Telemedicine in Sub-Saharan Africa: A Proposed Delphi Study

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Abstract

By the end of 2001, an estimated 40 million people worldwide—2.7 million under age 15—were living with HIV/AIDS. More than 70 percent of these people (28.1 million) live in Sub-Saharan Africa. Another killer, malaria, is responsible for as many as half the deaths of African children under the age of five. The disease kills more than one million children each year—2,800 per day—in Africa alone. As such statistics demonstrate, the need for medical care in Sub-Saharan Africa is paramount. Sub-Saharan Africa has fewer than 10 doctors per 100,000 people, and 14 countries do not have a single radiologist. The specialists and services that are available are concentrated in cities. This study examines the state of adoption of telemedicine in Sub-Saharan Africa. We present several examples of successful adoption of telemedicine in the continent, provide several research implications, and propose a Delphi study to identify the critical success factors that would enable successful implementation of telemedicine in Sub-Saharan Africa. While we do not claim that telemedicine will solve all of Sub-Saharan Africa's medical problems, we do contend that it is a starting point to reach Africans that live in areas with limited medical facilities and personnel.

1. Introduction

While Africa's medical problems are fast increasing with killer diseases such as HIV/AIDS and malaria, medical personnel and facilities to address these problems are just too limited, just to say the least. One strategy to address this seemingly lack of medical infrastructure is through the introduction of Telemedicine within the continent.

Telemedicine has numerous definitions. Thomas Bird coined the phrase in the 1970s, referring to health care delivery where physicians examine distant patients using telecommunications technologies [1]. The European Commission's Healthcare Telematics Program defines telemedicine as the rapid access to shared and remote medical expertise by means of telecommunications and information technologies, no matter where the patient or relevant information is located [4]. Thus, telemedicine involves the practice of delivering health care over distance using telecommunications equipment as simple as telephones and fax machines or as complex as PCs and full-motion interactive multimedia [7]. The delivery of healthcare using telemedicine has been reported in previous research at an individual level [6] and at a national level of analysis [9, 18]. However, although telemedicine holds enormous promise in transforming the accessibility of health care, there are strong barriers against its ability to reach the far-flung citizens of the world.

1.1. The digital divide

The digital divide is a widely discussed phenomenon where those social groups that are rich in technology get richer with the rapid foray into the information age of the late twentieth century, while the technologically poor get poorer. Unlike in many classical economic arguments of income disparity, there is no claim in this case that the advances in information and communication technologies (ICTs) developed nations have been enjoying have fed off the labor or resources of developing nations. Conversely, there is no claim that developing nations are faring absolutely worse *because* developed nations are doing better. However, it is clear that developed nations with the resources to invest in and develop ICT infrastructure are reaping enormous benefits from the information age [2, 17], while developing nations are trailing along at a much slower pace [16]. This difference in rates of technological progress is widening the economic disparity between the socioeconomic regions that the development literature commonly refers to as the North (referring primarily to Canada, the United States, and Western Europe) and the South (primarily Latin America, Africa, and Southeast Asia), thus creating a digital (that is, digitally fostered) divide.

The Internet offers developing countries the provision of efficient communications within and among developing countries, so that citizens can effectively help each other to solve their own problems. Sources of widespread public information such as television broadcasting, telephone services, educational institutions and public libraries are taken for granted in developed countries. In developing countries, however, such infrastructure is seriously deficient, and this cripples citizens' ability to gather information and coordinate with each other to solve their problems. Through efficient information dissemination, the Internet promises a quantum-leap boost in internal communications in developing countries.

Development researchers have hailed the Internet as a "great equalizer" [see 23], a revolutionary technological tool that enables efficient transfer of information on a global scale. This global information can be used for international trade, online digital libraries, online education, telemedicine, e-government, and for many other applications that solve vital problems in the developing world. The fundamental commonality of this class of problems is that although the North has an abundance of many of the resources that the South could use to solve some of its problems, there are geographical, political and cultural barriers that make it difficult or impossible for these solutions to be transferred effectively. In this paper we focus on bridging the digital divide specifically by extending the benefits of telemedicine to Sub-Saharan Africa.

1.2. Telemedicine in Sub-Saharan Africa

Numerous studies documenting the spread of the Internet in various parts of the world have highlighted the fact that Sub-Saharan Africa (SSA)—part of the world's second largest continent—is the region with the lowest level of economic, technological, and Internet development in the world [15, 16]. The delivery of healthcare is unarguably one of the most fundamental needs for SSA, considering the region's medical nightmare of growing medical problems with an acute shortage of medical facilities and personnel. Both academic and practitioner literature report on the many medical problems of SSA. The World Health Organization reported that by the end of 2001, an estimated 40 million people worldwide—2.7 million of them younger than 15 years—were living with HIV/AIDS. More than 70 percent of these people (28.1 million) live in SSA; another 15 percent (6.1 million) live in South and Southeast Asia [26]. Furthermore, malaria kills more than a million children each year—2,800 per day—in Africa alone. This represents as many as half the deaths of African children under the age of five. In regions of intense transmission, 40% of toddlers may die of acute malaria, even though there would be a good chance of survival with timely medical attention. Other diseases that kill millions of Africans each year include dysentery, cholera, typhoid, yellow fever, and diarrhea; there are many others.

Another major problem faced by Sub-Saharan countries is the shortage of medical personnel. Many developing countries have an acute shortage of doctors, particularly specialists. SSA has fewer than 10 doctors per 100,000 people, and 14 countries do not have a single radiologist. The few specialists and services available are concentrated in cities. Rural health workers, who serve most of the population, are isolated from specialist support and up to date information by poor roads, scarce and expensive telephones, and a lack of library facilities [5].

Telemedicine overcomes the barriers of physical distribution of medical resources by bringing medical personnel and expertise virtually to those who need them in SSA. In a bid to find a solution to the growing medical problems of SSA, many governmental, non-governmental, and international developmental organizations have engaged in an endless effort to implement telemedicine. For example, during the period 1996-2000 the International Telecommunications Union organized several missions of telemedicine experts to selected African countries. These missions tried to identify Africa's needs and priorities for the introduction of telemedicine services taking into account the state-of-the-art of the local telecommunications networks and their evolution [9].

However, most of SSA's telecommunications networks are very poorly developed [12]. Another obstacle is that few African countries have experience in the application of telemedicine, even in urban areas equipped with telecommunications infrastructure. Furthermore, African countries cannot afford the very sophisticated telemedicine solutions involving ATM, virtual reality, etc. Notwithstanding these obstacles, among many others, telemedicine adoption is still important and feasible for most, if not all, Sub-Saharan countries (Table 1).

Given that telemedicine is important and feasible for SSA, this study first presents some cases of successful telemedicine projects in the region (Mbarika, *Forthcoming*). We focus on SSA because countries within the region share a different socio-economic structure compared to the richer northern and southern African countries. In the next major section, we present a Delphi study to identify critical success factors for telemedicine implementation in Sub-Saharan Africa. We conclude with a discussion of further research.

1.2.1. Importance of telemedicine adoption in Sub-Saharan Africa

- There is an overwhelming need for the provision of medical and health care services, especially in areas outside the cities;
- Telemedicine links between hospitals and other medical institutions could bring overall improvement of health-care services by centralization and coordination of resources (specialists, hardware and software packages).
- The modernization of internal communication in the hospitals could considerably improve the efficiency of health-care delivery. It will be the basis for the introduction of telemedicine services.
- The maternity units in any region could be connected by a telemedicine link to the maternity service in a large regional hospital or to the referral hospital. This will allow remote monitoring of the health of pregnant women, especially those with pathological problems [9].
- Tourists would be encouraged to visit the country and visit remote areas if there is a facility for telemedicine. From all medical emergencies, good and qualified medical attention may be provided with the backup of telemedicine service.

1.2.2. Feasibility of telemedicine adoption in Sub-Saharan Africa

- There is substantial experience and expertise with regard to telemedicine in developed countries such as those in Europe, Canada, the United States and Japan;
- The provision of health care already consumes a large portion of national budgets;
- The Internet is making inroads into Africa: whereas in the mid-90s only about 12 countries in Africa had Internet access, it is now available, at least in the capital city, of all 54 African countries.
- Some global satellite networks such as those provided by HealthNet, Inmarsat and Intelsat have already been used for the delivery of telemedicine services to remote and rural areas;
- Most African countries are members of global satellite organizations and of RASCOM, and have in place earth stations, which could be used for such delivery. Past research shows that such African-Foreign alliances can provide the opportunity for African countries to improve on their telecommunications infrastructure such as those needed for the adoption of telemedicine [13].
- Email has many benefits for poor countries: it is cheap; hardware and software requirements are simple; and the information does not have to be transmitted in real time.
- The deployment of fixed or mobile telecenters, which are now considered a good solution to bring telemedicine services to rural areas, could be useful to telemedicine as well [9].

2. Telemedicine projects in Sub-Saharan Africa

2.1. Mozambique

Mozambique has 17 million inhabitants, covers an area of 801,590 sq km, and has a per capita GDP of about US$200—one of the lowest in the world. Fertility rates are high at 5.20 births per woman, but male mortality is 408 per 1,000 and female mortality is 364 per 1,000. Life expectancy at birth is 45 yrs. With such statistics, there is dire need for improved medical care.

In 1998, the Telecommunications Development Bureau (BDT) of the International Telecommunications Union launched its first telemedicine project in Africa [8]. Between the central hospitals of Beira and Maputo in Mozambique, a telemedicine link based on existing terrestrial and satellite telecommunications systems, was set up by a multidisciplinary group of partners that included Telecommunications of Mozambique (the country's main telecommunications operator) and WDS Technologies, a telemedicine equipment vendor from Geneva. Figure 1 illustrates the interconnection of main hospitals within Mozambique.

The project uses standard low-cost tele-radiology equipment, based on two PCs equipped with a radiological film digitizer (CobraScan CX-612T) and appropriate software and telecommunications interfaces. The system conforms to the guidelines stipulated by the American College of Radiology concerning image quality. Radiological images are digitized in less than 30 seconds, to up to 4,096 gray-levels at 300 pixels per inch. Images are compressed automatically without any loss of information, at a factor ranging from 5.5 to three. A special tool permits erasure of all names on the image in order to guarantee partial or full anonymity. Appropriate demographic or other kinds of information can be added to the image, which is then transmitted via dial-up telephone lines using a modem (up to 56 kbps). The link between Maputo and Beira uses digital microwave transmission (Figure 2).

The tele-radiology software, designed by WDS Technologies (Switzerland) and tested at the University Hospital of Geneva, provides support for the exchange of images. The user interface is the state-of-art but nevertheless remains simple and can be used by any technician or doctor familiar with Windows operating systems after a short training [25].

The project enables the central hospitals of Beira and Maputo to rely on standard low-cost tele-radiology equipment for the transmission and exchange of images and radiographs as well as their visualization. The system also permits transfer of laboratory results and facilitates verbal and written communication between physicians of both medical facilities (Figure 2).

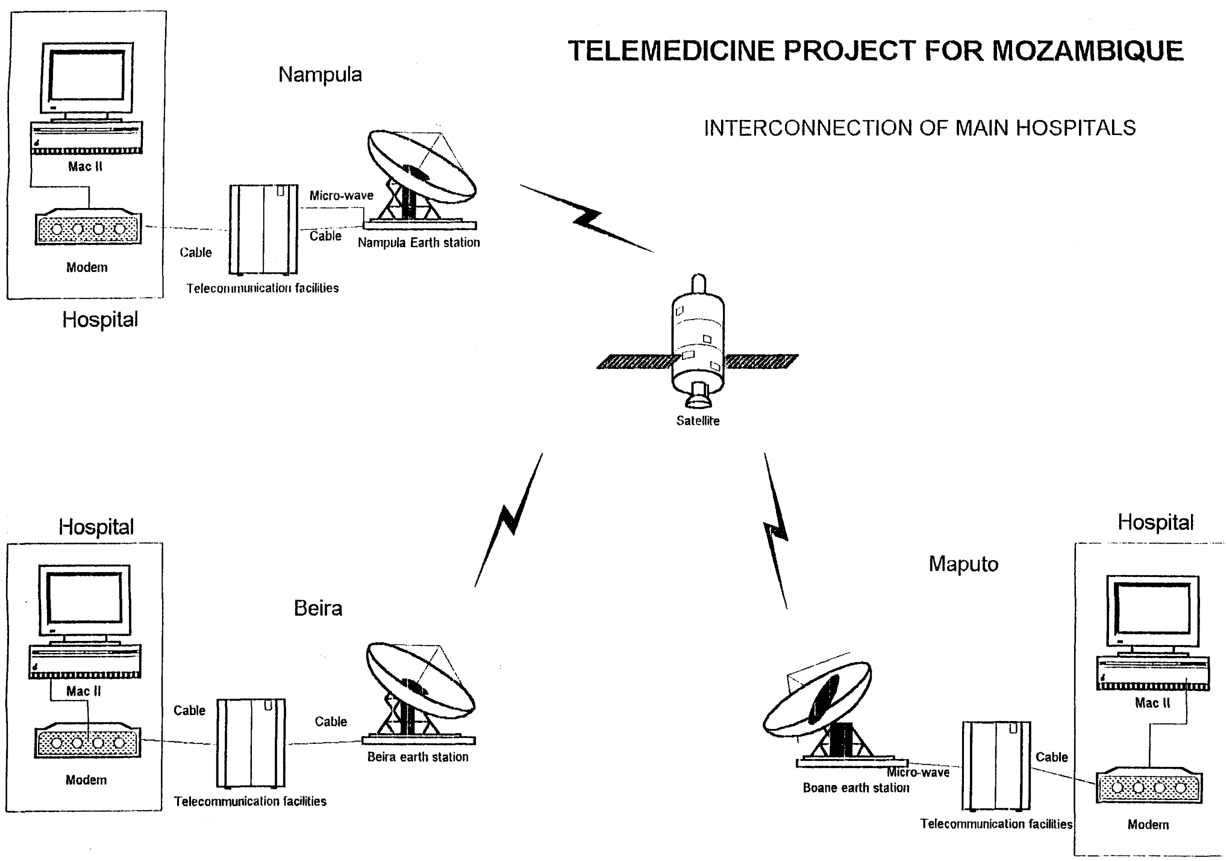
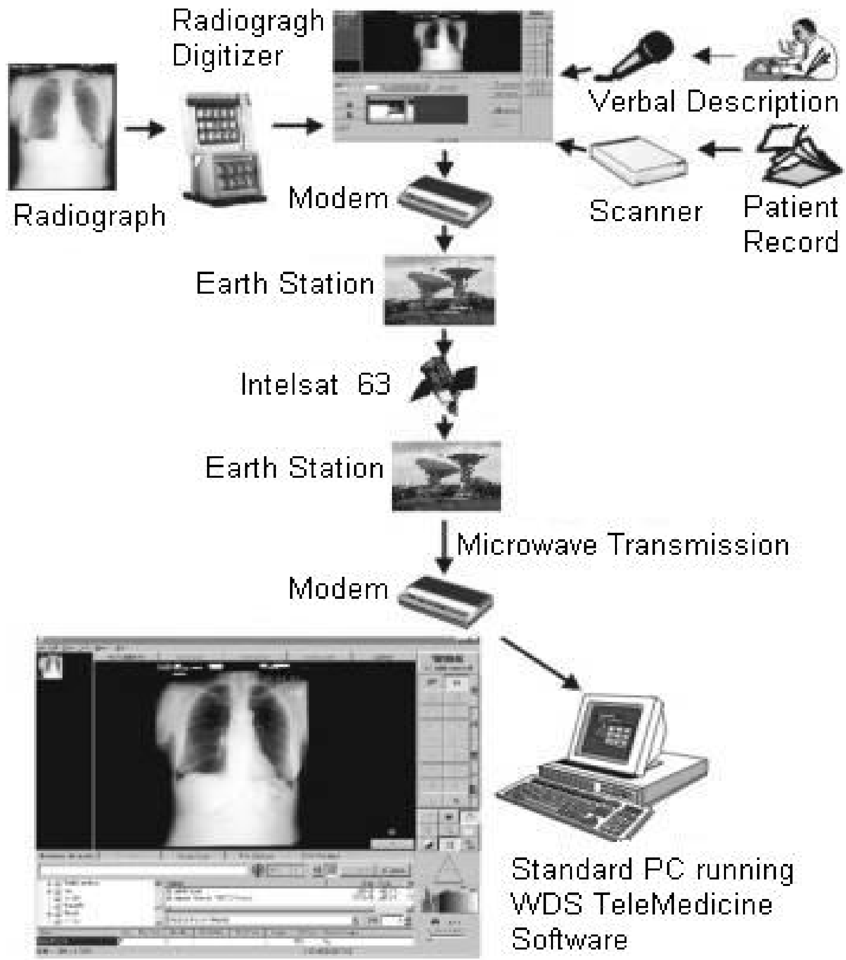


Figure 1. Mozambique telemedicine project layout [8, 25]

Figure 2: Tele-radiology in Mozambique [25]



Doctors at the Beira hospital are invited to ask the Maputo medical staff for a primary or second opinion in certain cases. The patient's medical record first can be sent down to Maputo in order to decide where further treatment should take place. Thus, both the patient and the hospital are able to avoid superfluous costs and inconveniences. This project is a concrete example of the benefits of collaboration between developed and developing countries. It provides an excellent example of the benefits of close cooperation between telecommunications operators and health care professionals.

2.2. Senegal

Senegal is a West African country of 10.3 million people, covering 196,190 sq km, and with per capita GDP of about US$ 1,600. From 1979 to 1992, the maternal mortality rate was estimated to have been 510 deaths per 100 000. With a low telephone usage of 13.2 users per thousand, SONATEL—the main telecommunications operator in Senegal—initiated Senegal's telemedicine project [3]. SONATEL also provided financial support for the project, which was implemented at various hospitals and health units in Senegal.

The Lille Regional University Hospital and the European Institute of telemedicine in Toulouse partnered with health institutions in Senegal. This project uses videoconferencing to conduct tele-consultations between health professionals. In-service distance training for health professionals is one of the key components. Training occurs in remote health centers through videoconference systems customized for medical use.

As a result of this project, three hospitals in three different cities (Dakar Fann, St. Louis, and Djourbel) are connected by telemedicine links, which allows transmission of medical images and other medical information [8]. The “Store and Forward” method for transmission of patient data is used to reduce costs and was implemented in phases, according to the availability of financial resources. The present condition of the telecommunications network in Senegal allows all three hospitals to connect by ISDN lines.

2.3. HEALTHNET: Multiple Sub-Saharan African Countries

Having been implemented in 20 countries throughout Africa, HEALTHNET is the most developed Africa-wide initiative, which aims at improving the practice of telemedicine among health professionals. HealthNet is SATELLIFE's computer-based telecommunications system that links health care professionals around the world [20]. SATELLIFE is a charitable organization based in Boston, USA. Using a low earth orbit satellite and phone lines, it provides email access in Sub-Saharan countries, serving over 10,000 healthcare workers. Where adequate telecommunications links exist, SATELLIFE and other organizations provide higher capacity email and Internet connections, which allow sending email attachments such as image files, permitting a form of low cost telemedicine.

In these email attachments, the patient's findings are described, and digital photographs of the patient and their investigations, such as electrocardiograms and x-ray films, are attached. This "store and forward" telemedicine does not allow real time interaction, but it permits specialist support in the management of difficult cases and is cost efficient. Modern digital cameras are small, robust, easy to use, and cheap (US$300-800). They can create high-resolution images (1900×1400 pixels or better) that are adequate for dermatology. With modifications, this technique can be effective for pathology and ultrasound.

There have been many telemedicine projects in Sub-Saharan Africa, both past and current. Some of these projects have been in place since the mid-1980s [5]:

- *Physician Collaborations:* Burn surgeons in Mozambique, Tanzania and Uganda have used HealthNet to consult with one another on patient treatment and reconstructive surgery techniques.
- *Data Collection:* In the Gambia, health workers who once had to travel 700 kilometers per week to collect data for a clinical trial employed HealthNet to send this information via electronic mail.
- *Health Care Delivery:* Physicians in Ethiopia use HealthNet to schedule consultations and referrals, making it unnecessary for ill patients to travel long distances with no guarantee of seeing a physician.
- *Medical Alerts:* Health care workers in Zaire's Vanga Hospital use HealthNet to send regular dispatches to report on progress in treating trypanosomiasis to health organizations in the North.
- *Access to Medical Libraries:* In response to a cholera epidemic in Zambia, the medical librarian at the University obtained literature from her “partner library” at the University of Florida, and then disseminated the information to all HealthNet users in the region.
- *Research:* Malaria researchers at a remote site in northern Ghana used HealthNet to communicate daily with the London School of Hygiene and Tropical Medicine and the Tropical Disease Research Center in Geneva.

2.4. Project SHARE (East Africa): Uganda and Kenya

The International Satellite Organization and the International Institute of Communications established the Satellites in Health and Rural Education (SHARE) project in the mid-1980s [14]. A satellite network was established that allowed for interactive video conferencing between medical facilities in St. John's (Canada) and medical facilities in two East African cities, Kampala (Uganda) and Nairobi (Kenya). The short-term objectives of Project SHARE were to establish an audio-conference link between St. John’s, Kampala, and Nairobi, and to enhance medical education and patient care at the Makerere Medical School in Kampala. The long-term goal was to teach the Ugandans and Kenyans how to maintain multipoint audio-conferencing technology and design distance education programs.

In December 1985, a satellite link was established with Nairobi, and in February 1986 with Kampala. The system was used for several months for pediatric teaching sessions, administrative meetings, transmission of electroencephalography (EEGs), and a variety of other applications. Pediatricians in St. John’s were responsible for the majority of the educational programs, with additional programs hosted by health centers in Ontario and Quebec. In total, more than 400 hours of programming was conducted, and approximately 100 tele-EEGs were transmitted over the satellite, from Nairobi for two months and from Kampala for ten months. EEG specialists in St. John’s accurately interpreted the majority of the tracings. This presents another great example of telemedicine adoption through close collaboration between developed countries, such as Canada and developing countries, such as Kenya and Uganda.

3. Proposal for Delphi investigation

To identify critical success factors for implementing telemedicine in Sub-Saharan Africa, we need to follow a three-step strategy. First, we need to identify factors needed for the establishment of viable telemedicine in Sub-Saharan Africa, and identify what forms of telemedicine practices are the most beneficial in a reasonable amount of time. The second step involves testing such factors using quasi-experimental design that would verify if they are indeed pertinent. This step would be more objective, and would give us more confidence and solid directions for the third step: Offering prescriptive directions for health care professionals and government policy makers who want to implement telemedicine in SSA.

In this research proposal, we are concerned with the first step of our strategy; that is, identifying pertinent factors. So far, we have examined published reports of successful projects to identify several factors that are important in implementing telemedicine in SSA. However, this is a limited source for identifying the most important factors. To obtain a more rounded view, it is necessary to obtain perspectives from the four major stakeholders in telemedicine: healthcare workers, government officials, non-governmental organizations (NGOs), and academicians [11, 24].

Rather than merely conducting a simple survey to find out what people think on the matter, we believe the best way to investigate this question will be to rigorously query the relevant experts and stakeholders [24]. An appropriate methodology for such a query is a Delphi study, an iterative procedure for obtaining subjective information from experts. Schmidt [21] has outlined a rigorous procedure for conducting ranking-type Delphi studies, which serve the dual purposes of soliciting opinions from experts and having them rank these opinions according to their importance. Other than a couple of sample applications that Schmidt gave in his original presentation, he has also used the methodology to rank software project risk factors that experts in three different countries identified [22]. Other studies that focused on assessing technology diffusion in developing countries have also used a ranking methodology [11, 19]. This methodology matches what we need to further investigate telemedicine in SSA.

Schmidt's [21] methodology involves three general steps: brainstorming for important factors; narrowing down the original list to the most important ones; and ranking the list of important factors. In the following sections, we will propose a Delphi study following this methodology that we plan to use to solicit the important factors affecting the effective implementation of telemedicine in SSA.

3.1. Choice of experts

For this study, the experts will be divided into panels. We will use four panels, divided along the lines of the experts' primary affiliation with the following four groups: practitioner, government official, non-governmental organization, and academician. We aim to have 10 to 30 experts on each panel [see 22] selected from within and outside SSA.

3.2. Phase 1: Brainstorming

We will begin the study by presenting them with the factors that we have identified from our investigation of the literature. This will provide a seedbed from which the experts can begin. Each expert will be sent an e-mail survey with the factors listed, and they will be asked to select with factors are important for telemedicine diffusion in SSA. They will be free to add and delete factors from our list as they see fit. In fact, we hope that the experts will add many factors that we have not identified from our search, reflecting their own approaches to the problem.

Next, we will collect the expert's responses, and eliminate the exact duplicates to yield a non-redundant list of factors affecting telemedicine diffusion in SSA. Following the procedure outlined by Schmidt [21], we will combine and group the remaining factors. Before proceeding to the next phase, we will return this list of grouped factors to the panelists for validation.

3.3. Phase 2: Narrowing down

In this phase, we will present the complete consolidated list of items to each expert; this will be the first time they will see those items that other experts have added. In the first phase, we will have treat the experts individually, having asked each expert to present a list and incorporating all the responses of every individual. In the other two phases, we treat the experts as panels: although they will respond to our queries independently, we will only retain items that are retained by the panel, not by individuals. Thus, the result of this second phase will be a pared-down list, one list for each of the four panels.

First, each panelist will be asked to select the most important diffusion factors. Those factors selected by a simple majority (51%) of the experts will be retained for that panel. This process will reduce the lists to manageable sizes. In Schmidt et al's [22] Delphi study, this process reduced the original list to 28% to 43% of its original size in each panel. For example, out of an original list of 54 items, only 15 items were selected by half the items, reducing the list to 28% of the original size.

3.4. Phase 3: Ranking

The final phase of the procedure involves each panel individually ranking the factors that are left on their lists. Each ranked list will reflect the priority order for the specific panel. In this phase, each expert individually submits a rank ordering of the items in his or her panel. From these submissions, we will calculate a mean rank for each factor. The rest of this phase involves modifying the rankings until an acceptable degree of consensus is reached within each panel.

Schmidt [21, 22] used Kendall's W [10] as the measure of consensus; we will use this or some other appropriate nonparametric statistic. If the consensus is below our threshold, we will return the results within each panel to the experts, and ask them to re-rank their items, in light of the feedback from other experts in their panel. We will repeat this process either until the panelists reach a satisfactory degree of consensus, or the value of Kendall's W does not change significantly for successive re-rankings. In that case, we will use the mean rankings to select the final ranking for the panel that failed to reach consensus.

3.5. Value of Delphi survey

From the results of the Delphi survey, we will obtain a more reliable list of factors, ranked in the order of their importance. These results will help us answer our first two research questions: identify the factors needed for the establishment of viable telemedicine in SSA; and identify what forms of telemedicine practice are the most beneficial in a reasonable amount of time. With these factors identified, we would be able to investigate possible best practices for telemedicine implementation in Sub-Saharan Africa.

4. Conclusion and further research

Generally, Africa has been portrayed as a troubled continent with no hope for resurrection from its many grueling socio-economic problems. Its medical nightmare has particularly seemed to be an unstoppable plague.

Our study builds upon previous research reports that examined Telemedicine cases in the sub-Saharan Africa region (Mbarika, *Forthcoming*). The reports show that steps are being taken to combat the many medical problems of the continent through the adoption of telemedicine. However, our Delphi study proposal presents an attempt to rigorously identify the critical success factors that would enable successful implementation of telemedicine in Sub-Saharan Africa.

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