Technology Transfer in Developing Countries: A Telemedicine Framework for an Assessment of Healthcare Needs and Proper Technologies

I. Introduction
The term telemedicine is one that excites the imagination—a linkage of the best in the delivery of healthcare practices with the newest and most powerful information and communication technology (ICT). Recently, rapid technological advances along with decreasing prices promise many opportunities in the field of telemedicine. Many scholars and practitioners propose telemedicine as an alternate solution to address emerging health problems: shortage of medical professionals in rural communities; lack of basic healthcare services; limited hospital capacity; rising child mortality rates; and increasing HIV/AIDS patients in developing countries. The common assumption among health researchers is that the transfer of telemedicine technologies and their application to the healthcare sector in any developing country could significantly improve the delivery of healthcare services and enhance the quality of life; however, the actual implementation of telemedicine systems and practices has not yet been widely adopted by healthcare practitioners.

Several factors—social, economic, political, legal, technological, and cultural— influence the decision-making process of telemedicine technology transfer and its implementation in developing countries. A better understanding of the technology transfer process can ultimately improve the flow and quality of telemedicine technologies and medical practices. However, transferring technologies from developed to developing countries can be a challenge to achieving its intended goals in the most effective, beneficial, and sustainable manner. As De Laet, M. (2002) states:

“Technology transfer requires work. This work entails educating, supervising, coaching, coaxing, persuading, and managing—not to mention shipping, hauling, digging, connecting, building, trying, testing, failing, and trying again. Much more work, in short, than the term technology transfer suggests” (pp 213).

Technology transfer is defined as a broad set of processes covering the flow of information know-how and knowledge resources; and it is the outcome of several decisions made by different stakeholders at local, national, and international levels. Dozens of models in technology transfer are available; however, there are no pre-defined models or frameworks in enhancing telemedicine technology transfer in developing countries. Depending on the contexts, types of technology, and needs of a country, telemedicine interventions and knowledge barriers can significantly vary with respect to technology transfer. In addition, earlier studies suggest that a mismatch between the sophistication of the technology and end-users requirements creates significant technological barriers. (Paul et al, 1999) Besides inappropriate technology transfer, there are several other factors—resource scarcity, lack of technology funding mechanisms, and
poor institutional infrastructures and management. About 50% of technology transferred to Sub-Saharan Africa lies idle or unused. (Poluta, 1996)

Addressing these issues in advance by identifying key success factors in technology transfer is crucial to diffuse telemedicine in developing nations. Some of these success factors include end-users awareness, perceived usefulness, easy access to information, availability of knowledge resources, and a sound business model that is well-supported by government policy and other regulatory frameworks. Most importantly, an understanding of end-users’ needs from a technology perspective at the grass-root level is considered to be a crucial initiative to succeed in telemedicine endeavors in the developing world. (Chau and Hu, 2002; Croteau & Vieru, 2002).

Therefore we need a telemedicine framework that is to be tailored to the specific context of healthcare in the developing world. From a telemedicine perspective, this paper elaborates on what governments of developing nations can do to ease and enhance telemedicine technology transfer, but it also aims at recommending viable approaches for decision makers in private industry, funding institutions, multilateral donor agencies, non-governmental organizations (NGOs), and interested citizens.

From a perspective of end-users (stakeholders—doctors, nurses, and local healthcare workers), the telemedicine framework plays a vital role in identifying key healthcare needs, determining health education and technological needs, and exploring feasible telemedicine solutions that are relevant to a particular context in any developing country. The end-users’ input in the decision-making process of technology transfer is crucial for sustainable community development. The people living within the community and across the country should be prepared technically, socially, and economically to undertake any telemedicine initiative. Otherwise, the consequences of technology transfer will be impaired. As Edworthy states:

“Without paying attention to the historical underpinnings of each country’s current health system, telemedicine could have negative impact on the well-being of those countries. And unless we understand the technological and cultural readiness of each country and its healthcare practitioners, much effort can be expended with little gain” (p.525)

Understanding the complexity involved in the process technology transfer, this paper proposes a telemedicine framework that considers a developing country’s perspective. This framework guides a country toward a proactive role during the process of technology transfer. This framework assists in identifying major healthcare needs, available knowledge resources, patient’s privacy and security issues, and the maturity level of ICT infrastructures within a country and across the world. The emphasis of the framework is to integrate community-supported technological solutions along with the best medical practices to treat people locally or remotely within a reasonable timeframe and at an affordable cost. Ultimately, the framework will serve as the basis for selecting sustainable telemedicine technologies, forming sound healthcare policies, and identifying best medical practices.
II. Proposed Telemedicine Framework

The framework consists of four segments (figure 1.1): an assessment of healthcare needs, the maturity level of ICT infrastructures, the degree of technological complexities, and the magnitude of patient privacy and security. This framework allows developing countries to select proper telemedicine technologies, based on the maturity level of ICT infrastructures and the degree of healthcare needs of a country. Each segment portrayed in figure 1.1 will be discussed and analyzed in detail in the context of the least developing countries in South-East Asia.

A. An Assessment of Healthcare Needs

Developing nations encompass a wide range of healthcare needs. To maximize benefits from telemedicine intervention in the healthcare sector, the healthcare needs of a country should be carefully assessed, analyzed, and prioritized. An assessment of healthcare needs is a prerequisite for seeking appropriate technological solutions that are applicable and sustainable in any given context in developing countries. This segment attempts to analyze healthcare needs by grouping them into two major categories—medical/clinical needs and educational/training needs. Each of these categories will be discussed as follows.

Medical/clinical needs can further be classified into two major scenarios—a needs assessment of emergency cases and non-emergency cases. Emergency cases mean a critical condition of a patient requiring immediate actions from participating healthcare providers for performing medical procedures and providing instant medical care. For example, patients suffering from severe injury, chest pain, sign of stroke, and pregnancy or delivery related cases require immediate attention from medical team. On the other hand, non-emergency cases, such as minor cold, discomforts, or routine medical check-ups, mean non-critical scenarios of a patient where the care providers do not have to act immediately.
In addition to medical/clinical needs, the governments of developing nations face a shortage of medical professionals and community-level care providers. To address this problem, developing nations should identify several types of healthcare education and training needs. Depending on the context and types of the healthcare systems, healthcare education needs can be assessed through a careful review of a country’s formal and informal education systems. During this exploratory stage, the relevant questions to ask are: What is the community’s level of healthcare, educational, and training needs? What are some community-level efforts to educate and train their community members in the area of healthcare? What kinds of healthcare problems do these rural communities face? Once the answers to these questions are known, then the next step is to identify applicable technological solutions and telemedicine practices that are the best for the particular context. Depending on the needs, the solution can be a distance learning, digital library, short-term computer-based health education seminar, and interactive multimedia training CDs and videos. Otherwise, providing a laptop computer to a physician or healthcare worker does not necessarily solve the increasing healthcare problems in the village but wastes limited critical resources that could be used elsewhere. (Driscoll, 2001)

**B. An Assessment of the Maturity Level of ICT Infrastructures**

The second segment in the framework analyzes information and communication technology (ICT)--the backbone of telemedicine systems. The maturity level of ICT infrastructures in the developing world plays a critical role in deciding the types of supporting technologies, clinical applications, and the level of interactions between a patient and a doctor in a remote setting. Multiple types of technology support interactions among healthcare providers. However only a limited number of them will be applicable in a country that has very limited ICT infrastructures. In such a case, e-mail, Internet, and tele-consultation (wireless phones and telephones) among medical professionals may be the best option in improving the quality of health services in rural communities.

Any country, organization, or NGO considering telemedicine would benefit by analyzing different ICT factors within the healthcare context before acquiring technological solutions. For example, if a country has a low level of diffusion of the most basic components of ICT--telephone, bandwidth connectivity, dependable electricity, and personal computer--the choice would be to select a simple store-and-forward type (asynchronous mode) of telemedicine applications. It is instructive to investigate the gross bandwidth statistics by the continent and within the country itself to assess the maturity level of ICT infrastructures because telemedicine involves both synchronous and asynchronous interactions among patients, doctors, researchers, and other healthcare providers within the country and across the world.

Understanding of the term “digital divide” is critical when attempting to measure the maturity level of ICT infrastructures. The term “digital divide” is often represented as a simple phenomenon, the difference between the ICT “haves” and “have-nots” (Norris, 2001, pp 3-12). Harvard professor Pippa Norris (2001, pp 3-12) offers a helpful definition of the digital divide, suggesting that it can be viewed from different perspectives: the ICT divide between regions and within an individual nation.
The ICT Divide between Regions: Norris’s first perspective is the divide between nations or regions, such as the differences in technology diffusion between, for example, South-Asia and East Asia or Asia and Europe. Table 1 presents an aggregate comparison of six continents based on Internet host sites. Host sites is the sole technology indicator used by United Nations Developing Program (UNDP) in its new Alternative Human Development Index (AHDl) “…to reflect ICT connectivity (access to ICT), to express a universally recognized requirement for benefiting from globalization in this age” (UNDP, 2002a, p. 21). With about 15 percent of the world’s online population, Asia has less than 7.5 percent of the host sites in the global Internet. Further, this statistic masks an imbalance within the continent.

Table 1: Internet Host Site Data For Six Continents

<table>
<thead>
<tr>
<th>Continent</th>
<th>Internet Host Sites (000)</th>
<th>As % of the world Host Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>10,659</td>
<td>7.5</td>
</tr>
<tr>
<td>Africa</td>
<td>275</td>
<td>0.2</td>
</tr>
<tr>
<td>Europe</td>
<td>15,325</td>
<td>10.8</td>
</tr>
<tr>
<td>North America</td>
<td>110,002</td>
<td>77.7</td>
</tr>
<tr>
<td>Oceania</td>
<td>2,897</td>
<td>2.0</td>
</tr>
<tr>
<td>Latin America and Caribbean</td>
<td>2,494</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Source: International Telecommunications Union (ITU), 2002

Table 2 displays selected data for the twenty-two countries from Asia. Of the many Asian countries, South Asia has a very limited share of the Internet host sites, and a low proportion of computers, Internet users, cell phones and bandwidth. Nepal, Pakistan, Sri Lanka, and Bangladesh have a significant disadvantage with respect to the maturity level of ICT infrastructures.

The ICT Divide Within an Individual Nation: Norris’ second perspective on the digital divide is the difference that exists within each nation. Using that lens, we are interested in the digital “haves” and “have-nots” on a country-by-country basis. Table 2 also lists Gross Domestic Products (GDP) per capita and GDP\(^1\) per capita adjusted for purchasing power parity for these countries. GDP has been found to be closely linked to technology diffusion and the low numbers for Asia suggest that only relatively wealthy countries and rich people can afford infrastructure to connect to the global Internet. In addition, richer countries that have higher GDP and higher percentage of urban population occupy the highest portion of the Internet bandwidth connectivity in Asia.

Table 2. The Internet in twenty-two Asian countries including SAARC Countries [Bold].
Sustainable development in the telemedicine environment. The exponential growth pattern will ultimately lead to improved access. There has also been a dramatic increase in the installation of Internet centers in several Asian countries. For example, in 2000, Asia's installed base was only 0.02% of the world's total, but by 2002, it had grown to 3.02%. This growth is largely due to the high cost of an Internet connection, which has been difficult to surmount. However, these stories also indicate that there are significant barriers that are not easily surmounted, like the uneven quality of electricity and telephone service, the lack of sufficient bandwidth (crucial for telemedicine), the high cost of an Internet connection among several others. (Ruth et al, 2003; Driscoll, 2001; Zhao, Nakajima, Juzoji, 2002; Wootton, 2001; Stanberry, 2001; IICD and InfoDev, 2002)

In terms of ICT infrastructures, Asia’s broadband capability has more than tripled since 2000 (Mauldin, 2002). The quality and quantity of international digital connections to and from Asia are also important. Figure 1.2 shows that Asia’s bandwidth is about three times larger than South America’s but it has only one fourth of that of Europe or North America. Even though the installed base is low by global standards, any kind of exponential growth pattern will ultimately lead to improved access. There has also been a significant increase in the use of wireless technology for voice and data transmission in Asia, possibly leading to more efficient use of business supply chains as well as more sustainable development in the telemedicine environment.
C. An Assessment of Technological Complexities

The third segment emphasizes on an assessment of the degree of technological complexities involved in the telemedicine environment. When we discuss this section, we can apply knowledge management perspective to diagnose the root causes of technological complexities and identify best knowledge management approaches to lessen problems in order to succeed in telemedicine endeavor and maximize health benefits.

Knowledge management (KM) is an emerging discipline that promotes an integrated approach to identifying, managing, and sharing information. One of the core principles of KM is that of capturing expertise and making it accessible to those in the community who need it. (Nonaka et al, 1995; Stewart and Stewart, 1999) KM perspective in the telemedicine environment refers to a broad collection of tacit and explicit knowledge of healthcare experts. Tacit knowledge is considered as care provider’s personal skills, common sense, and intuitive judgment in patient care environment whereas explicit healthcare knowledge is considered as documented knowledge resources—knowledge based rules, data repositories, healthcare protocols and procedures. (Cheah & Abidi, 2001) The tacit healthcare knowledge of community members is a key component in overall healthcare delivery systems; however, it is under-utilized in developing countries (2001). Cheah & Abidi suggest a six-step framework that aims to procure tacit healthcare knowledge using healthcare scenarios. (2001) Their framework will be useful if a telemedicine endeavor wishes to achieve its success within a given context by leveraging the existing health resources. Moreover, the local stakeholders should be encouraged and involved to capture knowledge resources—human, capital, intellectual, and natural—that exist within a community and leverage them as needed to address the local healthcare needs.
As shown in the framework, knowledge management’s perspective analyzes skills/knowledge --know-how in operating technology, understanding business models, interpreting data outputs, integrating telemedicine within the context of existing healthcare, managing organizational changes and users’ behaviors. Prior research in the area of technology diffusion suggests that the difficulty in learning technical knowledge creates knowledge barrier that inhibits technology diffusion. (Attewell, 1992) For instance, the complexities of these telemedicine tools involve more sophisticated technological knowledge to process data in a real-time providing instant response to the life-threatening case of a patient. The response time is critical to deal with more severe illness to meet patients’ emergency needs. As the degree of the patient’s illness and the maturity level of ICT infrastructures are increased, the level of technological complexities is also increased requiring sophisticated technological knowledge and skills. Therefore, careful attention is needed to operate these complicated technologies in a real-time situation and interpret the produced results that ultimately influence medical decisions pertaining to patients’ health.

Further, there is a wide range of technologies that can be used in telemedicine, from such a simple tool as the telephone to complex real-time interactive video, biotechnology, nanotechnology, artificial intelligence, language translations, and medical robotics (Nicogossian, et al, 2001; Doarn, 1997). Broadly, they can be categorized as synchronous (real-time) and asynchronous (store-and-forward) applications ( Maheu et al, 2001). Real-time telemedicine applications are more complex requiring expert knowledge and faster Internet connectivity whereas store-and-forward types of applications are simple, involving less skills and low bandwidth connectivity.

Often, each of these telemedicine technologies can suffer from inadequate hardware and software standards; system failures, difficulties in configuration, upgrade, and maintenance; and interoperability and reliability (Mandl, et al, 2001; Mavridis, et al, 2001; Byrd and Tunner, 2001; Report to Congress, 2001; Bauer & Ringel, 1999; Bashshur, Sanders, Shannon, 1997). Thus, a country purchasing medical and clinical software and hardware applications for the purpose of telemedicine use should thoroughly investigate the degree of technological complexities, identify knowledge capabilities, and make sure that they address the country’s particular healthcare, education, and technology needs. As Edworthy (2001) suggests:

“Selection of a particular technology will often dictate many other developments in health care. It may even dictate the type of medical training programme that is embarked on, depending on which country has underwritten the new technology” (p 525).

An ability to select and transfer proper technology and medical knowledge to local healthcare providers is crucial so that they can take over the responsibility for continuing administration, management, and control of telemedicine systems. Ultimately, this effort will drive the implementation of telemedicine and provide sustainability in delivering healthcare services to the rural communities in developing countries.
D. An Assessment of Patients’ Security and Privacy Issues:
The emphasis of the fourth segment in the proposed framework is to assess issues and concerns related to the telemedicine environment. As information and telecommunication technology continue to merge into mainstream healthcare systems, telemedicine faces a wide array of issues (Gutierrez, 2001). Such issues include costs, legal liabilities, insurance reimbursements, healthcare regulations, standards, and licensing requirements to practice medicine in different healthcare settings (Stanberry, 2001; Syms & Syms III, 2001; Report to Congress, 2001; Schwartz, 2000; Hodge, 1999; and Huston & Huston, 2000). However, patient privacy and security concerns about electronic medical records are the primary focus of the general public and medical communities (Mavridis et al, 2001; Tsai and Starren, 2001; Huston & Huston, 2000; Kun, 1999).

Advancement in healthcare technology opens more opportunities yet also presents many challenges regarding patient security (Joshi et al, 2001; Kun, 1999; Swartz, 1998), which have not yet been addressed effectively by telemedicine healthcare communities (Kun, 1999). Patient privacy and security issues are considered to be one of the major impeding factors in the diffusion of telemedicine in the developed world. However, privacy issues may not be considered as a major restraining factor for people living in developing countries. Obtaining better healthcare is much more crucial when it comes to a life-and-death situation than losing partial privacy.

In the proposed framework, the magnitude of privacy and security threats is dependent on the maturity level of the ICT infrastructures, the degree of patient-doctor interactions, and technological complexities. As shown in figure 1.1, if a patient has a life-threatening condition in a remote location, then the bandwidth connectivity must be capable of running synchronous applications to exchange in real-time patient’s data and perform surgical procedure. As the level of interactions increases from asynchronous to synchronous mode, the magnitude of security/privacy threats intensifies accordingly, requiring secured technologies to protect the patients’ personally identifiable data. When exchanging patient’s data in a real-time environment by using faster connectivity tools, the problems, such as system failures, power outages, security breakdowns, and privacy disclosers are more likely to occur, causing serious physical and psychological damage to a patient. (Giri, 2002)

Thus, a country considering telemedicine must thoroughly define patient privacy and security goals--confidentiality, integrity, and availability--from a telemedicine perspective. It is critical to identify commonly used technologies in the telemedicine environment, explore major security loopholes within these technologies, and recommend security measures to address these issues. Giri has highlighted a host of privacy and security issues and potential security mechanisms in the telemedicine environment in a recent conference paper presented to Telemedicine in Care Delivery, National Institute of Health, Pisa, Italy. (Giri, 2002) This paper serves as guidelines for any developing country interested in guarding patient privacy and security.
III. Potential Implications to Rural Communities

As ICT infrastructures continue to advance, several other added services with respect to healthcare in rural communities in developing nations become possible. A few Asian countries have made a good start by integrating telemedicine into their daily practices to deliver health services to their citizens. India has implemented several telemedicine projects sharing their positive experience (Hariss, 2002; Singh, 2002; Salam, 200); and other SAARC members also considered forming a health network to share knowledge resources. SATELLIFE has several initiatives in the area of healthcare, telemedicine, and affordable technological solutions for the rural communities in any part of the world. It provides an affordable satellite Internet access to health information and an opportunity for partnership to deliver better healthcare services to many developing countries. (Satellife, 2003) For example; a team led by NASA and MediTac is evaluating and testing new telemedicine technologies by conducting multiple projects in several countries such as Turkey, Ecuador, Egypt, Greece and the Dominican Republic. (Merrell and Doarn, 2002; Doarn, 1997) Low-end technologies such as satellite, wireless, and microwave connections in Uzbekistan, Cambodia, and Kosovo (Edworthy, 2001) and rural parts of United States (Thomas et al, 2002) have shown to be affordable Internet connectivity that could reach the rural areas around the world. However careful evaluation of these technologies is crucial for sustainability and applicability of telemedicine systems in the developing world. (Wootton, 2001)

As bandwidth and signal quality increase, it is much more feasible to offer greater access to information allowing health professionals to share patient medical records, databases related to health education and training, and other critical health information. If we look at the urban vs. rural population (table 2), about 90% in Nepal and more than 70% of the total population within SAARC countries now live in rural areas. In the global context “over 60% of the people in developing countries lived in rural areas, yet over 80% of the main telephone lines were in urban centers” (Petrazzini and Kibati, 1999). As telemedicine becomes a reality, it will, in fact, play a significant role in improving the access to healthcare services to the majority of people living in these rural communities around the world.

IV. Conclusion

Telemedicine has many versions of applications, from simple e-mail consultations to sophisticated real time interactions to remotely perform a robotic surgery. Depending on the context of a particular country, even a low bandwidth telemedicine can revive a number of sick patients suffering from all types of health complications. In addition, telemedicine technology does not have to be expensive to offer services in remote settings. Even simple framework with proper technologies such as combination of dial up Internet connection, e-mails, and CDROM with latest medical journals, case studies, and medical textbooks will add significant value to healthcare providers. Further, digitized audios and videos (multimedia training CDs) explaining several medical procedures that can be plugged in and played in a portable laptop or desktop could significantly enhance medical and clinical performance by assisting care providers to make reliable medical decisions. The low end of this spectrum is drastically easier to implement in Asia and can gradually lead to more sophisticated delivery systems. The
low bandwidth beginnings are not only a predictor to success in telemedicine, but they also deliver high quality, measurable results from the beginning to the developing world.

References:

Driscoll, L. (November 2001). HIV/AIDS and information and communication technologies, Policy Research International, Ottawa, ON, Canada
Edworthy, S.M. (September 2001). Telemedicine in developing countries, BMJ, v323
Giri, J. (June 12- 16, 2002). Patient Privacy And Security In Telemedicine Environment: Investigating Possible Privacy And Security Issues Within Internet-Based Telemedicine Information Systems From An International Perspective, Conference Proceedings, Telemedicine In Care Delivery (TICD), Symposium organized under the auspices of the International Society on Biotelemetry, PISA, Italy.
Gutierrez, G. MD. (2001). Medicare, the internet, and the future of telemedicine, Critical Care Medicine, v 29 (8), N 144
Harris, G. (2002). India: Telemedicine’s great new frontier: an indigenous technology effort is wiring up its healthcare systems, IEEE Spectrum, V 39, 14, p. 16 (2)


Mandl, et al. (Feb 2001). Public standards and patients’ control: how to keep electronic medical records accessible but private, British Medical Journal, v 322(7281), pp 283-286


SATELLIFE, Copyright © 1996-2003 by SATELLIFE, Inc. 30 California Street
Schwartz, J. (Feb 1, 2000). Medical web sites faulted on privacy, Washington Post, Tuesday, page E1

1 ITU: GDP per capita reflects real GDP /population
UNDP: GDP per capita (PPP S) reflects GDP for each nation at purchasing power parities.

2 Purchasing power parity (PPP) is income conversion method that could reflect the difference of living cost in different countries. For Press Freedom Index: scores of 0-30 equate to Free, 31-60 are Partly Free, and 61-100 are Not Free.
3 Urban population (of total population). The midyear population of areas defined as urban in each country, as reported to the United Nations. Worthy of mention is that because data are based on national definitions of what constitutes a city or metropolitan area, cross-country comparisons should be made with caution.

NUA: Total online population. The latest figures are used for each country from NUA survey. The art of estimating how many are online throughout the world is an inexact one at best. NUA collects data by the following rule:

- Where possible, 'How Many Online' figures represent both adults and children who have accessed the Internet at least once during the 3 months prior to being surveyed. Where these figures are not available, we use figures for users who have gone online in the past 6 months, past year, or ever.
- An Internet User represents a person with access to the Internet and is not specific to Internet Account holders. When the figure for Internet Account holders is the only information available, this figure is multiplied by a factor of 3 to give the number of Internet users.
- When more than one survey is available on a country's demographics, Nua will take the mean of the two surveys or, in the case where Nua feels one study may be more comprehensive/reliable than the other, Nua will quote this figure over the other.