Telemedicine in sub-Saharan Africa: The case of teleophthalmology and eye care in Ethiopia

Article *in* Journal of the American Society for Information Science and Technology · August 2006

DOI: 10.1002/asi.20448 · Source: DBLP

Telemedicine in Sub-Saharan Africa: The Case of Teleophthalmology and Eye Care in Ethiopia

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The authors examine the need and adoption of teleophthalmology in sub-Saharan Africa. Ethiopia, like most sub-Saharan African countries, is faced with limited specialists and health care services. These services are often concentrated in the urban areas, leaving most of the rural population (about 70% of the country) without adequate and timely health care delivery. In Ethiopia, the ratio of ophthalmologists to the population is 1:1,200,000, resulting in inadequate delivery of ophthalmology-related health care services. Using both primary and secondary data collection approaches, the authors report the need for telemedicine as well as the adoption and application of teleophthalmology in Ethiopia. Further, they present Ethiopia's teleophthalmology network, integrated teleconsultation, and teleeducation services. The authors conclude by presenting this research as a starting point to investigate further teleophthalmology and other telemedicine services for Ethiopia and by extension, other developing countries. Therefore, they bring a much-underresearched region (sub-Saharan Africa) and a much-underresearched technology (telemedicine) to the forefront of information systems (IS) research. It is the authors' hope that colleagues in the field will be motivated to investigate this "forgotten" region of the world that is yet to reap the full potentials of information and communications technologies (ICTs).

Introduction

With the advent of telemedicine, developing countries are learning newer ways of leveraging their information and communication technologies (ICTs) to play an increasingly vital role in the health care industry. Telemedicine is defined as a health care delivery mechanism where physicians and other medical personnel can examine patients remotely using information and telecommunication technologies (ICTs; Bashshur, Sanders, & Shannon, 1997). Because of its ability to allow medical personnel working in remote areas to transfer seamlessly medical laboratory results and patient data to hospitals and clinics for diagnostics and advice, telemedicine has the potential to decrease health care costs while increasing access, capacity, and quality of health care in sub-Saharan Africa (SSA; Council on Competitiveness, 1994; U.S. Department of Commerce, 1997).

Although SSA is afflicted by acute health care concerns (e.g. HIV, meningitis, malaria, malnutrition, cataract blindness), there remains an acute shortage of medical specialists and medical facilities in the region. Sub-Saharan Africa has, on average, fewer than 10 doctors per 100,000 people; 14 SSA countries do not even have a single radiologist (Fraser, McGrath, & St. John, 2000). The specialists and services that are available are concentrated mostly in cities. In most of SSA, current health care needs are hardly met due to inadequate capacity and competence, compounded by the limited number of health care specialists who are often concentrated in the urban areas. The case is even more severe in the area of eye care. In a study by the World Health Organization (WHO, 1995), SSA accounts for 5–6 million blind and 16–18 million visually impaired people. Among them, 200,000 are children under 15 years of age, who generally die within 2 years of becoming blind. In this report, WHO's Regional Director for Africa, Dr. Samba bemoans "Everywhere, blind people live difficult lives. But in Africa, where social support services are non-existent, blindness and

Received June 29, 2004; revised April 7, 2005; accepted August 26, 2005

 ● Published online 9 June 2006 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/asi.20448

extremely low vision, first and foremost, spell humiliation. Begging becomes the only way for those affected to survive." What makes this scenario grave is that timely consultations and health education could have prevented 80% of these incidents (Agraw & Samson, 2001; Bjorn, 1998; Tilkesew, 2002; Yoseph & Samson, 2002). Given this scenario, teleophthalmology, a variation of telemedicine aimed at remote eye care delivery, can provide an immediate solution to the current health care crisis by allowing SSA to virtually network with medical communities and specialists around the world, unimpeded by geographical or temporal barriers.

In this article, we examine the case of teleophthalmology in reducing incidences of blindness in Ethiopia, a sub-Saharan African country, with a history of strong alienation towards Western technologies, where the emergence of telephony was frequently considered by local inhabitants as "the work of the devil." However, Ethiopia has changed its outlook towards ICTS and embraced Ethio-Stream, a digital data network spanning the country using frame relay and an integrated services digital network (ISDN), to link itself virtually to the rest of the world (Samuel, 2001). In addition, cellular telephony is quickly gaining popularity, linking communities and providing access, independent of landlines. The classical view of physical co-presence is suddenly being challenged by virtual co-presence. People in remote, strife-ridden, disaster-struck, or inaccessible locations can use such technologies in telemedicine facilities to connect them to specialists located beyond geographical and political borders.

In this study, we use case studies to identify the factors aggravating the problem of blindness and present teleophthalmology as an ongoing viable response for Ethiopia's acute shortage of ophthalmologists. To aid our argument, we present the teleophthalmology process model along with an infrastructure and support model. We then examine the comparative benefits of teleophthalmology in terms of economic and socioeconomic benefits. We present infrastructure, process, and outcomes in a comprehensive framework. Finally, we address the prospects and constraints faced by Ethiopia (and by extension, SSA) in implementing such a solution.

The Case of Teleophthalmology in Ethiopia

Ethiopia is located in Eastern Africa, and is known as "The Horn of Africa" with a population of 65 million—marked by high illiteracy (32.8%) and low life expectancy (49.7 years for men and 52.4 years for women; WHO, 2003). Ethiopia's total health care expenditure is inadequate—at roughly 5.2% of its gross domestic product (GDP; Ethiopia Ministry of Health [MOH], 2003). Funding for eye care is marginal. Ethiopia has one of the highest blindness prevalence rates (Alemayehu, Tekle-Hamanot, Forsgren & Erkstedt, 1995; Budden, 1981).

As mentioned earlier, the need for specialized eye care remains a priority in SSA. According to the World Health Organization, the major causes of blindness in Ethiopia, as in the rest of SSA, are cataracts, trachoma, onchocerciasis (river blindness), and childhood blindness. Measles, vitamin A deficiencies, and traditional medicines contribute to the problem. Ethiopia is home to a unique eye disease called *river blindness*, an infection spread by Blackfly larvae leading to cataract like-symptoms and blindness. In addition, insufficient preventative health care and hygiene has been a leading cause of trachoma, a conjunctivitis-like scarring of the cornea followed by blindness. For all of these diseases and symptoms, remedial measures are generally through antibiotics and basic health care and hygiene. Early diagnosis, in each case, has the ability to reduce incidences in the future dramatically. To worsen the matter, the ratio of ophthalmologists to the population is 1:1.2 million (Ethiopia MOH, 2002), necessitating remote health care delivery. With so much at stake and so few to serve, teleophthalmology becomes a pragmatic choice for countries like Ethiopia.

Although there exists only a few teleophthalmology projects in SSA, most implementations have delivered positive outcomes. In South Africa, the University of Transkai Medical University's teleophthalmology projects have shown that the cost of sending a case (approximately 1 megabyte of data) via the Internet is $0.5 US, whereas the cost of an interactive session between the same institutions over the telephone may reach $10 US. These costs are also much lower compared to using fast surface mail (Gilbert & Foster, 2001) and continue to decrease with the advent of cheaper storage, faster processors, and better bandwidth (Della, 1999). Further, widespread availability of computers and the Internet offer a prolific ground for practicing telemedicine (Spielberg, 1998).

Research Method and Data Sources

To investigate the adoption and use of teleophthalmology in the context of Ethiopia, we use a multimethod case study approach involving a variety of research techniques and methods including: primary data from site visits, secondary data, and reviews of pertinent literature. According to Yin (1995), a case study method is advisable when investigating a contemporary set of events over which the investigator has little or no control. Case studies are in-depth studies of a few instances of the phenomenon of interest geared toward providing descriptions that permit an understanding and explanation of emerging phenomenon (Benbasat, Goldstein, & Mead, 1987; Miles & Huberman, 1994; Yin, 1995). Multiple case studies provide us with a deeper understanding of the need, adoption, and application of telemedicine in SSA, as well as valid conclusions that permit generalization. Therefore, we used complementary data-gathering techniques to capture the depth of issues fully with the appropriate quantitative and qualitative research techniques (Brewer & Hunter, 1998). We selected and utilized one or more methods based on satisfying the information needs of both health care providers and other stakeholders.

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Data Collection

Two-week site visits were conducted at several agencies in Ethiopia to observe the adoption and practice of teleophthalmology. The following agencies were selected for site visits: Addis Ababa University Faculty of Medicine, Ethiopia Ministry of Health, Ethiopian Telecommunication Cooperation, Minilik II Teaching Hospital, ALERT Nurse Training Center, ORBIS Ethiopia, International Telecommunications Union (ITU) Regional Office for Africa, WHO Office for African Union and United Nations Economic Commission for Africa (UN-ECA) Bethzatha Higher Clinic, Ethiopian National Telemedicine Committee, and the Ethiopian Ophthalmology Society. These organizations were identified and selected based on their direct relation with the implementation of, and according to their relevance to and experience in eye care services in Ethiopia. Data was collected through guided interviews with personnel from different branches of the organizations. The site visits provided a detailed understanding of stakeholder influences and involvement regarding teleophthalmology implementation. We selected institutions from each of the following targeted populations: public sector, private sector, and nongovernmental organizations. Thirteen selected staff members from 12 organizations were interviewed during site visits (Appendixes A and B). However, responses to this study were voluntary and subject to self-selection biases. The site visits enabled us to examine policy, management, technology, and the human aspects of implementing teleophthalmology at the national level.

The subjects were asked the following open question: What factors do you think contribute to successful adoption and practice of teleophthalmology within the health care sector? We prompted the subjects to elaborate on social, economic, and technological issues. In general, subjects were enthusiastic about potential benefits such as operational efficiency, equality of access to medical specialists, less waiting time, reduction of patient travel, reduction in the number of referrals to specialists, improved follow-up, and continued treatment.

Moreover, we obtained records of ophthalmology patients over a one-year period (June 2001–July 2002) from patient registration books of medical wards at the Minilik II—the only referral and Teaching Hospital in Ethiopia. Because of the paucity of ophthalmic facilities in Ethiopia, one option open to patients is to travel abroad to seek treatment. To guarantee the internal validity of the comparative analysis, patients referred to travel abroad for treatments were the only ones whose records were analyzed in detail. One-hundred twenty-one ophthalmic cases referred abroad were identified from patient registration books. Name, initials, age, sex, diagnosis, reason for referral, remarks, and date were recorded on a standardized form.

An Overview of the Teleophthalmology Infrastructure in Ethiopia

In telemedicine some low-cost solutions using simple technology have been developed. As Fraser et al. (2000) maintained that to achieve a sustainable telemedicine activity in developing countries, we should emphasize low-cost techniques, rather than expensive video-conferencing approaches. In our approach, the Ethiopian teleophthalmology activities are designed to be based on simple, low-cost technology: a personal computer (PC), medical equipment, and an Internet-based communication network. Software requirements are application level with capabilities ranging from image acquisition and analysis to the collection, storage, and transmission of images over existing communications network. The system would allow providers to capture, add text, and send still images from one site to another via e-mail.

Proposing a Workflow

The teleophthalmology process is aimed at linking peripheral diagnostic ophthalmologic devices with existing ICT infrastructure to create virtual connections with a network of specialists. With teleophthalmology, a trained technician digitally records and transmits records and images of the patient's ophthalmologic problems to a specialist via a computer network, usually a virtual private network (VPN) over the Internet (Coiera, 2000).

Based on this template, we outline the teleophthalmology system in Ethiopia. Medical experts at regional hospitals and nursing and medical schools would use the system for consultations with/second opinions from other experts. In addition, this teleophthalmology system would be used in the education of physicians, and to add to the experience of local health care providers.

Patient data (digital ophthalmic images) in rural areas would be obtained using technicians in health care centers who could acquire patient data (image, medical history, and diagnosis) and transfer it via e-mail over the Internet to specialists at the Minilik II hospital (Yogesan, Constable, Morgan, & Soebadi, 2000). An ophthalmologist at the referral hospital (Ophthalmology Unit at the Minilik II Hospital) could then download the images with medical data. During these transfer procedures, teleophthalmology devices and applications would maintain interoperablity by complying with international standards such as digital imaging communication in medicine (DICOM; http://dicom.nema.org/). In addition, because the use of teleophthalmology involves the use of multiple sets of images and data, care would be taken to reduce operational problems such as excessive bandwidth consumption and network downtime.

Upon receipt, an ophthalmologist at the referral hospital (Minilik II Hospital) would inspect the downloaded digital images, evaluate them, and provide immediate advice, or recommend a second opinion. By using digital connections, teleophthalmology allows for the creation of a virtual practice network to provide comprehensive eye care. Excessive costs are avoided while specialists have the advantage of virtual mobility (Zahlmann, Walther, & Liesenfeld, 1998). Patients that were traditionally recommended to return for follow-up procedures could then visit the nearest telecenter rather than

DOI: 10.1002/asi

travel to Addis Ababa, the capital. This in itself would be of tremendous help to rural dwellers who will no longer have to sell their personal resources such as jewelry and cattle to pay for such trips. In addition, this system makes communication more convenient. The workflow schematics are shown in Figures 1a–c and 2 and are outlined in Table 1.

Proposing a Teleophthalmology Infrastructure

Teleophthalmology applications include participants at both clinical and educational facilities. Telecenters would use a basic dial-up Internet connection to transmit e-mail files using store-and-forward technology. Similar projects have been implemented all over the world: teleophthalmology projects by the University of Arizona (Schiffman, Li, & Tang, 1998) and University of Oklahoma (Shanti, Lifshitz, Giladi, & Peterburg, 1998); OPHTEL, an e-mail-based store- and-forward systems for collaborative ophthalmology (Schiffman & Tang, 2000), and other store-and-forward systems developed by OphthWeb, which require 28.8 kilobytes per second transmission frequency, are emerging as effective interfaces for teleophthalmology and are being successfully integrated into routine clinical practice (Chew, Cheng, & Lam, 1998). In the case of Ethiopia, the project will use basic technologies and will be realized in two steps. In the first step, teleophthalmology will be implemented in

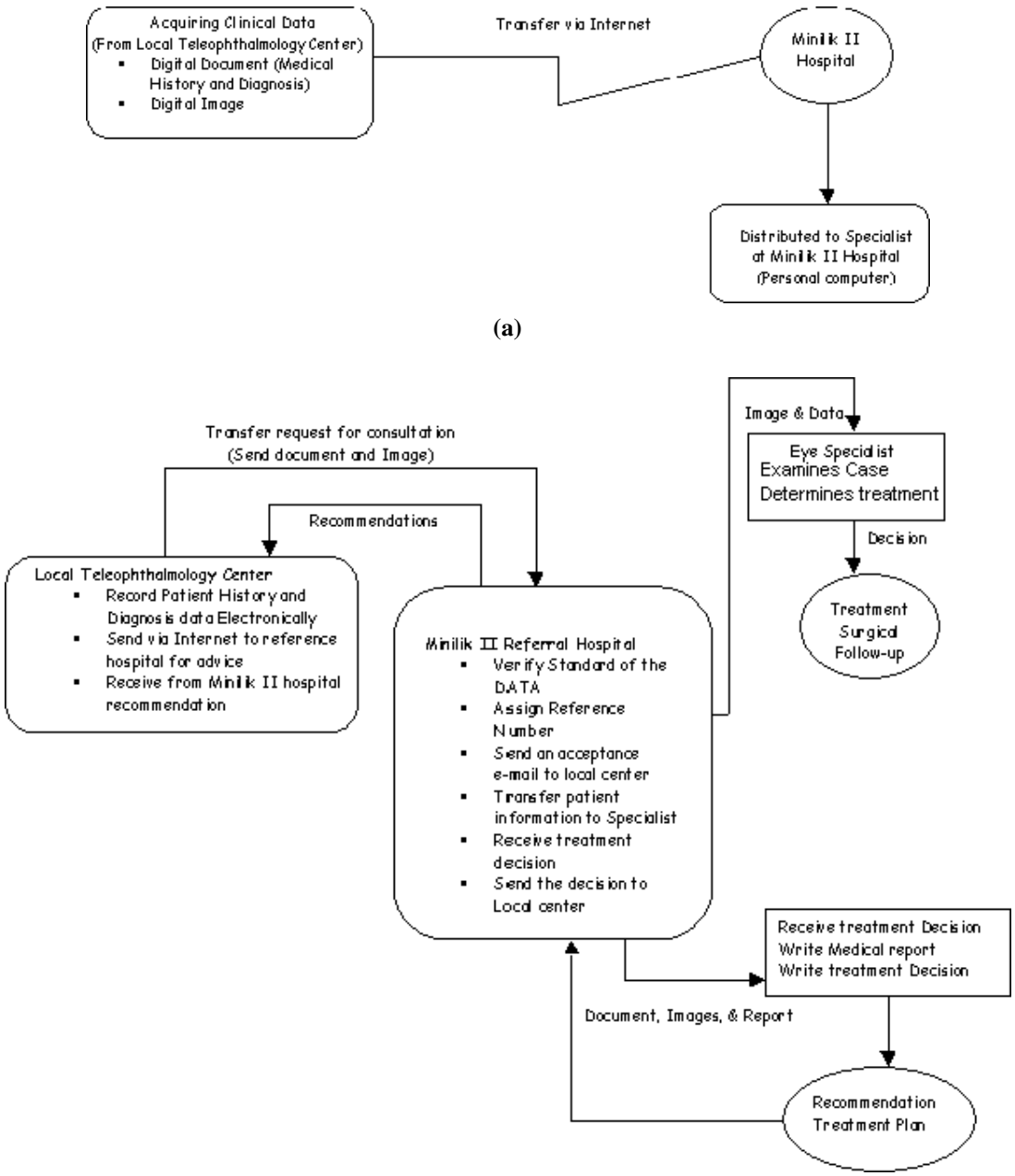

FIG. 1. (a) Data flow. (b) Procedures for consultation. (c) Organization and human resources.

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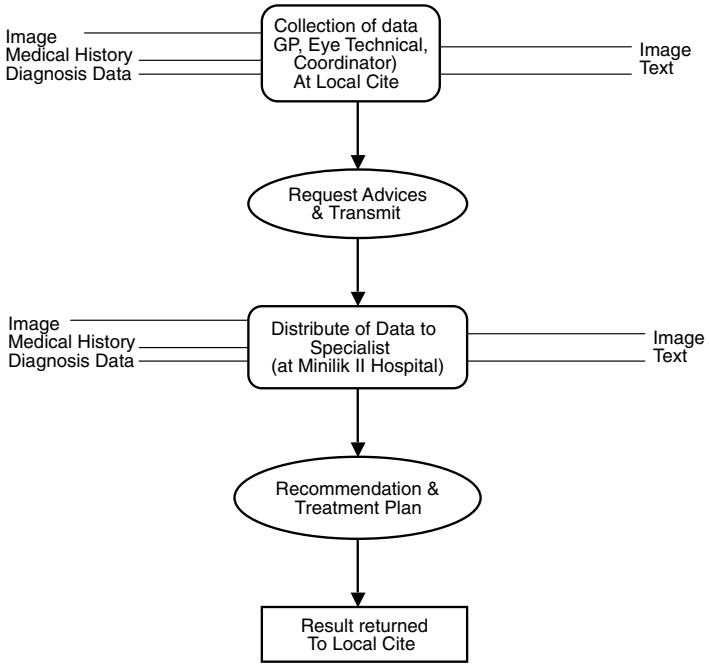

(c)

FIG. 1. (*Continued*)

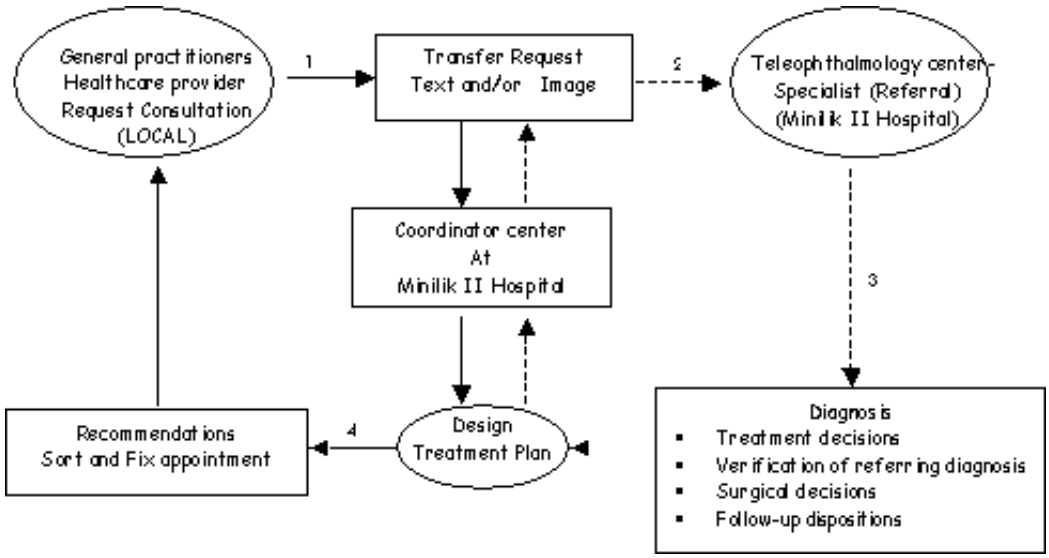

FIG. 2. Workflow.

Minilik II Hospital Centers for consultation, treatment, and education. In the second step, all health care centers would be integrated via a network with the central ophthalmology departments.

In our approach, e-mails can be used as a store-and-forward technology to exchange cases (text and images). Images would be acquired using the standard software and sent via e-mail client applications. Readily available commercial or freeware software systems, such as i-path (2003), TeleMed-Mail (2001), OpenEmed (2003), permit the integration of acquisition, compression, and delivery procedures.

Figure 3 shows the proposed teleophthalmology infrastructure for Ethiopia, which will use the existing network connector universities, regional hospitals, and nursing training centers:

1. Regional Hospital Telecenter Center (HTC), which includes Diredewa, Nazret, and Menilik II hospital
2. University Telecenter Center (UTC), which includes Addis Ababa, Gonder, Jimma, Dilla, and Alemayea Universities
3. Training and Care Telecenter Center (TCC), which includes Tigraye and ALERT
4. Coordination and Technology Telecenter Center (CTC)

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TABLE 1. Elements involved in workflow tip.

Data	Medical history Diagnosis data Image Note (Recommendation)
Procedures	Local to eye specialist Eye specialist to local Local to patient
Human resources	Coordinators /IT experts Eye specialists GPs or Eye technician/Eye nurses)
Organization	Sender site (local and regional hospitals) Receiver site (Reference hospital)

Note. IT = information technology; GPs = general practitioners.

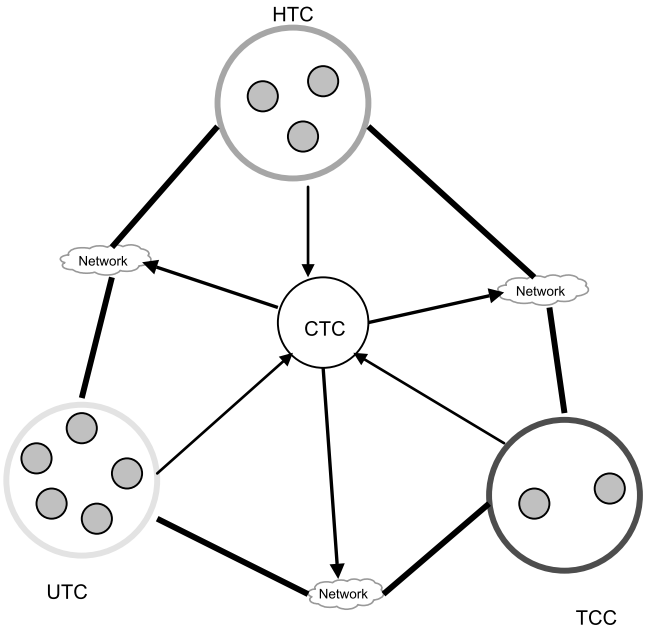

FIG. 3. Teleophthalmology infrastructure for Ethiopia.

In effect, the network of teleophthalmology centers will connect each regional hospital, nursing training center, and medical university using PSTN (Public Switched Telephone Network; Figure 4—map of Ethiopia). Moreover, the clinical and technical protocols on the operation of hardware and software for data archiving and transmission will be available.

In addition, using a store-and forward system (e-mail), the Telecenter technician or primary care physician saves the data and sends files to be examined to the specialist at the coordination center. The specialist looks at the patient information and images to make the diagnosis. Next, the primary care provider can review the diagnosis and communicate any vital information the specialist observed and advise follow-up treatments, provide medications, or request a second opinion.

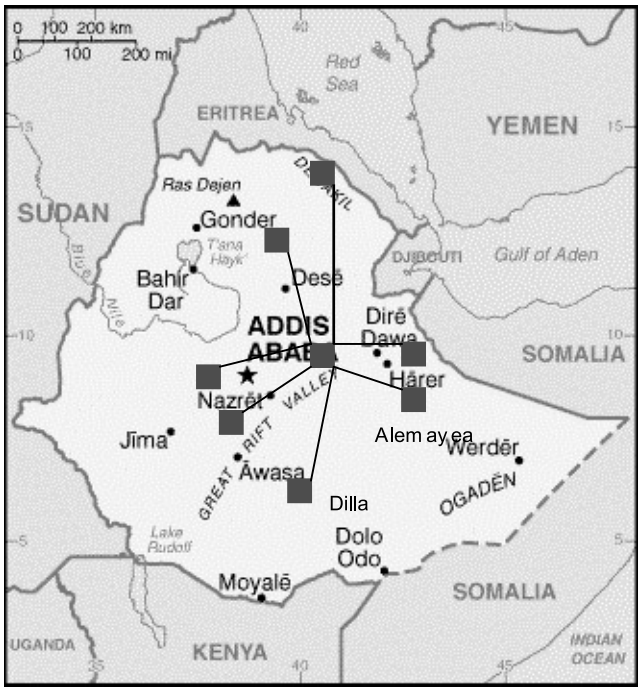

FIG. 4. The Ethiopian telemedicine network.

Comparative Assessments of Traditional and Teleophthalmological Services in Ethiopia

Economic Benefits

Economic benefits in terms of cost savings are major factors that motivate the adoption of technology (Auger & Gallaughev, 1997; Groth, 1993). Blackwell, Kelly, and Lenton (1997) stated that teleophthalmology is well suited for the diagnosis and management of acute conditions and for postoperative assistance to patients in rural areas. The dire situation that Ethiopia faces is a combination of acute cases of visual impairment and a lack of supporting facilities. The Department of Ophthalmology at the Minilik II teaching hospital cannot supply enough doctors to balance the national demand for ophthalmologists. As a result, decisions taken by the medical facilities to refer patients abroad have depleted the limited foreign currency of the country. For instance, from 2001–2002, the Minilik II teaching hospital referred 121 patients abroad with an estimated $605,000 US. This includes an average of $2,000 US for medical treatment and $3,000 US for lodging and personal expenses (See Table 2). Another example is the ORBIS Flying Eye Hospital, which costs the donor agency $238,000 US for one week of services. Remembering that Ethiopia, with a per capital GDP of $100, is one of the poorest countries in the world, it becomes obvious why health care remains a luxury for the Ethiopian population (WHO, 2003).

In contrast, the teleophthalmology process is aimed at linking peripheral diagnostic ophthalmologic devices with existing ICT infrastructure to create virtual connections with a network of specialists around the globe. Thus, excess costs

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TABLE 2. Referral reasons and cases.

Reason for referral	Number of case	% cases
Ultreoretinal procedures (vitrectomy, retinal reattachment surgery)	77	62.00
Penetrating Keratoplasty (PKP)	14	11.00
Refractive Surgery	11	9.00
Orbital Procedures (Orbitotomy, Reconstruction)	06	5.00
Diagnostic and possible interventions	06	5.00
YAG—Capsulotomy	05	4.00
Others	04	3.00

are avoided while adding to the mobility of specialists. Through virtual connections, teleophthalmology allows for the creation of a virtual practice network to provide comprehensive eye care. Take the case of India, for example, where telecenters are installed for approximately $5,000 and teleophthalmology is provided as a free service or at a nominal cost of $5 per person per visit. Even with such nominal charges, telecenter facilities can be expected to breakeven within a few years (Harris, 2002).

Socioeconomic Benefits

Eighty-five percent of the Ethiopian population lives in villages where medical facilities are extremely poor and access to health information is nonexistent. A hospital visit would entail traveling to the very few urban areas and would take a few days. Most patients are subsistence farmers, for whom the loss of a few days can lead to extreme privation. Teleophthalmology here can play an important role in reducing distance and improving access for the majority of the rural population in Ethiopia (Matthias, 2002). Teleophthalmology offers improved access to much-needed health information for the population of Ethiopians. Better eye care information will be available through teleeducation, which will contribute to the enhancement of quality of rural life. With the teleophthalmology infrastructure in place, other applications can be expected to emerge. The spillover benefits are broad—encompassing areas such as education, research, public health, health care administration, and clinical care (primary diagnoses, screening, and consultation; Flowers et al., 1991).

Teleophthalmology initiatives increase access to specialized health care and allow for early diagnostics, prevention, and cure (Gilbert & Foster, 2001; Melese et al., 2003; Sheldrik, Vernon, & Wilson, 1992; Tilkesew 2002). It also offers increased episodes of interaction and opportunities for follow-up, allowing improved continuing of care including clarification of advice previously given and time for detailed and considered responses (Badal 1999; Spielberg, 1998).

Teleophthalmology can also add to better management of scarce medical resources by refurbishing its ICT infrastructure and developing better communication facilities. In addition, the facility can be used concurrently for other telemedicine services with marginal costs of medical peripherals such as digital encephalography (EKG), spirometers, etc. In Ethiopia, access to health care for rural area patients is hampered by a lack of basic infrastructure and the low availability of specialists. General practitioners who work solo in isolated locations have often found it difficult to interact with colleagues. Teleophthalmology facilities will create virtual connections for seamless communications. Existing technologies, such as e-mail will ease communication between physicians in Ethiopia and their colleagues across the globe. Therefore, the main advantage of these networks is that it greatly reduces the isolation of health care service providers living in rural areas (Wootton, 2001). Physicians working in the countryside of Ethiopia can get access to assistance from ophthalmologists at Minilik II Hospital or outside of the university hierarchies at international levels (Roland & Bewley, 2001). Presently, the communication between general physicians and specialists at referral centers in Ethiopia is extremely poor. These situations affect timely delivery of health care services and delay treatment processes, resulting in higher costs and lower quality of services. Using teleophthalmology can transform information, reduce waiting time, and provide a more efficient use of existing equipment and medical resources. The result is better communication, leading to considerable reduction in unnecessary medical care expenses for the health care providers and the patients (Harison, Clayton, & Wallace, 1996). In being able to link with local or international sites, it enables health care providers to stay abreast of medical developments.

A teleophthalmology infrastructure can simultaneously be used to deliver distance education. Online delivery can contribute to reducing training expenses, increasing productivity, and providing a greater spectrum of training material from worldwide sources. Furthermore, it can offer access to university-level ophthalmology education via online course software, thereby delivering expertise and training without travel. Being able to get training without traveling overseas not only lowers costs, but also positively impacts society as a whole. This is of paramount importance in a country like Ethiopia where literacy is very low and the number of available health care practitioners is limited. Basic training for first aid, nursing assistance, and other preventative care can be easily simulcasted to multiple locations with marginal costs but significant benefits.

Finally, a teleophthalmology infrastructure can prompt increased communication between health service facilities. By allowing multiple medical centers to interact using existing ICT, teleophthalmology can bring together multiple options to address a specific medical concern. This could result in shorter waiting lists for ophthalmic consultations.

Furthermore, a communication network can also benefit national agencies in their policy-making initiatives. Site studies found a national-level involvement in teleophthalmology. Stakeholders were Addis Ababa University Faculty of Medicine, Ethiopia Ministry of Health, Ethiopian

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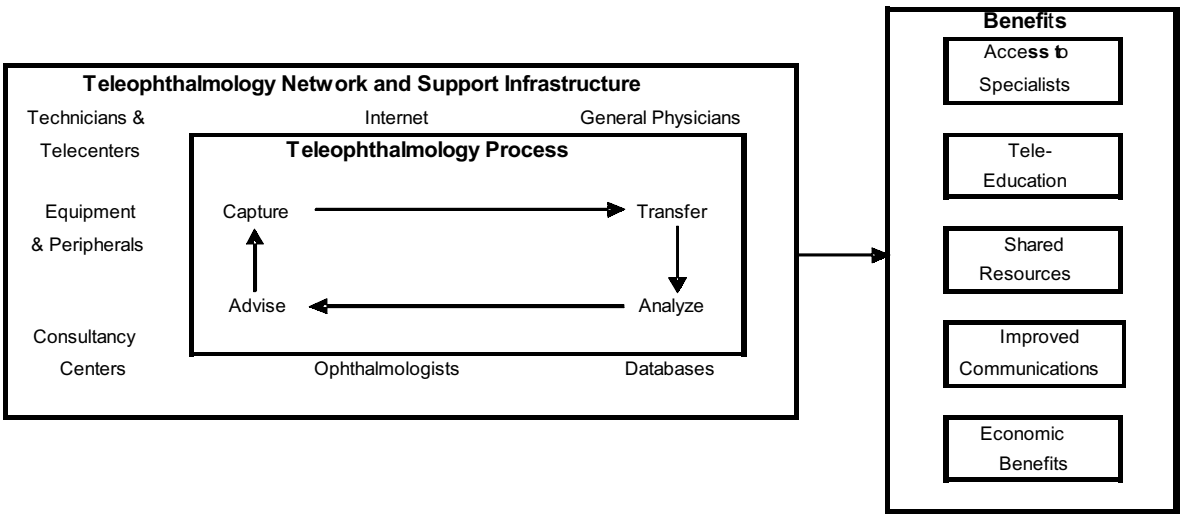

FIG. 5. A teleophthalmology framework for Ethiopia.

Telecommunication Cooperation, Minilik II Teaching Hospital, ALERT Nurse Training Center, ORBIS Ethiopia, ITU Regional Office for Africa, WHO Office for African Union and UN-ECA, United Nations Development Program (UNDP), and the Ethiopian Ophthalmology Society. With an established teleophthalmology network, these national and international agencies could immensely benefit from a more transparent communication infrastructure.

Figure 5 visually depicts a unified view of the teleophthalmology infrastructure, its process, and potential benefits. Infrastructure, a precursor to implementation of the technology, forms the outer core and identifies the elements and entities involved. Once the infrastructure and support system is in order, the teleophthalmology process can be set in motion. The outcome of the process and technology can be traced through economic and social benefits that teleophthalmology brings to fore.

Challenges

Despite all the advantages of teleophthalmology advanced earlier, one needs to be cautious when using teleophthalmology in developing countries; appropriate policies for telemedicine use need to drawn up and access to adequate bandwidth should be assured. Related legal and ethical issues, such as security and confidentiality of patient data and responsibility in cases of medical error, need to be addressed. Many factors should also be taken into account such as human factors; government and international policy issues; training of health care providers; and the level of the economy at which teleophthalmology can be successfully implemented and sustained in Ethiopia.

Moreover, teleconsultation challenges physicians' existing informal referral methods, which do not involve a standardized format such as a guide for clinical text or images. Further, there is a possibility that at some point the equipment will fail. The resources and chain of authority must be in place to enable a rapid return to normal operations. Finally, it is necessary to address issues related to e-mail, such as confidentiality, data integrity, authentication, timeliness, technical standards and policies controlling e-mail communication. In addition, health care organizations are also concerned with the integration of e-mail into the present workflow and workloads. Badal (1999) mentioned concerns about timeliness of answers and the liability of providers if they miss or fail to act upon information contained in the e-mail. Hence, a major limitation with this study is that we concentrate on what is technically feasible, and not what is socially and ethically viable. For example, because lawsuits are not much of a "culture" in African countries (as compared to how common they are in the United States) doctors practicing teleophthalmology (or other medical practices) have not historically been concerned with liability issues.

Conclusion

In this article, we discussed and analyzed eye care services and highlighted the ophthalmology situation in Ethiopia. We also discuss the lack of trained health care professionals, particularly physicians and specialists. Our study illustrates the social and economic benefits of teleophthalmology applications in Ethiopia, highlighting issues of access to specialists for patients living in remote areas, linking and sharing diverse medical resources. We further analyze teleophthalmology protocols and present a teleophthalmology network illustrating how various hospitals, health care providers, and medical school experts might use the system for consultations.

These procedures are in accordance with the widespread use of store-and-forward e-mail in telemedicine. Further, e-mail is a low-cost solution, attractive in developing countries that may have limited bandwidth.

In the past few years, more and more health care providers and policy makers have become exposed to the

DOI: 10.1002/asi

benefits of modern technologies. The need for health care is increasing because of new pandemics in developing countries such as HIV/AIDS, malaria, etc. Given the austerity measures faced by many developing countries, allocating more resources to the health care sector is becoming increasingly difficult. Therefore, there is a need to look at other solutions to enhance health care provision in developing countries. The need for the distribution of quality health care service in both urban and rural areas of Ethiopia should be addressed. Developing countries can make improvements in health care service provision with effective utilization and proper management of the limited available resources. In fact, the advancement in telecommunication and information technology makes teleophthalmology a viable solution for the problems of accessibility, quality, workflow efficiency, and costs of medical care. Brundtland (1999) said "we are moving from the industrial revolution to the information revolution. I am a promoter of Tele-Medicine, but even more so a promoter of equitable, quality health services to all people. Tele-Medicine is merely a way to achieve that. For many countries, getting set for this new opportunity is expensive. We need to encourage support systems so that all groups of countries can have access to this technology." Thus, technological innovations have shown the possibility of achieving the desired quality level while reducing the unit costs of patient care. They can contribute towards timely decision-making and professional isolation.

The need for the implementation of teleophthalmology in Ethiopia is demonstrated by the following facts: 85% of population live in rural areas; the shortage of health care providers in rural areas (ratio of ophthalmologists to people in rural area is 1: 3.8 million); and 80% of the causes of blindness are preventable. Contributory factors include the 1992 change to the Ethiopian health care system, and evolving views of health care and policy at provider levels. Moreover, the advantage of this solution is that the quality of health care delivery is enhanced for the patient, because potential blindness would be detected at an early stage and in an efficient manner. There is no delay of treatment, which could adversely affect outcomes. Early detection means early treatment and this, in turn, prevents blindness.

From the providers' and physicians' perspectives, time per patient is shortened. Overall, there would be time for more patients, which will result in extra patient revenue. From the payer's (whether that be the patient or organizations) perspective, costs associated with the production of replicating patient medical records and the transporting and sharing of records among distant physicians are eliminated.

In short, teleophthalmology projects exist in several countries and several studies have been completed (Berger & Shin, 1999; Klein et al., 1985; Tang & Schiffman, 1977). This article has contributed to the literature by providing an overview of the ophthalmology problem in Ethiopia and how information communications technologies can be used to enhance service delivery in the health care industry. This was illustrated with a case study on teleophthalmology in Ethiopia.

The wide presence of colleges and universities in Ethiopia with a relatively good infrastructure, such as computers, telephone, and networks, can make this project feasible. The networking project of different colleges and universities undertaken by the Ministry of Education in cooperating Ministry of Health and Ethiopian Telecommunication would also help facilitate this idea. The Storm Eye Institute (Charleston, South Carolina) and ORBIS International (New York, NY) are likely to offer international cooperation, financial help, and expert advice. The Department of Ophthalmology, Faculty of Medicine, Addis Ababa University and the Ophthalmic Society of Ethiopia would be potential candidates committed to securing requisite human resource support.

The potential for further research in the area of information systems and teleophthalmology in sub-Saharan Africa and developing countries in general is great. This study highlighted conditions in sub-Saharan Africa, and developing countries in general, which are very different from those found in the developed world. We bring a much-underresearched region (sub-Saharan Africa) and a much-underresearched technology (telemedicine) to the forefront of information systems (IS) research. It is our hope that colleagues in the field will be motivated to investigate this "forgotten" region of the world that is yet to reap the full potentials of ICTs.

There is therefore a need for further research to identify factors that may influence the adoption and diffusion of teleophthalmology in sub-Saharan Africa, other developing regions, and poorer communities of developed countries that are deprived of modern ICTs. There is also the need for more-detailed ethnographic case studies, which focus not just on technical but also on social, economic, cultural, and political issues that are characteristic of developing regions. This would give opportunities for improved health care and a health workforce, which would translate in overall economic growth and sustainable development for these disadvantaged regions of the world.

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DOI: 10.1002/asi

Appendix A

List of Organizations

Government Organizations

- Prime Minister's Office
- Ethiopian Ministry of Health
- Ethiopian Telecommunication Cooperation

Universities and Associations

- Addis Ababa University—Medical Faculty
- Addis Ababa University—Department of Ophthalmology
- Ethiopian National Telemedicine Committee
- Ethiopian Medical Association
- Ethiopian Ophthalmology Society

International Organizations

- International Telecommunication Union (Regional Office for Africa)
- World Health Organization (Office for African Union [AU] and Economic Commission for Africa [ECA])
- ORBIS (Ethiopia)

Private Hospitals and Clinics

- Bethzatha Higher Clinic

Appendix B

List of Personnel

Government Organizations

- Ato Bekele G/ Medihn—ICT Advisor in the Prime Minister's Office
- Sister Sosna—Ministry of Health/Representative of National Telemedicine Committee
- Ato Tesfaye Biru—General Manger of Ethiopian Telecommunication Cooperation

Universities and Associations

- Dr. Legesse Zerhun—V/Dean and Health Net and National Telemedicine Committee Member
- Dr. Samsone Bayu—Head of the Department of Ophthalmology, Addis Ababa University (AAU)
- Dr. Tilkesew Teshome—Staff and Chairman of Ophthalmology Society
- Dr. Daneal Zewdnech—Head of Radiology Department (Representative of National Telemedicine Committee
- Dr. Miliard Derebaw—Staff and Secretary of Ethiopian Medical Association

International Organizations

- Mr. Brahima Sanou—Head of the ITU Regional Office for Africa Liaison Officer to AU and ECA
- Dr. Alexander Correia—World Health Organization, Head, WHO officer for AU and ECA
- Ato Tilahun Kebede—ITU Senior Advisor (Telemedicine project)
- Dr. Wondue—Director of ORBIS Ethiopia

Private Hospitals and Clinics

- Dr. Ermias Mulugeta—Medical Director of Bethzatha Health Service

DOI: 10.1002/asi