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Recent Advances in Telepathology in the Developing World

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1. Introduction

The main challenge in healthcare delivery for most developing countries has been how best to take medical services to the remotest locations, because the greatest population lives in rural areas, where socioeconomic conditions and the means of communication are quite rudimentary (International Network for Cancer Training and Research, 2005). Particularly, there is a general paucity of pathology services in the developing countries and so often the correct diagnosis, which is key to survival, is hard to come by. Even in those centers where pathology laboratories exist, these are often the least developed clinical specialty. Hospitals and clinics located in these regions are generally limited in the care they could provide by the lack of pathologists and many of these institutions do not have well equipped laboratories with adequate number of staffs. Additionally, in view of the considerable distances between some rural and referral centers in the developing countries, consultation with an expert pathologist is a rarity, time consuming and expensive.

A wide range of factors have influenced the deployment and growth of pathology resources throughout the developing world. In sub-Saharan Africa, the shortage of medical staff in pathology laboratories is particularly severe. Except in a few cities, majority of specimens are not even sent for pathological examination. Delays and low quality of service makes the pathology tests of limited value to clinicians. General laboratory quality standards including quality control and quality assurance are non-existent or suboptimal (Malami & Iliyasu, 2008a) and the skill of the technicians is highly variable. Other pervasive problems for pathology laboratories in sub-Saharan Africa are related to limited opportunities for basic training in pathology and the lack of books, CDs and other educational materials for continuing improvement. The result is a lack of operational competency with little back-up (Ahmad, 2005; Ahmad, et al 2009). It is therefore apparent that, perhaps more than anywhere else, it is in these resource-constrained nations of Africa that the greatest unmet need for pathological services exists. It is crucial that innovative interventions address these needs to improve the quality of laboratory services. In the context of these considerations, therefore, it is quite fortuitous that the world has witnessed phenomenal advances in technology that incorporate new methods in communications and information technology into medical practice. This has virtually revolutionized the practice of pathology and helped to facilitate professional linkages and dissemination of cutting-age knowledge. These improvements in technology have largely solved the technical requirements for telepathology (Wells & Sowter, 2000). Consequently, there is a considerable literature on the

potential use of telepathology in the developing world resulting in a new look at how secondary and tertiary healthcare can be provided in these resource-constrained settings.
In the last couple of years a number of institutions and individuals have attempted to introduce telepathology to some developing countries with varying degrees of success but these had been hardly reported or properly documented. This chapter will, therefore, dwell on the background, opportunities and barriers to telepathology in these underprivileged locations.

2. Telepathology in perspectives

Telepathology is the subspecialty of telemedicine in which pathology is practiced at a distance using imaging and telecommunications. But unlike other applications of telemedicine, characteristic of telepathology is that data are transmitted mainly in the form of images. According to Weinstein et al telepathology can be defined as the remote primary diagnosis, consensus diagnosis, case conferencing, or expert consultation of either electronically transmitted, static, digitalized images, or real-time pictures obtained using remote robotic microscopes (Weinstein et al, 1987). In other words, telepathology may involve the acquisition of histological, cytological, and macroscopic images for transmission along telecommunication pathways for diagnosis, consultation, or continuing medical education (Baruah, 2005).
It is a comparatively new technique in medical practice whose initial use arose from the need for real-time diagnosis of frozen section material at hospitals that lacked tissue pathologists (Nordrum, 1996). From these humble beginnings, telepathology has entered a digital age and a level of sophistication that permits the practitioners to currently view high quality real-time colour images and to control all aspects of a robotic microscope at a remote location in the course of consultations that often take a fraction of a second (Wells & Sowter, 2000). Routinely, telepathology systems nowadays enable remote diagnosis (intra-operative frozen section and permanent section), subspecialty consultations, and better educational feedback. Second opinions, including even remote consultation across the globe, are not only technically feasible but also reasonably user friendly (Weinstein et al, 2001). Studies have shown that its accuracy is comparable with that of conventional light microscopy for most diagnoses. These and other advantages have influenced the decision of some developed countries which have made it a priority to incorporate telepathology applications into their healthcare systems in an effort to provide better services.
Telepathology links have evolved from the era when analog telephone lines were used characterized by slow data transfer to the extremely rapid transmission of today using wireless technology. The principle feature of telepathology is that communications are bidirectional, so data can be sent to and fro. It may employ store-and-forward method (static), real-time approaches (dynamic) or a third approach which is a hybrid system that combines static and dynamic elements. Store-and-forward systems are more widely used owing to their simpler technical requirements and affordability. Commonly, images were submitted by email or presented on a web based platform. Store and forward telepathology has its own limitations due to the disjointed nature of the images, and the significant diagnostic errors incurred with this method have been attributed to inappropriate field selection by the submitting pathologist (Weinstein, et al 2001). Although the real-time approach represents a reasonable substitute for in-person consultation and has the advantage of enhancing interaction, it is more time-consuming and expensive. Nonetheless,

dynamic telepathology using fully motorized robotic systems has revolutionized the field, and a concordance rate of 99-100% has been reported between telepathology and light microscopy diagnosis (Dunn et al, 1999; Weiss-Carrington et al, 1999).
Much progress has been made in the past couple of years in the field of digital imaging and virtual microscopy making the hybrid systems a lot more convenient than ever before such that 'virtual slides' can now be made where the entire slide is scanned at a very high resolution and then viewed by multiple pathologists (Leong & McGee, 2001) and without any loss of resolution. In this non-robotic real-time telepathology, the sampling error so common in static telepathology is eliminated and there is no requirement for expensive equipment. The significant deterrent is the high capacity needed for storing images which is on the average 150 Mb (Baruah, 2001).

3. Telepathology in developing countries

Characteristic of many developing nations is that scarce but highly-skilled manpower and healthcare services are concentrated in the urban centers. With specific reference to some of these nations, the uneven distribution of pathology service had resulted in serious consequences for the patients in the past (Ahmad, 2005). A continuing challenge is how to motivate and retain workers who are cut off from specialist support and up-to date information by poor road networks, archaic communication gadgets, lack of library facilities and an absence of opportunities for professional development. Also the type and sophistication in the level of diagnostic facilities varies widely from one developing country to the other. In view of these variations, the pertinent question had been how to evolve a cost effective strategy to guarantee steady improvement in pathology diagnosis and training of local personnel.
On the authority of Ahmad, the causes of poor pathology laboratories services in the developing countries are protean and primarily revolve around the failure to follow regulations, or in some cases, even to establish the relevant regulations (Ahmad, 2005). He goes on to point out other pertinent issues that impede the growth of pathology as:

- Low budgetary provision for laboratory services as a whole; traditionally most funds are spent on high-profile capital projects.
- Scarcity of laboratory staff: The rapidly rising demand for pathology services is not matched with the availability of skilled laboratory personnel.
- Poor training: The training of pathologists and technicians is suboptimal.
- Lack of appropriate equipment and infrastructure: There is often no infrastructure for maintenance, or even an assured supply of electricity.
- Lack of regulatory mechanisms: No license is required to establish a clinical laboratory in many developing countries.
- Lack of continuing education: Only in a few developing nations does provision for continuing education for pathologists and technicians exists.

The scenario in most developing nations can thus be summarized as that of pervasive weakness of laboratories facilities. Ironically, experience has shown that these peculiar circumstances also offer a unique opportunity for interventions. Importantly, there is almost universal enthusiasm from the local pathologists and technicians in the developing nations to improve the quality of pathological diagnosis and this should be an important incentive and motivation to organizations with interest in these kind of partnerships.

Conceivably a telepathology link utilizing simple and relatively cheap technology, like some of those in use in the industrialized world, would be quite ideal in these locations. Typically, the processes of setting up telepathology tend to pass through certain stages in developing countries. Funding for telepathology, so critical in these initiatives have largely been on one-on-one bases, and derived mostly from international organizations.

Of the available methods, static telepathology appears to have been accepted across most centers in the developing world. In a sense this can be justified as it has proved itself to be the more robust, least complicated and low-cost telepathology tool. Basically what the so-called 'store and forward' technique offers is that a large data set, in this case still images, are entered into a computer ('stored') and then sent ('forwarded') slowly to an expert in form of e-mail attachments. After examining the images, the recipient responds with a diagnosis. The use of improved hardware and software has made it possible to produce higher quality images that could be easily transmitted to remote locations by this method. Special telephone lines (ISDN lines) are used in some developing countries that transmit data faster than simple phone lines and allow real-time videoconferencing. On the other hand, the main advantage of using an internet-based system is that it is becoming even more accessible and a pathologist with basic equipment can utilize it to contact a consultant when the need arises. The advantages of these methods include the increased speed of the diagnostic process and convenience of use since both users do not have to be online simultaneously when an immediate response is not necessary. However, another limitation of static as compared to dynamic telepathology is the fact that the observer cannot control viewing of the specimen. Store and forward has therefore been found to be very effective in many developing nations.

4. Case studies of selected telepathology projects in the developing world

Attempts to practice telepathology in the developing world are not new. It is reported that one of the earliest uses of telepathology in practice occurred in 1973 from a ship docked in Brazil through a satellite that transmitted bone marrow smear images to Washington (Weinstein et. al., 1987).

iPath and telepathology.org are the best known websites that have been instrumental in the increasing level of awareness and usage of telepathology in developing nations. These and other websites provide web applications for discussion forums in telepathology that create a quick and easy method for tele-consultation from a pool of expert consultants.

The iPath network is based on software which was developed by the Department of Pathology of the University Hospital Basel, Switzerland, as an open source framework for building web- and email-based tele-medicine applications. (Brauchli et al, 2005). iPath was the first web-based platform that stored and shared medical cases together with attached images (both radiologic and microscopic) as well as other patient data in closed user groups. Since its inception, members of each of the closed user groups of pathologists, in particular had been enabled to review cases, suggest diagnoses and submit comments (Brauchli, et al 2004 and Brauchli, et al 2004b). Through this particular initiative, several successful telepathology projects have been established in the developing countries. By 2005, it was reported that the iPath telepathology server at the University of Basel (http://telemed.iPath.ch) was being used by many doctors from around the world for

second opinion consultations including pathologists from Bangladesh, Cambodia, Fiji, Laos, India, Iran, South Africa, and Thailand.
Some telepathology links that are still active in developing countries are described below.

4.1 Solomon Islands

One of the most celebrated telepathology collaborations is the one between National Referral Hospital of Honiara, Solomon Islands and the University Basle in Switzerland. Prior to the commencement of this service, the State of Solomon Islands had no pathologist at all and what little pathology service that existed consisted of sending specimens to the Royal Brisbane Hospital, Australia, for processing and diagnoses (Brauchli et al, 2004a).This was very frustrating as it often took 8 weeks or more for the results to return. This unacceptable scenario compelled an emigrated Swiss surgeon who had practiced in the Solomon Islands for 8 years to request for help from Basle University Hospital. After the appropriate contacts and consultations it was decided to explore the possibility of exchanging images and diagnoses over the internet on slides prepared from specimens in a new small histology laboratory that was to be established in Honiara. Basically, pictures of slides were taken with a Nikon OptiPhot microscope and a Nikon CoolPix 990 in Honiara and then digital images were sent to the iPath-Server in Basel where they were reviewed by a number of Pathologists from Europe and USA.

4.2 Egypt

Similarly, a pilot project began in the year 2003 between an institution in Egypt (the Italian Hospital in Cairo) and the Civico Hospital in Palermo, Italy applied static and dynamic techniques for telepathology which resulted in ease of consultations on many problematic pathological cases (Ayad & Sicurello, 2008). Subsequently, this project also expanded to two other hospitals (Charing Cross Hospital in London and the University of Pittsburgh Medical Center Health System in the USA). When fully functional this network will facilitate improved diagnosis for difficult cases and make available E-learning opportunities for individuals both in Egypt and the wider Mediterranean region.

4.3 India

Aside from the above projects that are driven by organizations from outside the developing world, there are also examples of projects that exist as partnerships between South-South groups/institutions. Some good examples of these could be found in India. Illustrative of the success of telepathology between institutions located within a developing country is the experience of using static telepathology consultation between a tertiary cancer centre (Tata Memorial Hospital) and a rural cancer hospital (Nargis Dutt Memorial Cancer Hospital) in Barshi, Maharastra both located in India (Desai, et. al., 2004). In this project it was proved that using existing telecommunication facilities and a 56 k modem, it was possible to have good telepathology consultation and a concordance rate of 90.2% was observed for diagnoses (Baruah, 2005). This telepathology successfully allowed quick and timely access to expert opinions and thus effectively bridged the gap between medically underprivileged, geographically distant rural areas and advanced centres using the static store and forward methodology.

PathoIndia, is a virtual pathology community hosted on iPath that aims to bring all the pathologists in India online, on one common interactive platform, so as to share and participate in the active telepathology quiz and group discussions; receive information about conferences, CME, etc; and collaborate on projects or publish articles on the website.

4.4 Argentina

Furthermore, it was reported that a telepathology and continuous education link had been established between a Latin-American Pathologist from La Rioja, a small Province of Argentina, from 1997 to 2007 and other pathologists based in Spain linked to a server (Jará & Barcelo, 2008). This network had evolved through many stages. At the beginning the digital images obtained were scanned from paper photos. The pictures had at least 1 MB each and when sent by e-mail took as long as 20 minutes each, through an analogue telephone modem connection. Subsequently, a Cybershot Sony 1.3 Megapixel (mpx) digital camera with 3× optical zoom, was used to capture the images directly from the eyepieces of the microscope. Then Corel Photo paint program was used for editing, compression and resized to 640 × 480 pixels (VGA). Since 2007, the center has had broadband ADSL Internet connection with the process becoming easier and faster.

4.5 Cambodia

Following on the successes of earlier initiatives, the telepathology project at Sihanouk Hospital Centre of Hope in Phnom Penh, Cambodia, has been used to successfully diagnose thousands of cases related to GI tract, thyroid, serous membrane and skin diseases using the iPath server at University of Basel. Furthermore, a case report emanating from Angkor Hospital for Children in Siem Riep, Cambodia, illustrated how telepathology enabled advice from distant providers for diagnosis and treatment of a paediatric patients (Froehlich et al, 2009). This is further proof of the extent the practice of telepathology continues to be used to improve healthcare delivery in a developing country.

4.6 Iran

Some of the earliest telepathology projects in Iran, which is a country like most other developing nations where there is no special telepathology network, have been highlighted in the literature (Mireskandari et al, 2004; Abdirad et al, 2006). These links between the University of Kerman in Iran and also the Cancer Institute of Tehran Universities of Medical Sciences with the iPath telepathology server based in Basle and UICC server Berlin were used for only telepathologic consultations. Based on the success recorded in these projects other institutions in Iran have also followed on to use the iPath website generally, even though there have been peculiar challenges which significantly restrict the use of telepathology in Iran.

Pathologists in developing countries display a great deal of enthusiasm about the open access to the latest expertise provided through these platforms that are free to all users. It has emerged that in the constant struggle to keep abreast of all new developments in the rapidly expanding field of pathology, telepathology could play a significant role in bridging the so-called digital divide. For many communities, their first experience of the practice of pathology has happened only with the advent of telepathology in which histopathologic

diagnoses using the electronically transmitted images instead of conventional glass slides that are transmitted electronically to a recipient. In these locations not only has it allowed for sharing of difficult cases with experts who are worlds away, but also for teaching and other applications.

In the ongoing search for cost effective interventions, an interesting scenario would be to employ Skype and MSN for remote consultation and web conferencing for telepathology in the developing countries. The capture systems in these modalities have been determined to be simple, which re-enforces the viability of the system for use in developing countries (Clóvis et al, 2008). The programmes MSN and Skype can be used for discussion of cases, second opinion, or even, in the case of Skype, for a video conference (chat) with the participation of some specialists in the most varied localization. In both systems one can even create a conference with many users.

5. Telepathology in Sub-Saharan Africa

There is paucity of data on the current status of telepathology in sub-Saharan Africa. Even within each country, it is difficult to provide current and accurate information on its numeric strength or successes with any degree of certainty. Nonetheless, a review of the literature showed that a few telepathology projects have been launched or are planned in sub-Saharan African nations though there is little or no information about progress in many of them.

5.1 Burden of disease, manpower status and healthcare funding in Sub-Saharan Africa

Africa occupies an area of approximately 30 million square kilometers with a total population of approximately 800 million people (United Nations, 2006). Sub-Saharan Africa can be defined as that part of Africa lying to the south of the Sahara desert. It is made up of 42 countries and 6 island nations, extending as far east as Mauritius in the Indian Ocean.

The continent has witnessed declining economic performances, a history of political instability, some of the lowest levels of development in the whole world and 41% of people in sub-Saharan Africa live on less than US$1 per day (United Nations, 2008).

The health sector in most of Africa presents a peculiar set of challenges and lags far behind its counterparts in the developed nations. The burden of disease is great and diseases such as tuberculosis and malaria each kill up to a million people annually. In recent years, acquired immunodeficiency syndrome (AIDS) has spread rapidly, especially south of the Sahara. Today, Africa has most of the HIV-positive people in the world according to current estimates. Maternal mortality is very high and there is a high prevalence of measles, lower respiratory tract infections and diarrhoeal diseases among children, and poliomyelitis has re-emerged as an important pubic health problem. The huge difference between Africa and the industrialized world is highlighted by the fact that the WHO African Region has 24% of the global disease burden but only 3% of the health work force; commanding less than 1% of world health expenditure. In terms of provision of doctors, most sub-Saharan African countries fail to meet the WHO recommended minimum standard of at least 20 doctors per 100 000 population. To compound this scenario, healthcare funding is grossly deficient in that the average per capita expenditure on health in sub-Saharan Africa is a dismal US$22.

5.2 Opportunities and examples of telepathology in sub-Saharan Africa nations

Since healthcare provision in sub-Saharan Africa is so precarious, many Pathologists practice alone in isolated and remote locations without adequate infrastructure. Opportunities for expert opinions or second opinions on histopathology, cytopathology or haematopathology are not readily available to the reporting pathologist in these settings. Coming from a realistic understanding of the situating on the ground, success in raising the standard of pathology services in these countries will probably take many years of careful planning and persistence. But current initiatives to transfer professional knowledge and expertise, including initiatives that employ telepathology, could improve on the available diagnostic capabilities, and do have an important place.

The advent of telepathology in sub-Saharan Africa is best viewed in the context of its growth in the rest of the developing world. Telepathology in sub-Saharan Africa stands to benefit from the previous successes and limitations experienced by telepathology networks and projects located in other developing countries which were implemented in similarly sparsely populated remote areas, where means of communication are simple and socioeconomic conditions are generally poor. It goes without saying that in view of the existing infrastructural and manpower limitations in these countries, these novel initiatives on the use of information and communication technologies (ICTs) in the health sector have been largely limited to the urban centers.

Currently, a few countries in sub-Saharan are at different levels of sophistication in their practice of telepathology. These projects have employed several technologies, ranging from simple telephony to e-mail to facilitate exchanges. Nowadays, a few initiatives have also embarked on more sophisticated practices, such as real-time image transmission and analysis over digital networks with chat and voice transmission over the Internet Protocol (IP).

In the last couple of years a number of influential publications have appeared in the literature on the limited experience with telepathology in a few African nations and some of these will be briefly highlighted here.

5.3 South Africa

South Africa has a national telemedicine system incorporating telepathology that was initiated in 1999 with 28 pilot sites established in six provinces.

5.3.1 Walter Sisulu University Medical School

In the Republic of South Africa, at the Walter Sisulu University Medical School, store-and-forward telepathology services have been used since 1995, with links to the Armed Forces Institute of Pathology in Washington and various pathology departments in Europe. In this network a digital microscope with Internet connection for 'live' telepathology now operates in the country, with full real-time remote control, and this has revolutionized small, remote histopathology departments lacking sub-specialists. The telepathology network facilitates histopathology teaching at the University, by using a library of 400 virtual (electronic format) slides that are easily shared and reproducible with an indefinite lifetime as compared with 3 or 4 years for glass-based slides (Banach, 2008).

5.3.2 Phone-based Telepathology linkup between UNITRA and MEDUNSA

The first South African phone-based linkup between Department of Pathology, UNITRA and Department of Anatomical Pathology, MEDUNSA was setup in 1995. The telepathology

and teleradiology workstations (now Telemedicine Unit) were installed at the Department of Anatomical Pathology, Histopathology and Cytology, UNITRA. The system has allowed sending still images (microscopy, x-ray, CT, ultrasound) to Telepathology Services of Armed Forces Institute of Pathology in Washington, USA, via the Internet. Results were obtained within 24 hours.

As an extension of the above project, the Department of Pathology, University of Transkei, Umtata has been involved in the development of telemedicine in the Transkei. Using existing facilities (PC, microscope and camera), which was later upgraded, they have managed to also establish a good telepathology, telecytology and teleradiology connection with Armed Forces Institute of Pathology in Washington, USA. There has also been the establishment of a real time pathology/cytology/haematology remote consultation with Anatomical Pathology Department at MEDUNSA and eventually to connect smaller hospitals around and establish telecytology services.

The growth of telepathology in South Africa has continued with the introduction of digital microscopes combined with Internet technology. Through the digital microscope it is possible to view in real-time whole slides as well as different chosen fields in different magnifications. In this project, three Nikon Coolscope were installed in the NHLS laboratories in Mthatha, East London and Port Elizabeth. All these microscopes are connected to NHLS server allowing real time viewing of the full slide on any PC connected to NHLS Intranet using Internet browser at any time of the day.

5.4 Cameroun

In Cameroun there is a notable experience from the body named Pathologie, Cytologie Dévelopment (PCD) in the use of telepathology for the detection of cervical cancer in Yaoundé (Cameroun). This organization has an important experience on providing equipments (second hand material) to pathology laboratories in Africa.

5.5 Ethiopia

A project was launched in 2004 and operated under the National Telemedicine Coordinating Committee of Ethiopia (Schneider, 2005). The project, in which telepathology is an integral component, connected ten hospitals in the country with the Tikur Anbessa Hospital and the Faculty of Medicine in one internet based network. It has improved access to continuing education and training, raised the level of access to care and drastically reduced the waiting time and cost associated with long distance travel by patients for diagnosis.

5.6 Africa calls programme on cytology

The dearth of training opportunities in cytology in Africa, has stifled the growth of this subspecialty and current economic considerations make the traditional short clinical attachments in cytology abroad increasingly difficult or impossible (International Academy of Cytology, 2007). A seldom mentioned, but critical role of telepathology is in cytology consultation and education. However, there is limited expertise in all but a few Africa nations, including Nigeria, where the opportunity for local training and continuing education in cytology is lacking (Malami, Iliyasu, 2008b). The concept of cyto-teleconferencing formed the basis of an innovation designed to promote diagnostic cytopathology in evolving countries of Africa by means of audio teleconferences. The project arose in response to needs assessments from sub-Saharan African countries and was

designed to facilitate the exchange of scientific information and technology from the western countries for practice improvement. The link provided participants from African Departments of Pathology with customized educational programmes in cytopathology (Annenberg, 2010). Since 1999, six sixty-minute programmes are broadcast live annually to centers in Botswana, Ghana, Namibia, Nigeria, South Africa, Sudan, Swaziland, Tanzania, Uganda and Zimbabwe. The programme was attributed to have improved the knowledge and skills of the participants in the practice of cytopathology and is thereby an effective method of telepathology achieved at a relatively low cost (Malami, 2008). In this model, the long distance phone and networking costs are assumed through a grant from the Anenberg Center for Health Sciences and Hologic Inc, and each of the participating hubsites was provided with teleconferencing equipment and downloadable PowerPoint presentation together with adjunctival educational materials.

5.7 UICC Telepathology Consultation Center (UICC-TPCC)

In 1999 the International Union Against Cancer (UICC) had established the Telepathology Consultation Center at the Institute of Pathology, Charité, Humboldt-University, Berlin, Germany. The strategy had been informed by the findings of a needs assessment of available facilities in different developing countries. This center had provided a free access to rapid second opinion and inexpensive diagnostic aid to pathologists all over the world (Dietel et al, 2000). True to the plans of its founders the UICC-programme has offered local pathologists in developing countries an easy and time-saving access to high-quality histopathological diagnoses with bias towards laboratories and institutions based particularly in Eastern Europe, Asia and Africa. The participating centers have benefitted in the form of expert advice on diagnosis which has often been of invaluable benefit to the local clinicians' decision making processes. This is an example of a telepathology link that has arisen from need for regional and international interactions for support in pathology diagnosis/education and training.

5.8 INCTR project on telepathology and teleoncology

The success of the UICC-TPCC provided the perfect setting for a new project of the International Network for Cancer Treatment and Research (INCTR) under the auspices of INCTR Pathology Education Program. The INCTR was founded by the International Union Against Cancer (UICC) and the Institut Pasteur. Its goals include assisting in controlling cancer in developing countries. INCTR with the support of the National Cancer Institute (NCI) Office of AIDS Malignancies is working to establish improved pathological diagnosis in the context of its African study of HIV+ and HIV- Burkitt lymphoma in equatorial Africa. In the initial stage efforts were made to scale-up basic and continuous education of pathologists and technicians in Kenya, Tanzania and Nigeria.

This project was the fallout of a meeting that was convened by the UICC in Paris in October 2008 specifically to explore how to support and promote diagnosis, therapy, education and research in the developing countries. It is intended that this project will offer central pathology review related to the highlighted clinical studies. As a secondary strategy, a telepathology project built on iPATH, the free web-based application developed at the University of Basel, will be introduced with the objective of using this for review, consultation and education (continuing and post-graduate).

The INCTR Telepathology Network would be an important means of combating the isolation of pathologists on the African continent and the lack of up-to-date information and education that impedes their work.

5.9 RAFT

The Réseau Afrique Francophone de Télémédecine (RAFT) project is an Internet-based tele-medicine network started in 2001 in developing countries of Western Africa. The technology used for the webcasting works with an internet connection, a Java-enabled Web browser (e.g., Internet Explorer or Mozilla) and the free RealPlayer software. The bandwidth is 30 kbits per second or the speed of a basic telephone modem, which is sufficient, and enables the participation of remote hospitals. The Geneva University Hospitals have been involved in coordinating the development of this network for eHealth in Africa, first in Mali, and now extending to 10 French-speaking African countries including Mauritania, Senegal, Morocco, Tunisia, and Madagascar. The core activity of the RAFT is the webcasting of interactive courses targeted to physicians and other care professionals, the topics being proposed by the partners of the network. These sessions put the emphasis on knowledge sharing across institutions, usually in the form of presentations and dialogs between experts in different countries (Geissbuhler et al, 2007). The results are a tele-medicine network that has been in productive use for over 5 years and has enabled various collaboration channels.

5.10 Proposed East Africa telepathology program

Another ambitious tele-education project, requiring a small bandwidth, is planned for East Africa. The development, long-term funding, legal framework, and other details and this project to be hosted at Nsambya Hospital, Kampala Uganda is still to be widely circulated.
In summary, the experience from some selected sub-Saharan African nations has shown that telepathology links have been introduced many of which rely on only a light microscope, a high resolution camera (video or digital) a workstation and internet access through a telecommunications network. This is appropriate as several nations do not have adequate national or regional capacities presently to replicate some of the highly sophisticated systems common to the developed world. International Internet bandwidth is rare and monopolistic national policies that tend to protect the inefficient national telecommunications providers are not helping the situation either (Dlamini, 2001). The motivation for new telepathology projects is provided by the glaring absence of opportunities for continuous capacity building. Therefore a critical element of most telepathology collaborative projects is that in addition to long-distance consultation, they also provide continuing medical education (CME) for physicians who submit cases. In terms of sustainability, there is a huge question mark still as most of the links or projects have developed from personal communication between local pathologists and overseas consultants rather than being corporate or government sponsored. Potentially, the mandate of these projects could be expanded or extended to establish national networks.

6. Barriers to telepathology in the developing world

Most of the existing telepathology systems were not really designed with the developing countries in mind. Demonstration projects for telepathology have been done for some years in the developing world, with a few spectacular successes. But given its potential benefits to these nations, telepathology is still a far underutilized and largely unexplored technology.

The matter is not helped by the heterogeneous nature of the countries involved and the pervasive problem of access to telecommunications services at affordable cost. Though there is scant quantitative data on the reliability and cost effectiveness of telepathology, a few isolated reports have published the assessment of the logistics, economic feasibility, and barriers to telepathology in South Africa and India and these data could be extrapolated to other developing countries.

The development of telepathology is a complex matter. This is more so in the developing world where a satisfactory ICT environment is frequently unavailable. But the impediments to the successful implementation of telepathology cannot be viewed in isolation of the larger picture that affects telemedicine and the practice of pathology itself. Weinberg argued that the same factors responsible for the inertia to the full-scale introduction of telemedicine might also explain some of the impediments to telepathology (Weinberg, 1996).

Detailed analysis of the barriers to telemedicine and telepathology appear in the works of Wootton, 2009; Mars, 2009; Desai, 2009; Weinberg, 1999; and also Sood & Bhatia, 2005. Some of these impediments are worth highlighting:

6.1 Socio-cultural barriers

Successful introduction of any new system into a community requires an indepth understanding of the social environment. Preliminary studies and demonstration projects have shown that there are could be significant socio-cultural challenges to integrating telepathology into the healthcare systems of developing countries. These factors may be political or cultural in nature or even just the natural tendency of the staff to initially resist any new technology. Ownership issues may need to be clearly settled too so that this does not threaten the sustainability of the telepathology project. Sometimes because of the limited number of doctors in developing countries, local physicians and health workers may be concerned that telepathology systems will be time-consuming and generate unnecessary extra work. It is therefore crucial that they be made aware of the potential and relative advantages of the technique from the onset. The local people, technicians and even physicians may also adopt a negative attitude to the use of telepathology. It is therefore pertinent to note that the design and development had to be such that would not dislodge existing practice of working in hospitals. Such attitude may arise from inadequate information. To establish a lasting collaboration a genuine effort should be made to familiarize with the local circumstances.

6.2 Inadequate laboratory infrastructure

Pathology, and by extension, telepathology is not the main focus of government health expenditure in the developing countries. Available resources are allocated to the control of life-threatening infectious diseases and some fanciful capital projects, while very little is directed at upgrading or maintaining the laboratories. Even the essential components of a telepathology system such as a microscope, a camera with software and a computer, may not be readily available in some developing countries. Procurement of these items may be difficult. Also, where they are available initial difficulties due to inexperience in using the equipment need to be overcome.

6.3 Archaic telecommunication facilities

Without modern telecommunication it would be difficult to introduce and sustain telepathology services in developing countries. The development and availability of

telecommunication facilities may be non-uniform, may not be developed at all, or they may be so poorly developed that it would be difficult or impossible to transmit data. In many existing networks connections are sometimes unreliable. For successful implementation of telepathology there must also be a stable communications strategy that reliably connects the centers with the Internet, without huge debts to pay for the connectivity. The improvements also should extend to internal communication in hospitals and remote medical centres. Internet services need to be widely accessible, even in rural parts of the developing world. In practice, a substantial proportion of telepathology work in developing countries is done by email or by web messaging. Email has many advantages in poor countries: it is cheap, hardware and software requirements are simple, and the information does not have to be transmitted in real time.

6.4 Funding and sustainability

Financial support is an important determinant of the sustainability of telepathology projects. Except for a few countries, there is a lack of telemedicine policies at national and regional levels and, as a result, a lack of budgets. Because of the cost of Internet access, even simple store-and-forward telemedicine is not always an affordable option in Africa or the rest of the developing world. Videoconferencing via ISDN is also expensive. Economic analyses of the viability of telepathology projects in countries with low resources have been rarely done. Besides, most telepathology networks in these countries are funded by international professional organizations. This heavy reliance on foreign donors may not guarantee sustainability of these services. Obviously, for the execution of telepathology services it is necessary to obtain steady funding to cover project costs comprising the costs for equipment, maintenance, telecommunications charges and staff training, as well as the costs related to the operation and running of the project, acquiring the physical space, supplies and travel.

6.5 Shortage of personnel

Local healthcare workers should always take a lead in developing and operating the projects whereby often what the practitioner needs is a passing knowledge of communication protocols, modems, and software. But it is wrong to assume that every pathologist, technician or health worker in the developing world is computer literate or able to use the Internet. Training is also required for not only information technology but also handling of camera and computer. Additional training in ICT is therefore critical to success in the developing countries in addition to support to improve their technical and media skills, prior to their involvement in telepathology projects. Also, it is often difficult to find dedicated personnel to carry out telepathology or to staff a telemedicine department. Thus staffs are expected to perform multitasking, especially in a low-volume centre. Telepathology would benefit from initiatives to train African healthcare workers in the use of information technology, such as those set up by the Fogarty International Center of the US National Institutes of Health. The training should emphasize simple, low cost techniques, rather than expensive video conferencing approaches that struggle to achieve sustainability even in developed countries.

6.6 Poor technical quality of slides

The limiting step in telepathology is availability of a well-processed histology or cytology glass slide. This is dependent on the skill of the technician. Lack of trained manpower for

histopathology processing has a very negative effect on the subsequent quality of a telepathology consultation. In the developing world, other contributory factors for poor pathology product or suboptimal technical material include the lack of infrastructure, equipment and uniform standards.

6.7 Unresolved legal issues

Regulatory approval, in particular, would be an issue in many developing countries. Also, legal problems would be created. There are presently extensive discussions concerning the potential risks and complex legal problems associated with telemedicine health care services provided to patients from remote locations using telecommunication and this will impact on the practice of telepathology. Legal problems relate generally to problems concerning the privacy of identifiable health information, and the reliability and quality of health data, as well as medical liability. Since telemedicine in developing countries is mainly practised across state borders, providers must be aware of the potential risks concerning medical liability in the respective countries where the patients are located. There is a need for developing countries to adopt rules and regulations to address legal aspects involved in the use of telemedicine in order to safeguard the rights of patients. Matters that need to be considered include mainly safeguards about data forwarding, security of the patient's data (including images), confidentiality and the responsibilities of health workers involved.

7. Future developments

Majority of the people living in developing countries do not have access to modern diagnostic services due to a host of factors. So the impact of telepathology in diagnostic work, education or second opinions remains to be fully felt. In this respect, the growth of telepathology in the developing world had been rather slow for reasons which are beyond the control of healthcare providers. These include the low telephone penetration, inadequate and expensive national Internet bandwidth and lack of skilled manpower.

On a positive note, the number of institutions that have embraced telepathology in the developing countries is increasing, and there is already an attempt to integrate the technique into the healthcare system in some of these low resource nations. If this growth is sustained, then the practitioners would also have to grapple with the problems associated with managing rapidly growing telepathology networks in future. Hopefully, the net increase in the numbers should provide the impetus to standardize the practice of telepathology through technological solutions that are well adapted to the local environments. Until now, establishing telepathology services in the low income countries had been mainly hampered by the high implementation costs. The identification and implementation of proven low-cost technology approaches would therefore optimize telepathology services.

Virtual pathology holds a great promise but poor communications facilities and epileptic power supply are some of the greatest challenges to it. Future technical improvements may assist telepathology links, but simple technology like the store-and-forward e-mail system would probably continue to play a leading role. Notably some successful models in remote areas are based only on an email account with an Internet service provider and the local-rate telephone call charges. In future we could see more innovative use of web applications such as Skype or MSN or even mobile phones with built-in cameras in telepathology. This sort of telepathology networks in the developing world may not necessarily provide the quality of

service obtained in the industrialized countries now or in the foreseeable future. However, if used by healthcare workers trained to follow simple photographic and email procedures they can improve specialist access in remote areas.

A yet unharnessed benefit of telepathology is in clinical research. The technique could also be mutually advantageous to the extent that while local pathologists stand to benefit from the professional interactions, mentoring, education and access to improved research facilities while consulting experts also get special opportunities to review unusual or rare pathological entities. Apart from tele-consultation, what has proved to be especially effective in many low-resource nations is tele-education. Numerous examples of this can be cited, but valid concerns remain that if telepathology is used on a larger scale it may stifle the development of local resources and lead to a culture of dependence on Western expertise. However, if properly managed these rare educational opportunities may prove to be the catalyst for developing telepathology services in the developing world.

A still unresolved issue is the cost effectiveness of telepathology. In South Africa, apart from the common problems relating to the technical and organizational challenges of introducing telemedicine another area of concern was the relatively low usage of the telemedicine system, which raised questions about its cost-effectiveness (Gulube & Wynchank, 2001). Rough calculations suggested that only about 0.1% of the potential telemedicine demand from the developing world was being met (Wootton, 2008).

An important research question is how best to scale up telepathology projects for greater benefit to the people in low-resource countries? Further studies are needed especially to define the minimal technical and ethical implications of introducing telepathology in individual developing countries. Also more studies focusing on telepathology outcomes should be conducted to confirm its clinical benefits and cost-effectiveness. These would ensure acceptance, economic viability and effectiveness, as well as sustainability.

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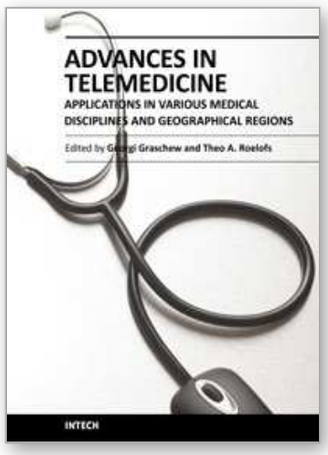

Advances in Telemedicine: Applications in Various Medical Disciplines and Geographical Regions

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Innovative developments in information and communication technologies (ICT) irrevocably change our lives and enable new possibilities for society. Telemedicine, which can be defined as novel ICT-enabled medical services that help to overcome classical barriers in space and time, definitely profits from this trend. Through Telemedicine patients can access medical expertise that may not be available at the patient's site. Telemedicine services can range from simply sending a fax message to a colleague to the use of broadband networks with multimodal video- and data streaming for second opinioning as well as medical telepresence. Telemedicine is more and more evolving into a multidisciplinary approach. This book project "Advances in Telemedicine" has been conceived to reflect this broad view and therefore has been split into two volumes, each covering specific themes: Volume 1: Technologies, Enabling Factors and Scenarios; Volume 2: Applications in Various Medical Disciplines and Geographical Regions. The current Volume 2 is structured into the following thematic sections: Cardiovascular Applications; Applications for Diabetes, Pregnancy and Prenatal Medicine; Further Selected Medical Applications; Regional Applications.

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