.

The e-mail and Web services are hosted on Linux-based servers [7], protected from the instability of the local electric power supply by three dozens truck batteries.

The distance learning system e-cours [10] was developed at the University of Geneva and is specifically designed to minimize the use of network bandwidth while providing high-quality sound and display of didactic material, as well as feedback from the students to the teachers via instant messaging. The student can adjust the quality of the video image (the "talking head"), of which the educational value is limited, in order to save resources. A bandwidth of 28 kbits/second is therefore sufficient to follow the course and enable remote areas to participate in distance learning

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activities. It is based on free and widely available tools such as Linux, Apache, and Firefox. It is browser-based, and works on most desktop operating systems (see Table 1 and 2 for details on the required technique for server and clients).

Similar projects using the same technologies are deployed in Mauritania, Morocco and Tunisia, and other countries such as Djibouti, Madagascar and Burkina Faso have also joined the project recently.

TABLE 1. HARDWARE AND SOFTWARE REQUIREMENTS OF THE DISTANCE LEARNING CLIENT.

- Operating system: Windows 95,98,2000, Mac OS, Linux, Solaris, or Irix;
- PC 166 MHz, 64Mb RAM;
- Sound card;
- Screen 1024x768 preferred, 800x600 possible;
- Netscape 4.0 or Internet Explorer 4.0 or later, Java enabled;
- 28 kbits/s Internet connection (56 kbits/s bandwidth necessary for video images);
- Real Player and Acrobat reader plugins

TABLE 2. HARDWARE REQUIREMENTS FOR THE DISTANCE LEARNING SERVER (WEBCASTING EQUIPMENT).

- PC 500Mhz, Windows 98, 128 Mb RAM, sound card;
- Webcam server AXIS 2400;
- Microphone;
- Document video camera WolfVision or equivalent;
- Ethernet hub or switch, 10 or 100 Mbits/s.

III.RAFT OBJECTIVES

The RAFT project has a number of objectives. One of the main goals was to motivate the talented medical professionals to go to regions where they are most needed, medicine in first line in rural areas farther away from the capital. This was motivated by the accessibility of Internet access and thus access to continuing medical education.

A second objective is some help with the creation of educational content adapted to local realities in the countries, as most information published on the Internet is not applicable in these rural settings.

The development of South-South telemedicine network in the countries of French-speaking Africa was another objective to not only have a one way access to continuing education but to give the medical professionals also a possibility to express their ideas to other local colleagues.

The integration of the specific needs for the primary education care and the rural sectors in the network were also regarded as an important part of the project.

To increase the human capacity to develop, maintain, and publish medical content of quality with the added local value was another objective by creating local knowledge on the publication of information. These technical skills are important to create a sustainable use of the technology.

IV.ACTIVITIES OF RAFT

Over 18 months, the project in Mali has enabled the development of a functional national telemedicine network, which connects several health institutions in Bamako, Segou and Tombouctou, where medical teams have been trained for the use of Internet-based tools. The medical Web portal to publish information is in place. Webcasting systems for distance learning have been implemented in Geneva and Bamako (for broadcasting). Continuing medical education courses are now broadcasted on a weekly basis. Several tele-consultations have taken place, to follow patients that were operated in Geneva and then returned to Mali. The tele-consultation system is also used to select appropriate cases and guide their work-up in order to optimize patient evacuation to hospitals in the North or to prepare humanitarian missions. The number of these consultations is currently limited by the number of partners in the network.

Various types of collaboration have been enabled by the project and will be described in the following paragraphs:

- *North-South tele-education*: topics for post-graduate continuing medical education are requested by physicians in the RAFT countries; courses are then prepared by experts in Switzerland and broadcasted over the Internet from Geneva. New courses are produced and broadcasted on a weekly basis (every Thursday) on a variety of topics (see Table 3). The material is also stored on a web server and can be replayed from the medical Web portal. Typically, these courses are followed by 50 to 100 physicians and students in a specially-equipped auditorium in the RAFT country University Hospitals. They are also followed by smaller groups or individuals in the Segou and Timbuktu regional hospitals and in the rural community of Dimmbal, which is about 875 miles away from Bamako. Other French-speaking countries in Africa also join these courses: Senegal, Mauritania, Morocco, Tunisia , Ivory Coast, Burkina Faso , Madagascar, Niger and Djibouti.
- *Webcasting of scientific conferences*: several sessions of international conferences have also been broadcasted, with simultaneous translation in French, in order to make the presentations accessible to colleagues in the RAFT country, where the practice of the English language is still limited. Using the instant messaging feature of the system, remote participants can intervene and ask questions to the speakers.
- *South-South tele-education:* post-graduate and public health courses developed by the various health institutions in Bamako are web-casted to regional hospitals in Mali and to other partners in Western Africa (see Figure 1). The content produced is anchored in local, economical, epidemiological and cultural realities, and provides directly applicable information for the participants.
- *South-North tele-education*: medical students training in tropical medicine in Geneva follow courses and seminars organized by experts in Mali on topics such as leprosy or iodine deficiency. The exposure to real-world problems and field experts enables a better understanding of the challenges for developing countries and implementing health care and public

health projects in unfamiliar settings.

- *North-South tele-consultation*: the same system of the tele teaching can also be used to send high-quality images from one partner to another enabling the remote examination of patients or the review of radiographic images. Tele-consultations are held regularly, in medical fields where expertise is not available in Mali, such as neurosurgery or oncology (Figure 2).
- *North-South tele-consultation*: the same system can be used to send high-quality images between the partners enabling the remote examination of patients or the review of radiographic images. Tele-consultations are held regularly, in areas where expertise is not available everywhere such as in Mali with neurosurgery and oncology (see Figure 2).
- *South-South tele-consultation*: physicians in regional hospitals can request second opinions or expert advice from their colleagues in the University Hospitals via e-mail. This can include the exchange of images obtained using digital still cameras or scanned radiographs.
- *South-North tele-consultation*: the case of a leprosy patient, where the treatment is followed in Geneva, has been discussed using the teleconsultation system. It enabled the expert in Bamako to adjust the treatment strategy.

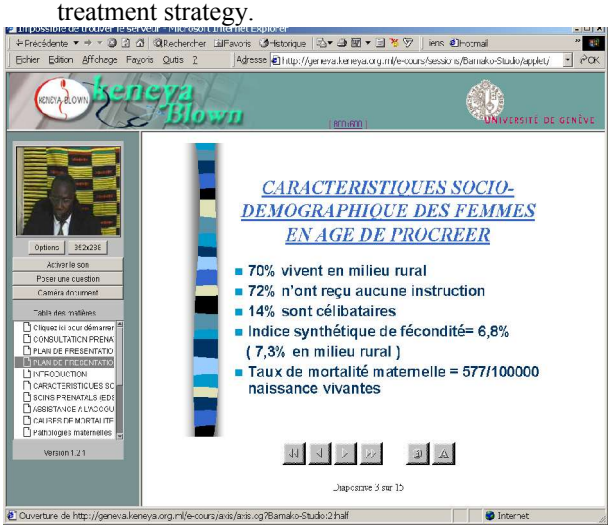

Figure 1. Screenshot of a student view of a course webcast showing the teacher (top-left), the didactic documents (main window) and controls for the sound and the instant messaging tool (left column).

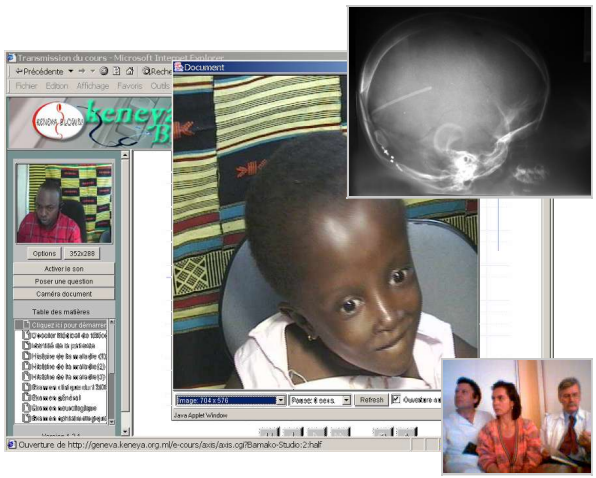

Figure 2. Screenshot of a teleconsultation session, showing the various documents available: the image of the patient, of the physicians, the radiographic images and other clinical data.

V.RESULTS

After all, the RAFT project has been successfully implemented and is in routine use since two years. The partners are satisfied and several countries are joining the initiave regularly.

In total, over 100 teleteachings have been held from north to south and from south to north (see Table 3 for example topics). 20 telecosultations north to south have been hall and 10 south to north.

TABLE 3. TOPICS OF DISTANCE LEARNING COURSES REQUESTED BY THE PHYSICIANS IN THE RAFT PROJECT FROM THE COUNTRY UNIVERSITY HOSPITAL (AFRICA).

- Antiretroviral therapies in Africa;
- Iodine deficiency, public health strategies;
- Shoulder radiology;
- Arterial hypertension during pregnancy;
- Ultrasonic evaluation of arterio-venous fistulae;
- Herpes virus infections;
- Hospital hygiene;
- Thoracic traumatology;
- Tomodensitometry of ENT pathologies;
- Adjuvant therapies for breast cancer;
- Drug prescription and dispensation;
- Modern imaging of thoracic aneurysms;
- Investigation of brain tumors in children;
- Pharmacovigilance;
- Hydrocephaly;
- Obstrical vaginal Fistula :surgical approach.

The experiences gained in the RAFT project highlight the need for a strategy that is adapted to local needs and realities. Applications need to help locally; otherwise they will not get used. In our case this means a strong reduction of the available bandwidth. Still, the sound turns out to be the important part together with the slides. The video only has a minor importance.

VI.LESSONS LEARNED

At the infrastructure level, three kind of problems were identified: a) the instability of the basic infrastructure and in

particular of the electric power supply has caused many problems; b) the limitation of the international bandwidth, which is often misused, in particular by e-mail accounts hosted out of the country instead of in the country (Mali has less bandwidth for the entire country than some Western Universities), and c) the unavailability of reliable connectivity beyond the large cities.

These problems are improving with the overall development of the national infrastructure, although the deregulation movements in the ICT sector and the deployment of mobile telephony will - at least initially - favor the most profitable markets, which are not those where telemedicine tools are most needed. For instance, the focus on mobile telephony probably limits investments in wired infrastructure that is needed for Internet access, especially in remote areas to avoid expensive satellite connections. Similarly, the deployment of wireless metropolitan area networks provides rapidly the needed connectivity, but should probably be gradually replaced by the more sustainable wired, optical fiber-based communication infrastructure.

Basic communication tools such as e-mail are efficient and can be used productively. It is important to develop local capacity to implement and exploit these tools, not only to improve the technical expertise and the reliability of telemedicine applications, but also to limit the use of international bandwidth for information transfer that remains local. Most physicians in Africa still use US-based e-mail accounts for exchanges that remain local, due to a lack of reliable local e-mail services.

At the content level, there is a steady demand for North-South distance learning. However, several topics for seminars, requested by physicians in Africa, could not be satisfactorily addressed by experts in Switzerland, due to major differences in diagnostic and therapeutic resources and techniques, and due to discrepancies in the cultural and social contexts. For instance, there is no magnetic resonance imaging capability in Mali and the only CT-scanner has been unavailable for months. Chemotherapeutic agents are too expensive and their manipulation requires unavailable expertise. Even though diagnostic and therapeutic strategies could be adapted, practical experience is lacking, and other axes for collaboration have to be found. A promising perspective is the fostering, through decentralized collaborative networks, of South-South exchanges of expertise. For example, there is neurosurgical expertise in Dakar, Senegal, which is a neighboring country of Mali. A teleconsultation between these two countries would make sense for two reasons: a) physicians in Senegal understand the context of Mali much better than those from northern countries, and b) a patient requiring neurosurgical treatment would most likely be treated in Dakar rather than in Europe.

Beyond content, collaboration between the stakeholders of telemedicine applications must be organized, in order to guarantee the reliability, security, safety and timeliness for exchanging sensitive information, in particular when the communication is not synchronized. Computer-supported collaborative work environments have been developed. For example, the iPath project [5], developed by the Institute of Pathology in Basel, organizes “virtual medical communities”, which replicate organizational models of institutions in distributed collaboration networks, including clearly identified responsible experts and on-call schedules. These new forms of collaboration over distances, across institutions, and sometimes across national borders also raise legal, ethical and economical questions, questions that are beyond the scope of this paper.

The “induced digital divide” is another potential problem. The centrifugal development of the communication infrastructure implies that the remote areas, where telemedicine tools could be most useful, will be served last. As in most developed countries, physicians are reluctant to practice in remote areas, and the ability to interact with colleagues and follow continuing medical education courses can be significant incentives. Besides the accessibility problem, this also influences the content of the telemedicine tools, which will typically be initially geared towards tertiary care problems. It is therefore important to make sure that the needs of the periphery of the health system are taken into account in these projects. An efficient way to do so is to have the periphery connected to the telemedicine network early. Satellite-based technologies for Internet access, such as mini-VSAT, are sufficiently affordable to consider developing remote access points before the ground infrastructure becomes available.

Finally, there is a need to develop local content-management and other technical skills. Local medical content is a key for the acceptance and diffusion of health information, and is also essential for productive exchanges in a network of partners. It enables the translation of global medical knowledge to the local realities, including the integration of traditional knowledge. Medical content-management requires several levels of skills: technical skills for the creation and management of on-line material, medical librarian skills for appropriate content organization and validation, and specific skills related to the assessment of the quality and trustworthiness of the published information, including the adherence to codes of conduct such as the HONcode [4].

Now is the time for the development of a telemedicine infrastructure in medical teaching centers and their connection to national and international computer networks in order to foster multi-lateral medical expertise exchange with a predominant South-South orientation.

The deployment of Internet access points in rural areas (Dimmbal in Mali, see Figure 4), with the use of satellite technology, enabling not only telemedicine applications but also other tools for assisting integrated, multi-sectorial development. In particular, education, culture and the local economy can profit from these developments. The mini-VSAT technology, recently deployed over Western Africa, offers an affordable, ADSL-like connectivity. Sustainable economical models, based on the successful experiences with Internet cafes in Africa, are being developed to foster the adaptation of this infrastructure by rural communities.

VII.PERSPECTIVES

The use of asynchronous, collaborative environments

enables the creation of virtual communities and the control of workflow for getting expert advice or second opinions in a way that is compatible with the local care processes. The open-source tool developed for telepathology at the University of Basel [5] is being implemented, not only for telepathology, but also for radiology and dermatology.

The development and maintenance of locally- and culturally-adapted medical content in order to best serve the local needs that are rarely covered by medical resources available on the Internet is another important point. New tools are being developed: regionally adapted search engines, open source approaches [14], and adapted ethical codes of conduct. The Cybertheses project [1] and the resources from the Health On the Net Foundation [4] are used to train physicians, medical documentation specialists and librarians.

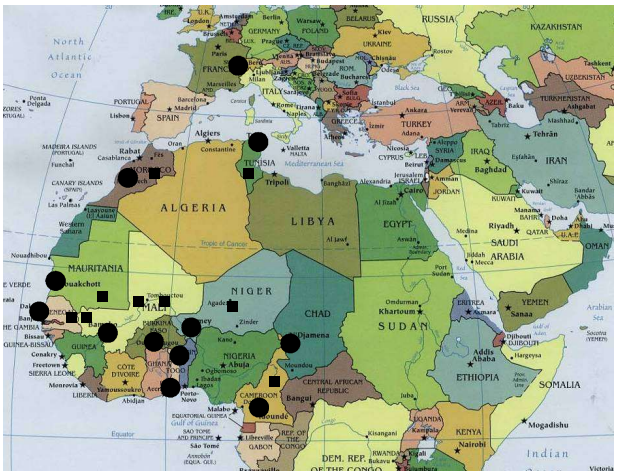

Figure 3. Geographic distribution of the institutions participating in the RAFT project. Circles represent teaching institutions located in capitals or large cities. Squares denote remote access points (fixed or mobile) connected via satellite links.

Figure 4: Telemedicine in the first line: Dimmbal in Mali, 875 Miles away from the capital without telephone or electricity.

VIII.CONCLUSION

Telemedicine tools have an important role to play in the improvement of the quality and efficiency of health systems in developing countries. They offer new channels for communication and collaboration, and enable the dematerialization of several processes that are usually hindered by deficient physical infrastructures. They also expose some risks, and in particular the exchange of inappropriate or inadequate information, and the potential aggravation of local digital divide between the cities and the rural areas. These risks must be examined when designing telemedicine projects and can probably be mitigated by the development of South-South communication channels, the use of satellite-based technologies to incorporate remote areas in the process and by fostering a culture and skills for local medical contents management. These aspects are being further investigated by the RAFT project.

ACKNOWLEDGMENT

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