Telemedicine for Africa: collaborative action between Italy and Swaziland against HIV infection

R. Pizzi, L. Oreni, S. Grassi, A. L. Ridolfo, S. Rusconi, F. Croce and M. Galli

Abstract - Telemedicine is a powerful tool to support remote hospitals to promote health in developing countries. However, Digital Divide is a strong obstacle to the diffusion of this technology. We developed a Telemedicine platform with a minimum need of connectivity and software resource and high usability, to support the Swaziland caregivers in their fight against the AIDS/HIV disease. The platform offers the possibility of real-time professional consulting, learning tools, scientific documentation availability, and data exchange to the physician of the Siteki Hospital in Swaziland, whose number is severely insufficient. The platform is supported by the physicians of the Division of Infectious Diseases, Hospital L. Sacco, Milan, Italy, and has been implemented using the WordPress CMS enhanced with LMS facilities to ensure an easy management by the African caregivers. After the positive training and testing stage, we aim to integrate the platform with the Siteki Hospital information system to facilitate the clinical data exchange.

Keywords - Africa, AIDS, CMS, consulting, Digital Divide, Internet, e-learning, HIV, LMS, Swaziland, Telemedicine, web.

I. INTRODUCTION

A. Digital Divide

"*…In the 21st century, the capacity to communicate will almost certainly be a key human right. Eliminating the distinction between information rich and information poor countries is also critical to eliminating economic and other inequalities between North and South, and to improving the quality of life of all humanity.*

Converging developments in the fields of information and communications offer immense potential to make real progress in this direction. The pace at which the price of communications and information systems has fallen has also undermined the previously rigid link between a nation's wealth and its information richness. There is an unprecedented window of opportunity.

But the present reality is that the technology gap between the developed and developing nations is actually widening. Most of the world has no experience of what readily accessible communications can do for society and economy."

Nelson Mandela, Telecom 95 Speech, October 3, 1995 [1].

The massive spread of the Internet among the population should in principle reduce inequality and improve the quality of life of all social strata also as regards health, through immediate access and better health care.

Vice versa, the reality is a strong social difference in the access to the Internet, which leads to further accentuate inequalities of those who already have a privileged position, denying advancement opportunities for the less privileged (Fig. 1).

Digital Divide is called the gap between people who have access to digital technologies and those who have not.

Particularly in developing countries, sources of information and new models of communication are not easy to access. This limits the ability of these polutions to gather information and to coordinate with each other to solve problems.

Digital Divide in developing countries arise from several types of obstacles:

- physical (access to computers, and network connections to access the Internet)
- economic (costs of applications, engineers, trainers, software, maintenance and infrastructures)
- cultural (the use of technology requires a certain level of education)
- institutional (a large number of users cannot access the Internet at work or in public sites)
- political: the Internet is considered a form of digital democracy and is often considered a dangerous technology whose spread must be limited and controlled.

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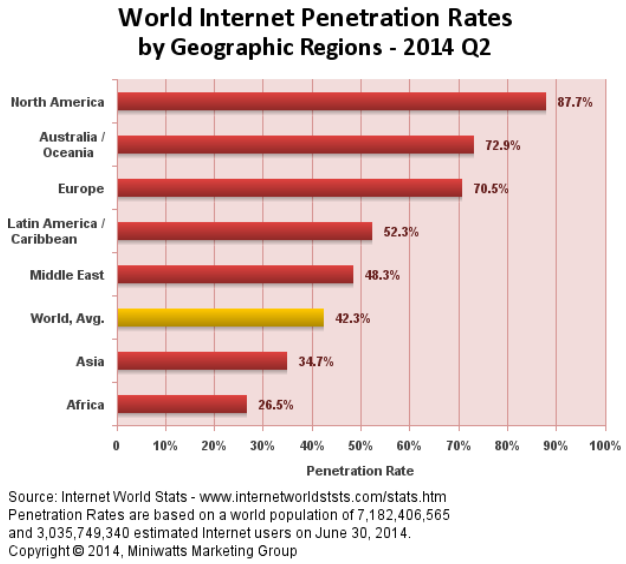

Fig. 1 Inequalities in the Internet diffusion

B. Health problems in Sub-Saharan Africa

Many developing countries suffer from a severe shortage of physicians, especially specialists. The Sub-Saharan Africa has, on average, less than 10 doctors for 100,000 people, and 14 countries do not have any radiologist [2]. Specialists and available services are concentrated in the cities.

Health workers in the rural areas, serving the majority of the population, are isolated from specialistic support and updated information, because of bad road conditions and poor and expensive telephone services.

Swaziland is a small country that lies between South Africa and Mozambique. Swati and English are the official languages.

Economic growth and social integrity are constantly threatened by the scourge of AIDS, so that the United Nations Development Program has determined that if this issue continues to remain unsolved, "the long-term existence of Swaziland as a country will be seriously threatened" [3]. From 2000 to 2009, life expectancy has dropped from 61 to 32 years [4]. Swaziland has the highest prevalence of HIV in the world as of 2012 (26.5% of people aged 15-49, 41% of pregnant women) [5]. The scourge of tuberculosis is also serious (18% mortality) [6].

The Primary Health Care system in the Lubombo Region (Swaziland) refers to the Good Shepherd Hospital (GSH) of Siteki [7], which carries out most of the laboratory tests and follows the majority of the more than 6,000 patients receiving antiretroviral therapy (ART). A network of health workers called "Rural Health Motivators" (RHMS) have been activated, as the first link in the chain of the Primary Health Care system in Swaziland [8].

In this frame we find the cooperation, started in Swaziland over a decade ago within the “Esther” European alliance, between the Department of Clinical Sciences "L. Sacco", University of Milan, Division of Infectious Diseases (Director: Prof. M. Galli), the NGO ANLAIDS, Lombardy Section, and the NGO Cospe, Tuscany Section, on the issue of the global action against HIV / AIDS [9].

The overall objective of the project initiated by the Division of Infectious Diseases, Hospital L. Sacco, is to contribute to the free access of vulnerable social groups to the care, support and prevention against HIV / AIDS.

Specifically, the project aims to improve access to antiretroviral therapy services in the rural communities of the Lubombo Region, initiating and supporting the following activities:

- strategic planning of ART services in the Lubombo Region and implementation of ART services at a regional level.
- implementation of ART services in two rural clinics. Decentralization planning of ART services.
- staff training in rural clinics, especially on antiretroviral therapy.
- training of primary health workers, of community leaders and of family members of HIV-positive patients.
- awareness-raising activities of the community by means of meetings on the issues of treatment, care and support of HIV-positive patients, organized with the support of traditional authorities and support groups formed by people living with HIV.

The training of local medical and paramedical staff is therefore a critical point of the utmost importance [10][11], and the project of the telematic platform HARP (Health Assistance Remote Platform) should be seen in this perspective.

II. Materials and Methods

A. Telemedicine

Telemedicine can be defines as the ability to provide health care through the use of interactive technology and telecommunications. Basically, Telemedicine allows patients to be visited live on video for immediate care or to transfer video / images / data to the doctors for diagnosis and treatment.

Telemedicine is an invaluable tool for healthcare anywhere in the world is implemented.

The uses of Telemedicine can be classified by the different services that can provide:

- Real-Time consulting

This is the most common use in Telemedicine. It allows the doctor to communicate with the specialist without moving the patient. The specialist can assess the state of health through video observation of the patient, clinical evaluations through direct interview and analysis of clinical data and diagnostic images provided by the doctor.

- Store and Forward (asynchronous)

When caregivers are not available simultaneously and immediately, a voice dictation or text of the patient’s doctor including lab data, pictures and / or video, x-rays, etc., can be sent via e-mail or placed on a server and made available to the specialist. The specialist then proceeds with his diagnosis and its treatment suggestions.

- Home Care

When a patient is discharged from hospital and is under observation after surgery or other medical procedures, Telemedicine can take care of her/him at home.

It is possible to assist the patient and monitor her/him real-time. A special equipment is designed to receive the vital signs through sensors attached to the patient (temperature, pressure, cardiovascular parameters, blood sugar) [12] and the patient can interact with physicians through video conference. An emergency call facility is available 24/7, the patient's data are stored for analysis and and alarms can be set and checked by the nurses.

Particularly in developing countries the usefulness of Telemedicine is evident, as on one side it allows the access to quality specialistic consulting , on another side it allows to avoid long and uncomfortable travels of the patients to reach the clinical centers. The main advantages of Telemedicine in a developing country can be sketched in these points:

- Rural Doctors and Clinics

Doctors can attend continuous training courses directly from their clinic centers, can consult remote specialists allowing patients to develop a greater confidence in local doctors.

- Patients

Patients can remain in their community and can be supported by their families. The fact that they don't need to travel allows a better comfort and a significant reduction of costs. They can access urgent care immediately, or an early diagnosis is possible. If hospitalization is needed, it is possible to stabilize the patient's condition prior to transport her/him. Useful health courses for population become available (nutrition, neonatal care, oncology, etc).

- Hospitals

Improvement of surgery procedures due to videoconference consultation. Improvement of care through specialistic consulting. Reduction of visits to the emergency room. Promotion of medical training.

B. Telemedicine in Sub-Saharan Africa

The decision to implement a Telemedicine application for health care workers in Swaziland is due to the main features of this technology [13][14], that yields an important response to the needs of health care in African countries.

The Internet is slowly gaining momentum in Africa: while only a few years ago only 12 countries in Africa had access to the Internet, now Internet is present, at least in the capital cities, in 53 countries out of 54.

The e-mail has many advantages in poor countries: it is cheap, the hardware and software requirements are simple and the information does not need to be transmitted in real time [15].

The Internet connection can be supplied via satellite, allowing to send images as attachments, for a low-cost but effective Telemedicine. The observation of the patient can be described in an e-mail to which digital photographs and other examinations are attached, such as electrocardiograms and X-rays. It is a "Store and Forward" mode, which does not allow real-time interaction, but is cheap and allows specialistic support in the management of difficult cases.

Modern digital cameras are small, robust, easy to use and inexpensive ($ 300-800). They can create high-resolution images (1900 × 1400 pixels or more) suitable for example for the tele-dermatology and tele-pathology [16].

Photographing an X-ray image on a lightbox with a digital camera is a potential solution, whereas a laser scanner for X-ray plates is expensive (about $ 30,000) [17] [18]. This technique offers lower resolution than conventional radiography, but the image quality can be improved with image processing algorithms. Also, a digital image can be stored directly to hard disk, CD, DVD, tapes and easily recovered for follow-up purposes [19] . Image compression techniques can be used to send the images via e-mail to consult a remote radiologist. These techniques may not provide the quality of the data that we expect in modern hospitals.

However, if used by trained health care professionals can improve health care in remote areas.

Connectivity and training remain major challenges. The rapid spread of satellite phones, cell phones and wireless networks is going to solve the first problem. In the most remote areas, however, there are still many barriers for access to computerization, including an intermittent power supply, unreliable telephone lines and lack of maintenance.

C. Telemedicine in Swaziland: the HARP platform

The purpose of the HARP platform, which has been developed on the basis of the collection of the specific local medical and health needs, is indeed to offer health care remote workers a multi-media tool through which Italian doctors can provide information, consultations, distance learning and transmission of scientific documents.

A thorough knowledge of the local reality and needs, which determined and guided the design of the HARP platform, took place by means of several missions of doctors of the Institute of Infectious Diseases of the L. Sacco Hospital at the Good Shepherd Hospital in Siteki, which provides secondary and tertiary care to approximately 250,000 residents of the Lubombo region.

The Good Shepherd Hospital is the reference clinical center of a huge amounts of patients, many of whom (75%, about 3,000) in the treatment for HIV [20].

In this frame, the missions highlighted important gaps to be filled [21]:

• cope with the limited time availability of medical and nursing staff, using tools that allow both to facilitate the registration of the patients and of the medical acts (database of observations);

• facilitate the possibility of access to clinical information and of knowledge development on HIV AIDS by the staff , by means of the connection with search engines and suitable tools;

• allow a possible access to advice, suggestions and experience exchange with highly specialized centers located in other countries.

In addition, the contact with a physician of the Hospital of Siteki assigned to the HIV and TB treatment, and the possibility of a satisfactory connection to the Internet through

Internet key (nominal speed 1024/256 kb/s), confirmed the feasibility of our project.

The platform is devoted to interact both offline and in real-time with the Hospital L. Sacco doctors, through five key features:

- request for scientific publications, and upload by the Italian side of the required publications;
- remote consulting, mainly devoted to specific patients. The platform allows easy access to questions, categorized by topic, and to their responses, which can in turn be followed by a reply, thereby initiating a communication chain that is recorded on the platform;
- training courses which doctors can join. The courses will provide documents for download, tutorials and other interaction modes that will be gradually established;
- virtual rooms where doctors can interact via audio and videos, e.g. attending seminars;
- reports upload / download service: the existing clinical data reports can be loaded on the platform from Swaziland and new queries based on the needs of GSH can be carried out by the L. Sacco Hospital.

The resulting reports will be published on the platform; by accessing the platform the remote caregivers will be able to download the reports in a format useful for statistical data analysis, that can be performed by the L. Sacco Hospital upon request. The new query and data analysis results will become available on the platform.

More technically, the online platform, as well as all the generated documents that can be accessed both on-line and off-line, provide a synchronous and asynchronous information exchange :

- synchronous communication by VOIP, video conference and interactive presentations;
- asynchronous remote consulting instruments by text-audio-video information exchange.

HARP has been implemented by adopting the CMS (Content Management System) [22] and LMS (Learning Management System) [23] technologies.

These tools facilitate the development and maintenance of websites, making it possible to easily build and update a dynamic website of any size. In this way, they ensure the continuity of the platform management, while maintaining, at the same time, the possibility of code changes.

Among the available CMS, preference was given to the usability with respect to scalability and configurability. The best candidate was found to be the open source CMS WordPress [24], turned into LCMS by interconnecting two very robust and innovative plugins: BuddyPress [25] and ScholarPress Courseware [26]: the first one allows to extend the capabilities of WordPress with the social network functionalities and the second one adds to the platform all the main LMS tools.

The Telemedicine platform has been installed at the Hospital L. Sacco, on an IIS 6 (Internet Information Services Version 6 [27] Windows Server 2003.

Access to the platform is web based, after login with the personal authentication credentials (Fig.2).

Fig..2 Home page

The menus are arranged in such a way as to separate the functional list (main menu, text) from a secondary list (icons with links to Home page, Contacts and list of registered Doctors). The Contacts page is a simple form for direct communication with the platform administrator.

All the platform functionalities are symmetrically available for doctors in Swaziland and in Italy. Each section includes a user help (Fig.3).

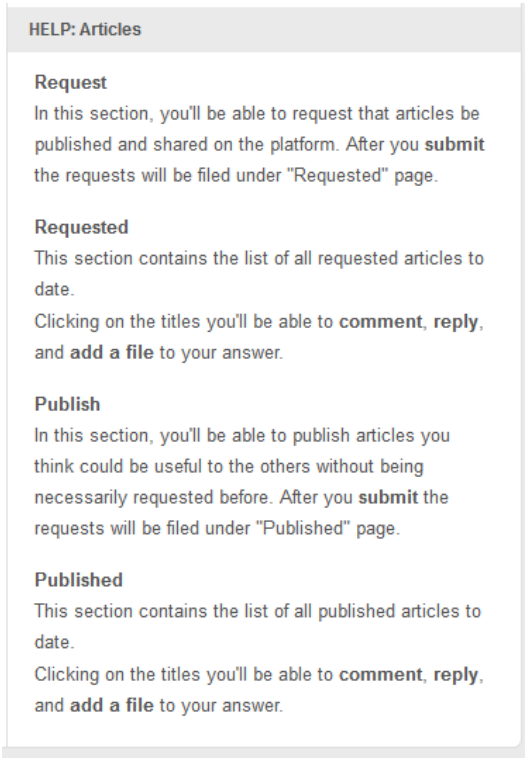

Fig. 3 Help

The site map is sketched in Fig. 4.

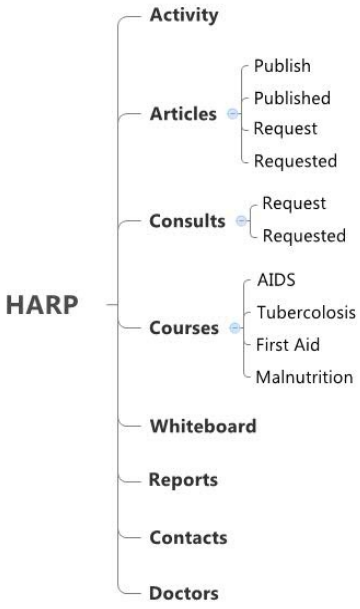

Fig. 4 HARP sitemap

More specifically, after the login the user can access the following sections of the main menu:

- "Activity", section that shows all the news recorded by the platform, suitably filtered (all the News, courses News and Mentions, i.e. public messages where the user is mentioned).
- "Articles", divided into four pages: "Request" consisting of a form to request scientific publications; "Requested", the archive of the requests in the past; "Publish" that allows to upload the medical articles in text format (pdf, doc, odt, txt, rtf, etc.). The uploaded documents are placed on the "Published" page. The user can comment the paper, or, if there is a request, submit a document (Fig. 5).
- "Consults", section that includes two pages: "Request", which presents a structured form to fill out to request a clinical consultation, and "Requested", the repository of all the consultation requests submitted in the past, completed with the answers posted by the doctors (Fig. 6).

It is possible to start a discussion for each consultation request. Physicians can intervene at any time by posting a comment with any kind of attachment (text, images, etc.). All the posts are announced via e-mail to the interested users.

- "Courses", the heart of the e-learning system for distance education.

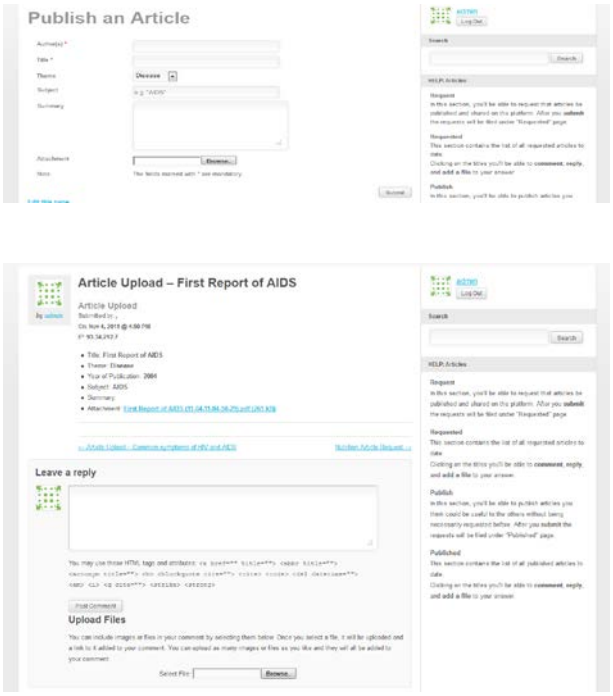

Fig. 5 Publish an article

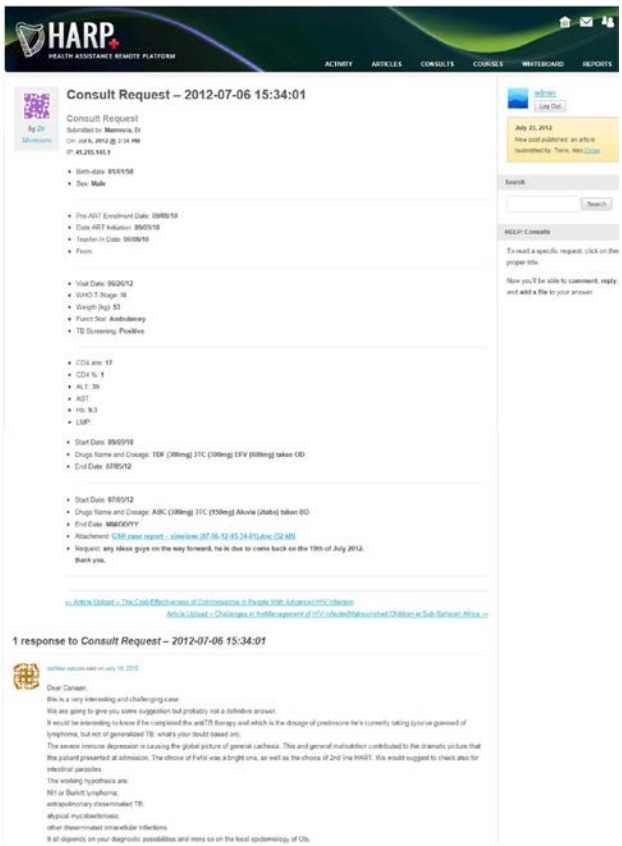

Fig. 6 Consult request

Each course appears in a list with a reference icon and an abstract (Fig. 7). The user who is interested in joining a course is assigned to it as Student. The platform administrator can assign the Teacher status to a suitably specialized physician, thus allowing the user to manage the course by publishing readings, exercises, appointments, deadlines, and bibliography (Fig. 8). This material can be viewed and used by the students enrolled in the course.

Fig. 7 – Courses

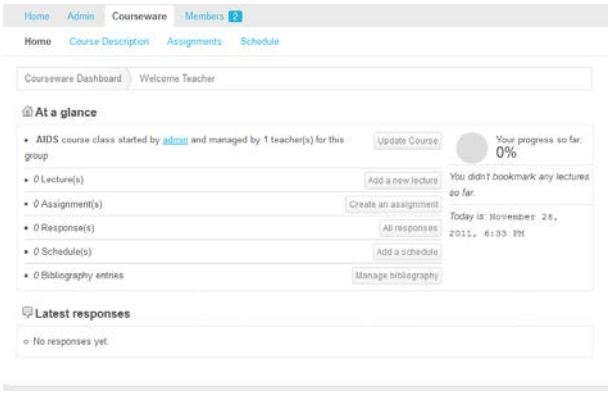

Fig. 8 Student Dashboard

- "Whiteboard", section for the synchronous interaction among users, obtained by integrating in HARP a free web collaboration service [28,29] (Fig. 9). Doctors can access this platform's page both from Italy and from Swaziland and take part together, after entering a password, in interactive presentations, video conferencing, voice chat.

Fig. 9 Whiteboard

- "Reports", section that provides an area to share the data files and the reports extracted from an MS-SQL Server database integrated into the platform [30]. Indeed this section allows to upload the clinical data files and to access, display, download in pdf / excel / XML / CSV / TIFF / MHTML formats the reports generated and published on the platform.

The Italian doctors can download the reports and process them by means of suitable data analysis tools, on the basis of specific requests by the Swaziland caregivers. The results will be then uploaded on the platform (Fig. 10).

Fig. 10 Reports

III. Results

We developed a complete web platform, available without the need for any other additional infrastructure and optimized to be portable and easily manageable even for non computer-skilled personnel. Also, taking advantage of some powerful plugins as WordPress Form Manager [31] and Courseware [32] makes the project highly customizable for future updating and improvements.

A mission carried out on March 2012 at the Good Shepherd Hospital in Siteki allowed the installation of a dedicated desktop PC and the activation of a wireless Internet connection to access the online platform.

The continuity of the power supply has been ensured through a UPS device, even though no particular problems of instability emerged.

The testing phase did not reveal any structural or operating problem. After using the platform with sample data for a while, the doctors of Good Shepherd Hospital and of Hospital L. Sacco in Milan have already interacted on real clinical cases.

IV. Conclusions

HARP is the product of a direct involvement, in the frame of various missions, of the health staff working in Swaziland. In this respect this project differs from other studies, in which Telemedicine applications were first implemented and in the following applied to the remote health reality and evaluated by users through questionnaires [33] [34].

The GSH staff involved in the project has received a suitable training on HARP, both during the mission, and with a web meeting that has clarified some doubts on the practical use of the application. An easy and intuitive interface has minimized the learning time of the GSH medical staff.

We aim to improve the platform's software in order to facilitate the interaction among doctors by improving the posting system, for example by activating their transmission and notification both via e-mail and sms.

We also aim to simplify the clinical reports exchange, creating handy interfaces for data transmission, improving the interaction between HARP and the local database[35][36],, to allow direct queries and to yield the Swazi doctors interesting statistical analyses on all the available data.

It is also possible to improve the platform security using a VPN [37] that directly links the server at the Hospital Sacco with the users in Swaziland.

In order to achieve real benefits, however, the use of HARP must become continuous and must be extended to other health professionals, both of GSH, and of the above cited two clinics / four rural communities in the Lubombo Region [38].

The major limitations that hinder the use of the application at full capacity are due to the quick turnover of the medical and paramedical staff, with the need to often redefine the contacts with the reference physicians, and at a low doctor-patient relationship (one doctor for 3,000 patients), which may discourage physicians, if not sufficiently motivated, to devote part of their time to Telemedicine.

Thus maximum effort will be made to improve the interaction with the African caregivers [39].

We also mean to spread the platform usage developing a network of African and Italian/European Hospitals, in order to improve the diffusion of this technology and its advantages to a broad range of population that so hardly can access professional health assistance [40,41].

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