

A TeleMedicine Transfer Model for Sub-Saharan Africa

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Abstract¹:

Given the documented benefits of telemedicine, especially in resource-constrained health-care contexts, we empirically examine the factors they contribute to successful transfer of telemedicine to Sub-Saharan Africa. The results indicate that policies specific to the advancement of ICT influence the country's advancement in ICT infrastructure and telemedicine capabilities. Likewise, the level of ICT infrastructure and the nature of the country's health services sector impact the telemedicine capabilities of that country. Additionally, telemedicine seems to be more valued in regions where resources for health-services provision are scarce, and its value tends to diminish as the resources become abundant. However, telemedicine seems unable to thrive where ICT infrastructure is scarce. This is an indication that the value of telemedicine to SSA is leveraged by leveraging ICT infrastructure in general and ICT for telemedicine, in particular.

I. INTRODUCTION

Sub-Saharan African (SSA) is facing continuous health threats characterized by spread of infectious diseases, high levels of infant and maternal mortality, low level of life expectancy, and deteriorating healthcare facilities and access to prevent health. Widespread poverty along with general low income levels of the population, low education levels (especially among women), inadequate access to clean water and sanitation facilities and poor access to health services have contributed to the high burden of ill-health in the continent. Shortage of access to health services in the region is further complicated by the concentration of healthcare services in urban centers. In Ethiopia for instance, 25 of 25

dermatologists and 40 of the 56 radiologists are located in the capital, Addis Ababa (MOH-ETHIOPIA, 2006). An estimated 70% of SSA populations live in rural areas. The rural communities have no access to, or are far from, health facilities, resulting in over 65% of SSA population lacking essential healthcare services, healthcare investments and retaining healthcare providers. This situation is further aggravated by the high population growth. Poor nutritional status, infections and a high fertility rate, together with low levels of access to reproductive health and emergency obstetric services, contribute to one of the highest maternal mortality ratio in the world. The growing inequalities in health status, problems of access and the difficulty of controlling the growth of costs have prompted most SSA countries to engage in reforms of their health sector. For example the SSA, with 24% of the global burden of disease, has only 3% of the world's health workers, and spends less than 1% of the world's health expenditure (WHO, 2006). International organizations and major foundations are currently giving a high priority to combat HIV/AIDS, tuberculosis and malaria. However, the major problems with regard health infrastructure, specifically health workers are their failure to develop healthcare services. This may require adjustments if the objectives of equity, efficiency and quality are to be attained. Telemedicine initiatives represent an attempt to address some of these pressures, and have a real potential to improve accessibility, quality of healthcare, improving the provision of services in rural area and of giving access to distance training for rural community of SSA populations (Kifle et al., 2004, Kifle et al., 2005; Kifle et al., 2006 Mbarika, 2004).

Telemedicine is defined as the use of information technologies to exchange health information and provide health care services across geographical, time, social, and cultural barriers (Reid, 1996). In general, telemedicine technology includes both store-and-forward - asynchronous as well as live videoconferences - synchronous transmissions via satellite networks (Bergmo, 2000; Wootton et al. 2000).

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In the last decade, pilot studies in SSA countries have shown the potential benefits of telemedicine for patients and healthcare providers. The results demonstrated the socio-economic impacts of telemedicine, and its potential in the area of improving accessibility, containing costs, and providing quality care (Bashshur, et al. 2002; Brady, 2005; Brauchli et al., 2004; Craig et al., 2005; Kuntalp et al., 2004; Kifle et al., 2006).

Craig and Patterson (2005) note that there are basically two reasons for the implementation of telemedicine in developing countries: 1) because there are no alternatives (i.e. problems related to access and its potential role in the delivery of medical care to patients, as well as health care provider perspectives), and 2) because telemedicine has geographic advantages over traditional medicine (i.e. increasing access and cost benefits of telemedicine compared with traditional alternatives). Moreover, the implementation of telemedicine in developing countries is considered a major innovation not only at the technology level, but also at the social levels of the healthcare system (Bashshur et al., 2002). In general, a main objective of telemedicine in developing countries is to facilitate cost-effective delivery of healthcare services to the majority of the population in rural and urban areas (Hailey, 2005; Hailey et al., 2002; Perednia and Allen, 1995b; Roine et al., 2001)

Despite high hopes, however, telemedicine has been slow to come into routine use. Numerous studies document the diverse problems related to telemedicine technology diffusion in general (Brady, 2005; Kuan and Chau, 2001; Tulu et al., 2005); these studies often point to scarcity of resources, poor telecommunication infrastructures such as bandwidth, and the impact of the Internet. Other frequently mentioned factors in the literature are non-technological issues such as organizational, human elements, policy and standards, and socio-economic issues (AaS, 1999, 2001; Hu et al., 2000; Jennett et al., 2005; Leidner and Kayworth, 2006; Odedra-Straub, 1996; Scott et al., 2005; Straub et al., 2002). However, the majority of attention is focused on the technology aspects of telemedicine, where the challenges are often affected by multiple actors such as individuals and organizations (AaS, 2001; Ash, 1997; Chen, 2003; Han, 2005; Hu et al., 2000). In the past decade, researchers have tried to come up with research models that focus on the integration of non-technological and technological barriers of telemedicine (Bashshur et al., 2002; Jennett et al., 2004; Mantzana et al., 2007).

This study examines Information and Communication Technology Transfer (ICTT) as it applies to telemedicine in SSA, to address these issues, we adopt a positivist research approach as philosophy and methodology to guide our empirical research, and we used the Partial Least Squares (PLS) statistical analysis method to test the structural and measurement model.

RATIONAL FOR RESEARCH

This study explores key factors influencing the transfer of telemedicine technology studies is based on the following rationales:

- recent unfolding developments in ICT in the SSA region
- considering the region's multiple medical problems that stimulate new approaches such as telemedicine for improving access and reducing costs
- issues related to shortage of medical personnel and facilities in Sub-Saharan African countries. For example, the Sub-

Saharan Africa region, has only 3% of the world's health workers, and spends less than 1% of the world's health expenditure (Kifle, et al., 2006); 23% of SSA countries have no medical schools, and 47% have only one (Hagopian et al., 2004); 87% of medical specialties located in urban area

- many parts of SSA are affected by the "brain drain" phenomenon: migrant from the public sector to the private sector; as well as migration to richer or more stable countries. Many qualified specialists leave their countries to work in Western Europe and North America. For example, it is estimated in Ethiopia that about one-third of the medical doctors have already left the country (IOM, 2004);

I. THEORETICAL BACKGROUND

In general, the literature review emphasizes that the use of telemedicine is motivated by its effectiveness and efficiencies; therefore we focused on evaluating telemedicine outcomes and their benefits in areas of providing high quality care, improving accessibility and/or containing costs of healthcare (Bashshur et al., 2000; Håkansson , 2001; HTU, 2003,2005; IOM, 1996; Lugn, 2006). Each of these telemedicine outcomes includes distinct methodologies for assessing approaches. Generally, access refers to geographic separation (Penchansky and Thomas, 1981); cost refers to the relationships between cost and benefits as compared with the alternatives (McIntosh and Cairns, 1997); and quality refers to the satisfaction of patients and physicians as well as technical quality (Bashshur, 1997). We have also focused on visually-based clinical applications at the level of maturity (radiology, dermatology, pathology, ophthalmology), application purpose (diagnostic, consultation, monitoring) and how communication infrastructures are utilized (technology, bandwidth, synchronous, asynchronous). Further, we have examined the impacts of national infrastructures that can make a difference in telemedicine transfer outcomes at the national level.

TELEMEDICINE INFRASTRUCTURE OUTCOMES MODEL

The model proposed here has three predictor constructs that we postulate to influence telemedicine outcomes on the national level – ICT policies, ICT Infrastructure, and the capabilities of the health sector institutions. National ICT policies have three dimensions: (1) general ICT policies (the government's objective to prioritize ICTs for national development) (Courtright, 2004; Chechi et al., 2002; Gurbaxani, et al., 1990; Rigby, 1999; Straub, et al., 2001; UNCSTD, 1997; Wild and McCube 1996); (2) e-health policies (the government's attitude and commitment to improve healthcare development by using ICT) (Anderson, 2000; Fujimoto et al., 2000; Jennett and Siedlecki, 2001; Jennett et al., 2004; Scott et al., 2002; Vargneses and Scotte, 2004; WHO, 2000); and (3) data security policies (the government's awareness and support of setup standards and procedures for telemedicine communication improvement) (Blobel, 2000; Gilbert, 1997; Janczewski and Shi, 2002; Kumekawa, 1997; Sandberg , 1995; Stanberry, 2000; Tulu, 2003; Wachter, 2000).

ICT infrastructure, a telecommunication infrastructure with Internet connections (bandwidth), impacts telemedicine outcomes unidimensionally according to availability, security and

affordability (Datta and Mbarika, 2004; Iakovidis, 2000; Mbarika et al., 2002; Meso and Duncan, 2000; Puskin and Sanders, 1995 Tulu et al., 2005). Also, national policies (ICT, data security, e-health) have a direct effect on ICT infrastructure. Thus, ICT Infrastructure is a construct that is both independent and dependent.

Finally, we have the health-sector environment (Bashshur, et al., 2005) with two dimensions, one that impacts the practice of health in general, and the other that influences especially telemedicine. These factors are (1) the effectiveness and (2) the readiness of government in the healthcare institutions respectively (AaS, 2001; Ash, 1997; Bashshur et al., 2005; Hu et al., 2000; Kifle, et al., 2005a). Figure 1 displays the national-level model.

TELEMEDICINE CAPABILITIES AND OUTCOMES

Based on the existing literature, telemedicine offers socio-economic benefits, reduces costs, and improves access to healthcare service providers and patients. Economic benefits in terms of cost saving are the major factors that motivate the adoption of technology (Groth, 1993; Augur and Callaugh , 1997). Moreover, social benefits in terms of increased access to specialized healthcare (Gilbert and Foster, 2001), improved interaction and opportunities for follow-up (Badal, 1999), and reduced isolation of healthcare service providers (Wootton, 2001) are other reasons to adopt telemedicine.

The International Standards Organization (ISO) recommends that health outcomes have to be based on some agreement ensuring the purpose and important to measured. The IOM model (Field, 1996) defines outcome indicators in relation to access, cost, and quality of care. Access refers to the ability of an individual or group to obtain needed services (Penchansky and Thomas, 1981). Cost refers to the economic evaluation of telemedicine compared with traditional alternatives depending on transport costs, volume, time sensitivity of care, and the cost of the alternative (Dolittle et al., 1998). Quality refers to the satisfaction of clients and providers and the process of care for technical quality (Hailey et al., 1999).

The social and value outcomes of telemedicine dimensions deal with the issue of uneven geographic distribution of healthcare resources, healthcare facilities, and human resources. Generally the level of healthcare facilities and specialist skills is not the same as in developed countries. We note that issues of inadequate access to healthcare, and rising health costs are a consequence of the high level of disease burden. Telemedicine transfer outcomes are one method to improve health levels and reduce health service delivery costs in developing countries. The potential of telemedicine systems can be expected to improve access to healthcare, and the efficiency with which it is delivered. Even if the benefits of telemedicine are substantial, the practice of telemedicine is still not considered as part of healthcare in most SSA countries, as the literature illustrates. However, it is hoped that telemedicine can address four major concerns: First, healthcare access is made possible for remote (isolated), confined patients, and improved by lowering geographical barriers. Second, human resource development is promoted, and recruitment and retention of physicians in rural areas is encouraged. Third, in terms of the issue of quality of care, telemedicine will provide clinicians better, timely information about the patient. Therefore, through the Internet, the healthcare staff will receive information that may be

vital to patient care. Based on the above discussion we offer the following hypotheses:

- H1** Telemedicine capabilities are positively related to social outcomes of telemedicine.
- H2** Social outcomes of telemedicine are positively related to value outcomes of telemedicine

ICT POLICIES

According to the UNCSTD (1997) definition, “A national ICT policy is an integrated set of decisions, guidelines, laws, regulations and other mechanisms geared to directing and shaping the production, acquisition, and use of ICTs.” This extensive phrasing reflects a policy that will inevitably intersect with a number of other areas. Thus, “specific technology policies that guide the development of information systems in a specific country”, indicating “the level of support for technological development” (Loch et al., 2000,) is a widely recognized factor that affects both the diffusion of telemedicine and the intensity of telecommunications (Courtright, 2004; Gurbaxani et al., 1990b; Kamel 1995; Kraemer et al., , 1992).

Moreover, government policies are highly instrumental in the diffusion of computing in a society (Gurbaxani et al., 1990a). This reality is significant within the context of Sub-Saharan Africa, where governments control most of the ICT infrastructure (Mbarika, 2001; ITU, 2000, 2001) and uphold different policies that influence the acquisition and use of the infrastructure by private organizations. Furthermore, many SSA countries have very low levels of per capital income, and the major source of economic output is agriculture. Various studies have examined the effects of ICT policies on the development of ICT infrastructure (Checchi et al., 2002; Dutta, 2001; Gurbaxani et al., 1990b; Hakken, 1991; Handy and Mokhtarian, 1995; IDRC, 1998; King et al., 1994; Kraemer et al., 1992; Raman and Yap, 1996; Tractinsky and Jarvenpaa, 1995; Wild and McCube, 1996). Most of these studies argue that national ICT policies influence and promote ICT diffusion. In the case of African countries within the domain of AISI, a number of studies have been undertaken, such as reviewing informatics policies in 10 SSA countries. This study defined national informatics policy as a “plan for the development and optimal utilization of information technology”. Today almost all SSA countries have ICT policies for socio-economic development, even though the follow-up and action plans differ from country to country. These action plans and their impact are formally measured by the effect of policy context on the adoption of a particular technology. Thus, to increase the success of policies, the availability of funding, the status of the existing infrastructure, top management support and on-going commitment and local context of the system are all important factors for the outcome of telemedicine. Thus, from the literature we hypothesize:

- H2a:** Policies that favor the development of ICTs in general (not necessarily with a specific focus on healthcare) are positively related to telemedicine capabilities.
- H2b:** Policies that favor the development of ICTs in general (not necessarily with a specific focus on healthcare) are

positively related to the level of ICT infrastructure.

SECURITY AND STANDARD POLICIES

The evolution and growth of telemedicine is mostly focused on the use of ICT to provide healthcare services and access to healthcare information across distance. The use of these ICT networks techniques is the primary difference between telemedicine and traditional face-to-face care delivery; therefore, privacy, confidentiality and standards are key issues associated with care delivery and the use of Internet for care delivery. Hence, privacy, confidentiality and security issues emerge when care is delivered across a distance or via Internet. For example the 2001 Telemedicine Report to Congress notes, "The Internet will most likely play a key role ..." and it identifies "privacy, security, and confidentiality" as key issues affecting the industry (HIPAA, 1996,2003).

The American Medical Association (1996) calls on those "who use telemedicine systems to have a responsibility to make prudent and reasonable use of those technologies necessary to apply current and future confidentiality and privacy principles and requirements to telemedicine interactions" (AMA, 1997). Furthermore, in Guidelines for the Protection of Health Informatics Association (2001), it is noted that, "telemedicine transmissions are vulnerable to security breaches through telecommunication line linkages." Therefore, telemedicine should have a confidentiality policy in place, and this policy should contain a clear statement of the confidentiality expectations of all staff (healthcare or IT) providing telemedicine services (Blobel, 2000; Tucker, 1992).

Standardization is one of the most important issues for the successful development and deployment of telemedicine systems, since many standards are developed independently of the organization originally preparing the standard. Examples of standards relevant to telemedicine system development and deployment include: Health Level 7 for Electronic Data Exchange (WWW.hl7.org); IEEE P1073 – Instrumentation and IEEE P1157 – Data Model from the Institute for Electrical and Electronic Engineers (IEEE); and Imaging from Digital Imaging and Communication in Medicine (DICOM). Many issues concerning policy forming and decision making about the implementation of telemedicine systems are related with the construction of an open standardized environment. The role of standards in telemedicine must be viewed in the context of healthcare organizations, the technology drive, and the different interests of the different actors. Any individual organization or project involved in telemedicine applications has to make its own decisions concerning official standards, de facto standards, and proprietary solutions (Grimson et al., 2000; Iakovidis, 2000). Thus, from the literature we hypothesize:

- H3a:** Policies specifically tailored to ensure data security and standards are positively related to telemedicine capabilities.
- H3b:** Policies specifically tailored to ensure data security and standards are positively related to the level of ICT infrastructure.

E-HEALTH/TELEMEDICINE POLICY

The literature on e-health and telemedicine policy, in general, is relatively recent, and remarkably sparse; the few extant articles point out the need to address the e-health policy issue at both national and international levels. During the last five years, however, most national governments have developed ICT policy for healthcare (WHO, 2004). The objectives and goals of the various governments are rather similar. Nevertheless, the level of defining the policies and translating them into projects and programs differs from country to country (Fujimoto et al., 2000; Johnston et al., 2004; Klecun-Dabrowska, 2000; Scott et al., 2002).

Scott et al. (2002) defined e-health policy as "a set of statements, directives, regulations, laws and judicial interpretations that direct and manage the life cycle of e-health." According to the WHO, policies help to develop a vision of the future, define short, medium, and long-term references, determine objectives, set out priorities, delegate roles and define means of action and institutional arrangements (Cassels and Janovsky, 1998; Walt et al., 1999; WHO, 2000). Policy and decision makers within the health system must see telemedicine as part of the larger domain of health service delivery, as they work to integrate telemedicine services into the traditional delivery system (Mitchell, 2000). ITU Recommendation SG 2/6-98 (1998) includes encouraging National Ministries of Health to work together to develop a unified telemedicine policy. Moreover, Jennett et al., (2004) recommends that "e-health be integrated into existing healthcare systems in a policy, not just a practicable manner, and that this be achieved with a 'global' perspective." However, many telemedicine projects in developing countries, particularly in SSA countries, are implemented and evaluated as stand-alone (pilot) initiatives. Sanders and Bashshur (1995) state that much of the appeal of telemedicine remains intuitive, and is based on fragmentary rather than systematic empirical research.

Moreover, telemedicine policy can support decision-making in the context of greater public awareness and cost benefits of proposed options. At the same time, however, the absence of some public policies has posed problems for telemedicine, as other policies have been devised specifically to encourage its development and implementation. For example, these policies include demonstration project funding, technical assistance, and infrastructure development that support not only healthcare but also all sectors of the socio-economic development. As Hämäläinen and Hyppönen (2006) stated that the evaluation of health policies is not very common and a need exists for multi-disciplinary evaluation covering the whole implementation chain from policy objectives to its impacts. Thus, from the literature we hypothesize:

- H4a:** Policies specifically tailored to promote the application of ICTs in healthcare (as opposed to general ICT policies) are positively related to telemedicine capabilities.
- H4b:** Policies specifically tailored to promote the applications of ICTs in healthcare (as opposed to general ICT policies) are positively related to the level of ICT infrastructure.

ICT Infrastructure

As we stated earlier, telemedicine is health care delivery in which physicians examine patients remotely using ICTs. To

enable the use of telemedicine, a country needs a solid ICT infrastructure (Adam, 1996, 1997; Avgerou, 2003; Datta and Mbarika, 2004; Heeks, 2002a ; Puskin and Sanders, 1995). According to McLaughlin (2000, p. 2), an ICT infrastructure is defined as "... a physical system of telecommunications pathways and connections that transmit voice, video, and data ... encompassing a web of telecommunications, information, and computing technologies." Internet refers to the interconnection of computer networks using a standard packet switching protocol for communications (Verhoef, 2000).

Although the Internet has significantly affected the processes of healthcare delivery, it is only one of the tools used in "digitizing" and improving the management of healthcare information. However, in SSA countries, there is usually a concern about speed and transmission rate, data availability and the reliability of connectivity. This has a big impact on the safety and quality of the image transmission through Internet. Therefore, available technology must be identified (Plain Old Telephone System, POTS; Integrated Services Digital Network, ISDN, or Asynchronous Transfer Mode, ATM), and telemedicine clinical applications using it must be balanced with it. For example, if we use POST connection for video conferencing, we know that there will be relatively slow data transmission and low quality images.

Due to various socio-economic and political problems faced by most countries of Sub-Saharan Africa, the region is reported to have the lowest levels of most ICT-related infrastructures in the world (Goodman, 1991; Mbarika, 2001, 2002). The literature reports extremely low levels of basic telephone penetration, less than one phone line per 100 people, in most Sub-Saharan Africa countries (ITU, 2001; World Bank, 2001). A primary reason for such low levels of ICT infrastructure is the cost of acquiring and maintaining telecommunication infrastructure (Mbarika et al., 2002).

The limitation and availability of communication infrastructure and bandwidth also determine the types of telemedicine clinical application area and purpose used. The two main delivery types of telemedicine are: (1) real-time, are also known as videoconferencing "synchronous"; and (2) store-and-forward telemedicine, also known as "pre-recorded" or "asynchronous." Real-time telemedicine applications require more bandwidth, and the interaction between the participants is essentially immediate, without time and space variation, whereas in the case of store-and-forward telemedicine, information is gathered (text, data, images, etc.) in electronic or digital form, and sent to the other participant (receiving site), who views it at a convenient time and reports back to the sending site.

Much of the research into telemedicine technologies has taken place in OECD countries, in particular the US, Australia, Canada and Europe. These countries have a relatively appropriate infrastructure already in place, and extending and expanding the existing health and telecommunications infrastructure have facilitated rollout. In addition, these societies already have significant technology diffusion, and the general community functions at a comparatively high level. For developing countries without a developed telecommunication infrastructure, the transfer of telemedicine presents specific problems. The deployment of telemedicine benefits from the growing availability of telecommunication infrastructures and services. For example, a government-sponsored national initiative in the United States, the

National Information Infrastructure (NII) initiative, was implemented to increase infrastructure for telecommunications and computer technology in all sectors, including health care. These major initiatives also include the importance of Internet and high-speed network connection to use telemedicine technologies.

In SSA countries, major difficulties are associated with the availability of telecom infrastructure at affordable costs. Other often-cited problems common in most SSA countries include instability of the electric power supply, limitation of international bandwidth, and difficulty in finding Internet connectivity beyond large cities. Even if access to infrastructure has relatively improved somewhat at the national level, and traffic costs are declining as a consequence of liberalization policies, the current costs of using the existing infrastructure can be prohibitive to most healthcare providers and practitioners. Part of the problem has to do with international links (standards adoption); another part relates to the lack of a policy on telecom infrastructures for telemedicine applications; yet another with deregulation and the widening gap between those who have access to infrastructure and those who do not. Thus, we hypothesize:

H5: More reliable and readily accessible ICT infrastructure is positively related to telemedicine capabilities.

II. METHODS

We have followed quantitative research tradition, based on deductive reasoning. Following the QPR recommendations for IS research (Straub et al., 2004), the paper adopts instrument, internal, and statistical conclusion validit to accurately claim generalizability of the results. A survey-based methodology was employed. To minimize errors in survey data, we followed three steps First, we designed the instrument to avoid problems that commonly affect reliability Second, we addressed the issue of survey bias that might be introduced by the wording of questions relating directly to the notion of construct validity (Paulhus, 1991). *Finally*, we wanted to avoid problems with the survey data (improper sampling procedures and nonsampling errors are typically attributable to poorly designed survey instruments, vague, inconsistent or misleading administration procedures, or respondent reactions to the research process itself The sampling was most representative of the target population, and the research findings represent actual values from the target population. However, the conclusions from the study are not directly applicable beyond the target region, SSA, the focus of the theory and the subject of the study.

The test of this research model includes two major stages: the estimation of the measurement model and of the structural model. In the estimation of the measurement model, we evaluated in terms of reliability and validity. This measurement model also helped to establish the relationship between the constructs and the indicators (*i.e.*, items) used to measure them. This implies the examination of internal consistency, convergent validity, and discriminate validity of the instrument

Data was collected through a web survey, as well as through the standard postal method. In constructing the instrument, we

followed generally accepted guidelines for building survey instruments (Straub et al. 2004). Question development expert, Pilot tested, modified questions.

The questionnaire was divided into five parts (this, however, was not known by the respondents), each containing a series of related questions. The first section dealt with the capabilities and outcomes of telemedicine, second national policies (ICT, e-health, security), third national ICT infrastructures, fourth health environments (health infrastructure and readiness) , fifth some demography items and content details. All questions were structured using an ordinal scale. Open-ended questions were also included, to record factors not anticipated and to provide further explanation. The Web questionnaire was similar in structure to the postal questionnaire, except that HTML form tools were used to enforce consistency in the Web questionnaire. The subjects for the present study were physicians or telemedicine experts.

The statistical analysis method chosen for the proposed model and hypotheses testing was PLS (Partial Least Squares) Version 3.0. We conducted a two-step analysis: first a measurement model, and then testing the hypotheses using a structural model. The measurement model indicates the strength of the measures used to test the proposed model, whereas the structural model and hypotheses are assessed by examining the significance of the path coefficients and the variance accounted for by the antecedent constructs. Moreover PLS produces estimates of R2 which can be used to examine model fit, the same as conventional regression analysis.

III. RESULTS

Two hundred and twenty responses were received. These responses represent physicians from 21 different SSA countries, others who are not located in SSA, and experts outside the region. Of the 220 responses received, 11 (five from the online group and six from the mail-in group) lacked sufficient information to be included. Also, fifteen of the respondents were excluded because of their insufficient knowledge of telemedicine. All responses to the survey were voluntary. All participants were encouraged to complete all the questions in the survey. Of these participants, 194 reported that they had knowledge of telemedicine (49 very knowledgeable, 84 knowledgeable, and 61 somewhat knowledgeable).

The respondents were largely specialized in six major image-based telemedicine clinical specialties: radiology (15 percent), pathology (12 percent), ophthalmology (11 percent), orthopedics (10 percent), dermatology (9 percent), and cardiology (9 percent). The remaining 37 percent of the respondents were practicing other clinical specialties. Approximately 84 percent of the respondents were male, and 16 percent were female (A very typical gender gap in the medical profession in most SSA countries). The respondents were primarily medical doctors and healthcare-related specialists. More than 71 percent of the respondents were medical doctors (practitioners), and approximately 29 percent held a PhD in healthcare-related specialties. Forty-two percent of the respondents were from teaching hospitals. The remaining 58 percent were from non-teaching hospitals (25 percent), private clinics (10 percent), and others (23 percent). About 65 percent of the respondents reported that they had used the Internet more than 3 years, and the additional 28 percent reported that they had used the Internet 1 to 2 years. Less than 9 percent of the respondents

reported that they had used the Internet less than 1 year. Cronbach Alpha values were above 0.7, the acceptable range (Nunnally, 1978), and most were above 0.8, a range considered acceptable and strong of the. There are, in general, four steps involved in testing and refining the measurement model: confirmatory factor analysis, checking for cross-loadings, reliability measures of the constructs, and discriminant validity (Boudreau et al., 2001; Chin, 1989; Straub 1989).

We used PLS to run Confirmatory Factor Analysis recommended by Chin (1998), who suggested that only items with loading equal to or greater than 0.7 were very significant. From the total of 51 items, 9 items did not load adequately in the initial instrument the remaining 42 items were adequately loaded and significant (Gefen et al., 2000).

The second step in testing the measurement model was to assess whether any item cross-loaded on a construct other than the one for which it was theoretically specified (Chin, 1998a, b) Cross-loadings are not directly computed by PLS; they must be manually constructed, as suggested by Wynne Chin (www.discnt.cba.uh.edu/chin/plsfaq.htm). The results obtained in our case, forty-two items were loaded adequately in the initial instrument (51 items). To assess the internal consistency for the indicators of each construct, the composite reliability was calculated. All constructs in this research model exhibited very good internal consistency. Composite reliability of the telemedicine social, e-health policies, data security policy, ICT infrastructure, and healthcare infrastructure constructs values were above 0.90, it indicating that the measurement model demonstrates high internal consistency.

As another measure of reliability to assess convergent validity, we examine the Average Variance Extracted (AVE). AVE values should be greater than 0.50, which means that “half” or more of the variance of the indicators should be accounted for” (Fornell and Larcker, 1981, p. 46). All AVEs for the latent constructs in this study were very good.

Table 1: Matrix of Latent Construct Correlations Between Latent Constructs; Square Root of AVE Is Leading Diagonal

	AVE	IC	EH	SP	II	HI	RE	SO	VA	TC
IC	0.635	0.797								
EH	0.861	0.473	0.928							
SP	0.834	0.398	0.553	0.913						
II	0.640	0.219	0.442	0.361	0.800					
HI	0.643	0.141	0.128	0.079	0.098	0.802				
RE	0.774	0.310	0.411	0.404	0.484	0.134	0.880			
SO	0.673	0.292	0.185	0.116	0.016	-0.007	0.133	0.820		
VA	0.710	0.334	0.221	0.285	0.058	0.092	0.133	0.489	0.843	
TC	0.690	0.342	0.298	0.308	0.083	0.199	0.168	0.283	0.349	0.831

Diagonals represent the average variance extracted (AVE), while the other matrix entries represent shared variance.

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Constructs	Reliability Co efficiency	Cronbach Alpha
Telemedicine Capabilities	7	0.78
Telemedicine social	5	0.88
Telemedicine Value	3	0.81
ICT Policies	6	0.87
E Health Policies	3	0.92
Data security	3	0.90
ICT infrastructure	11	0.91

Results of the assessment of the structural model are presented in Table 2 also provides a summary of all the results obtained for overall models.

Predictor Constructs	Predicted Constructs	Hyp.	Path	t	P (t)
Telemedicine Capabilities	Telemedicine value	H1a	***0.435	5.425	0.000
	Telemedicine Social	H1b	**0.230	2.891	0.004
ICT Policies	Telemedicine Capabilities	H2a	**0.314	3.710	0.000
	ICT Infrastructure	H2b	-0.018	0.257	0.797
Data Security	Telemedicine Capabilities	H3a	**0.286	3.196	0.002
	ICT Infrastructure	H3b	***0.272	3.653	0.000
e-Health Policies	Telemedicine Capabilities	H4a	*0.220	2.295	0.023
	ICT Infrastructure	H4b	***0.435	5.896	0.000
ICT Infrastructure	Telemedicine Capabilities	H5	*0.208	2.491	0.014

* $P < 0.050$; ** $P < 0.010$; *** $P < 0.001$

	R2	F	P (F)
ICT infrastructure	0.315	17.291	0.000
Telemedicine Capabilities	0.292	39.387	0.000
Telemedicine Social	0.353	25.779	0.000
Telemedicine Value	0.226	27.885	0.000

The overall model result shows that an adequate percentage of variance (R2) is explained for all dependent constructs in the study (R2 = 31.5 % for ICT infrastructure, 43.7 % for telemedicine capabilities, 35.3 % for telemedicine social outcomes, and 22.2 % for telemedicine value outcomes).

Hypothesis H1a, referring to the relationship between telemedicine capabilities and telemedicine value outcomes, documents a significant impact on telemedicine value outcomes ($t = 4.794$; $p = 0.000$). This suggests that telemedicine capability has a strong relation to telemedicine value, implying that a well-defined procedure, infrastructure and image based consultation service would exert a positive influence on clinical improvement, and reduce the time and effort of healthcare services and its societal cost.

Hypothesis H1b, referring to the relationship between telemedicine capabilities and telemedicine social outcomes, documents a significant impact on telemedicine social outcomes ($t = 2.735$; $p = 0.007$). This suggests that telemedicine capability has strong relation to telemedicine social outcomes, implying that increasing services and improving collaboration among physicians would exert a positive influence on the level of healthcare services, and improve patient access to healthcare services for underserved citizens.

Hypothesis H2a, referring to the relationship between general ICT policy and telemedicine capabilities, documents a significant impact on telemedicine capabilities ($t = 3.111$; $p = 0.002$). This suggests that ICT policies have strong relation to telemedicine capabilities, implying that governmental promotion, influence and encouragement of the development, implement of ICT would exert a positive influence on increased clinical improvement, quality of care and improved collaboration among physicians.

Hypothesis H2ba, referring to the relationship between national ICT policy and ICT infrastructure, is not supported ($t = 0.270$; $p = 0.787$). This relationship does not seem to hold in SSA. This suggests that ICT policy does not have a significant effect on ICT infrastructure, implying that a good national ICT policy is not directly related to telemedicine capabilities.

Hypothesis H3a, referring to the relationship between data security policy and telemedicine capabilities, documents significant impact on telemedicine capabilities ($t = 2.505$; $p = 0.013$). This suggests that data security policy has strong relation to telemedicine capabilities, implying that governmental support, providing and enforcing standards and procedures to prevent system and data failure, would exert a positive influence on increasing clinical improvement, quality of care and improved collaboration among physicians at national and international levels.

Hypothesis H3b, referring to the relationship between data security and ICT infrastructure, is significant ($t = 2.748$; $p = 0.007$). This suggests that data security and standards have a positive impact on ICT infrastructures, implying that a national policy should be tailored to ensure the security and standards increasing the development of ICT infrastructures.

Hypothesis H4a, referring to the relationship between e-health policy and telemedicine capabilities, is not significant ($t = 0.318$; $p = 0.751$). This relationship indicates e-health policy does not have a significant effect on telemedicine capabilities. This indicates that e-health policy is not a significant influencing factor in telemedicine capabilities, implying that improvement in quality

does not necessarily relate with e-health policy.

Hypothesis H4b, referring to the relationship between e-health policy and ICT infrastructure, documents significant influence on ICT infrastructure ($t = 5.393$; $p = 0.000$). This suggests that e-health policy has strong relationship to ICT infrastructure, implying that a good e-health policy would exert a positive influence on the use of telemedicine.

Hypothesis H5, referring to the influence of national ICT Infrastructure on telemedicine capabilities, supports telemedicine capabilities ($t = 3.136$; $p = 0.002$). This suggests that an ICT infrastructure is positively related to telemedicine capabilities, implying that the level and availability of ICT infrastructure are important for the development of telemedicine.

VALIDATION OF THE STUDY

We followed the rigorous method (Starub et al., 2004) for evaluating the quality of our research, and the validity of reflected physicians' perceptions of telemedicine transfer in SSA. It includes pilot study, statistical power, reliability, and internal and external validity.

IV. DISCUSSION AND LESSON LEARNT

The result confirms the belief of physicians that telemedicine has real social value in health outcomes, and points out that increasing patient access to healthcare, and saving societal cost, have very significant effects on telemedicine capabilities. This study also highlights the need of specific policies such as e-health and data security, rather than general ICT policies. The result confirms that reducing technical and infrastructure barriers improves practical knowledge, and enhances telemedicine and traditional medicine outcomes. It is also interesting to discover that if there is good health infrastructure, perhaps telemedicine is not valued so much; also when health infrastructure is poor, then telemedicine is unable to stand on its own.

Furthermore, the results suggest generally considering a more explicit priority-setting exercise focused on societal perspectives, in terms of possible clinical application of telemedicine, to use limited resources more rationally. It also indicates that pilot projects are necessary on the integration of IT into the health sector, incorporating aspects of technological capabilities and values as well as social outcomes. The study provides substantial evidence that limited access and a lack of alternative health care are fundamental conditions under which telemedicine services are to be considered, and prosperity reengineering should be viewed as a continual iterative decentralized improvement of health and human resources. Generally, all the findings significantly contribute to comprehensively understanding the use of visually-based clinical services employing store-and-forward communication for socioeconomic benefit decisions.

LESSON LEARNT

We studied the areas of telemedicine transfer to SSA. No claim for generalization is made. Thus the lesson learnt are a summarized below.

(1) Telemedicine must address the majority of the rural areas and especially at primary care level where most of the problems can be easily solved by getting a second opinion, such as

radiology, dermatology, pathology, and ophthalmology.

(2) Telemedicine systems require a real commitment of all the involved parties, especially support from governments.

(3) Telemedicine services depend on the acceptance of physicians who must own the system; therefore their involvement is important in the development and implementation of the project.

(4) Standards and security are often mentioned as relevant points.

(5) Telemedicine technology should be user-friendly, and users must be well trained and supported to function effectively.

(6) Economic sustainability for long routine practice and maintenance of the equipment is also important.

(7) It is highly desirable to improve government policy for access, cost and availability of the Internet, especially in the rural areas.

(8) Education in medical schools and arrangements of seminars and workshops for specialists in the use of technology is necessary.

(9) The role of nurses and other healthcare technicians needs to be emphasized and increased.

Conclusion and Contribution

This study also has important implications for practice, and could provide some prescriptive directions for policy makers in the SSA governments, and motivation to adopt visually-based clinical applications of telemedicine. Besides the general implications for the governments and the research community, multinational companies involved in telemedicine and other ICT projects could better understand the factors influencing the transfer of telemedicine in SSA. Government policy makers will have new insight into the effectiveness of various national infrastructures on telemedicine transfer in their respective countries. This could help them focus efforts on visually-based clinical applications and low-cost (store-and-forward) telemedicine technology.

The most significant implication of this findings is that we offer healthcare providers advice that can be important in implementing visually-based clinical applications and store-and-forward telemedicine, due to its low cost and the rapid growth of the internet in the region. In order to promote telemedicine technology transfer to some extent, carefully comparing applications and existing infrastructure, as well as choices of hardware and software appropriate to the country, will help the success of telemedicine. This study describes how important it is to identify the application purpose (clinical or non-clinical) and dimension (visually-based or not), environmental circumstances (urban and rural; academic and non-academic), communication infrastructures (bandwidth capabilities) and media options (asynchronous store-and-forward, and synchronous videoconferencing), policies (data security, legal, standard) and costs; all these factors affect the decision-making process and telemedicine capabilities in SSA regions. Moreover, the transfer of telemedicine is a process that requires time, adequate support and resources. Therefore, introducing and using visually-based telemedicine requires "champions" that are interested in the use.

This study is also important to telemedicine infrastructure providers, such as telecommunication equipment manufacturers and service providers; our empirical findings can improve their direction by providing insight into local healthcare organizational

practices and cultural aspects that have to be considered for the transfer of visually-based clinical systems. Therefore, international and multinational organizations may be in a better position when they consider the design of a telemedicine system, so that the physicians of developing countries find the telemedicine system user-friendly.

In most SSA countries, there is a rationale for adopting an innovation, and in the field of healthcare, it is most often based on some evaluation of a pilot project, even though most of the claims (cost cutting and efficiency) are not well documented through scientific research (Wootton, et al., 2000; AHRQ 2001). Relatively image-based applications with convincing evidence of effectiveness are documented, such as teleradiology, telepathology and teledermatology (Brauchli et al., 2004; Kifle et al, 2006b). Thus, looking at the study domain in individual countries or specific telemedicine applications will hopefully provide deeper insights to policymakers with the ability to assess the impact of system changes on telemedicine outcomes (quality, access, cost and healthcare services). there are many other issues, such as organizational and physician acceptance, that influence telemedicine transfer in SSA.

Further work and research limitations

Telemedicine is relatively new in SSA, the pool of actual users of telemedicine was not that big during the period of this study. It will take many more years to come up with meaningful generalization of the results to other developing countries. Therefore, generalizability must be considered as an issue. To address this concern, as the use of the technology grows in SSA, further research could focus more on responses by specialty groups and location.

Research regarding telemedicine in general is very rare in developing countries. I strongly believe that further research is important in this area. This can be done by using longitudinal multi-method case study analysis of cross comparisons of multiple projects within the country. Findings of such research could eventually be carried over to other developing countries with similar contingencies.

Moreover, as noted in my literature review and the course of the study, my theoretical model is not exhaustive, particularly in the area of the impacts of organization and individual on telemedicine capabilities; these issues suggest the need for additional research, incorporating other variables not measured in this study, such as healthcare organizational and physician acceptance of telemedicine technology (Venkatesh et al., 2003; Chau and Hu Jen-Hwa, 2001). An interesting approach would be exploring these issues through qualitative and quantitative methodology. Focus groups such as radiology applications in organizational analysis, case studies and mixed methodological approaches could lend support to these data through triangulating techniques (Yen, 1978). I believe that TAM or UTAUT (Venkatesh et al., 2003) questionnaires could be included in a modified or revised version of this instrument.

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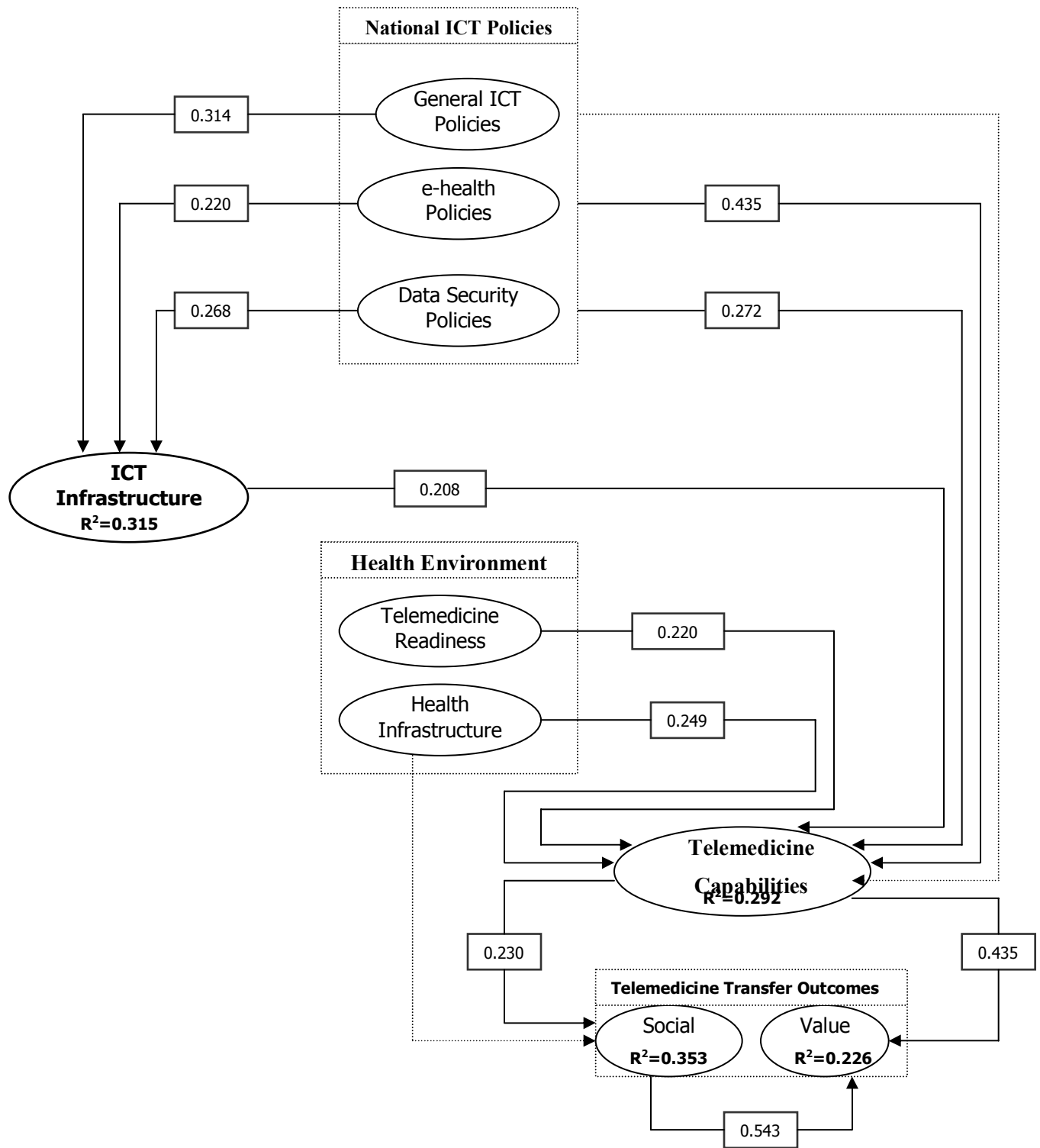


Figure 1: Telemedicine Transfer Model