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1. Introduction

Telecommunication technologies are being used to change the healthcare industry in unprecedented and irreversible ways. These technologies are enabling delivery of healthcare to remotely placed patients and facilitating information exchange between generalists and specialists. For many decades now, the use of advanced telecommunications and information technologies has been investigated in an effort to improve healthcare. In particular, the focus has been centered on telemedicine. Telemedicine has been defined as the delivery of healthcare and the exchange of health information across distances, including all medical activities: making diagnosis, treatment, prevention, education and research (Craig, 1999). Telemedicine is also defined as the use of telecommunication technologies to provide medical information and services (Perednia & Allen, 1995). It may be as simple as two health professionals discussing a patient's case over the telephone, or as sophisticated as using satellite technology to broadcast a consultation between healthcare centres in two countries using videoconferencing equipment. The American Telemedicine Association defines telemedicine as the use of medical information exchanged from one site to another via electronic communication for health and education of the patient or healthcare providers and for the purpose of improving patient care (ATA, 2001). Wootton (1996) considered telemedicine as a process, rather than a technology: telemedicine connects patients and healthcare professional in a chain of care.

Telemedicine, the provision of healthcare services, clinical information, and education over a distance using telecommunication technology existed long before the Internet. Some authors noted that telemedicine was broadly conceived even when the term was used almost three decades ago (Willemain & Mark, 1971). Some of the first telemedicine reports were of group therapy (Wittson, Affleck, & Johnson, 1961), nursing interactions (Cunningham, Marshall, & Glazer, 1978), education and training (Menolascino & Osborne, 1970), telemetry (Fuchs, 1979), televisits to community health workers (Straker, Mostyn, & Marshall, 1972), and home care (Mark, 1974), among other applications. In many cases, no physician was involved, and interactivity was not a necessary part of the transaction.

Telemedicine provides a solution to the problems of accessing healthcare, especially among rural populace or in developing countries such as Nigeria, where the lack of availability of information for medical management and physical barriers such as geographic isolation prevent patients from reaching

healthcare practitioners to meet their needs. Telemedicine is proving invaluable as the trend of the medical profession grows increasingly towards specialities and subspecialities. Now a patient visiting a general practitioner can consult a specialist via telecommunication facilities, saving both considerable amount of time and money for quality medical care as opposed to the increasingly outdated method of transporting the patient to the specialist for a face-to-face visit.

Telemedicine's applications have also been encouraged due to the widespread use of cheaper, more user-friendly telecommunication equipments such as personal computers, Internet access, satellites, videoconferencing, and telephone among others. The objectives of telemedicine and its applications are to enhance citizen's equality in the availability of various medical services and healthcare despite geographical and economic barriers, to reduce direct and indirect cost (loss of production or income) to patients and the healthcare industry, to save travel time and costs for both practitioners and patients from one geographical location to another, and to improve consultation and co-operation among various units of healthcare in both special cases and primary care by bridging the distance between practitioners and specialists.

Currently, Nigeria has a population of more than 120 million people, a major percentage of which live in the remote rural and poorer areas with most of the best equipped hospitals including teaching hospitals and medical experts located in the urban cities. This situation prevented the majority of people living in remote rural areas from reaching healthcare practitioners to meet their medical service needs. Consequent upon this, governments at federal, state and local levels have been making healthcare in these remote areas their focal point over the years so as to enhance the citizen's equality in the availability of various medical services and clinical healthcare despite geographic isolation; but this has not yielded any serious results. Therefore, establishment of an Internet-based telemedicine system would be most useful in achieving government's aims of enhancing citizen's equality in the availability of various medical services and clinical healthcare despite geographic and economic barriers. This among others would improve quality of healthcare in rural and outlying areas, lower costs of delivering healthcare and give remotely placed physicians the opportunity to consult any patient's case. In this paper, an Internet-based telemedicine environment is developed for Nigeria specifically to support consultations among physicians and provide a secure access to remote patient records. It further discusses some of the challenges and implementation issues of telemedicine in Nigeria.

Thus the rest of this paper consists of: Section 2 focuses on the history of telemedicine since preelectronic era to date while Section 3 presents the Internet-based telemedicine system in Nigeria. Section 4 examines some of the challenges and implementation issues of the system in Nigeria while Section 5 concludes the paper.

2. The History of Telemedicine

The purpose of this section is to present the history of telemedicine in a way to show how this new discipline, and its body of knowledge and practice, has developed and evolved. In particular, it will be useful in a way to understand some of the key experiences that have propelled the development of this new and challenging form of healthcare. By presenting the key examples that led physicians and other health professionals worldwide to make use of different forms of telemedicine, it also aims at showing what have been some of the key driving forces that have made possible the flourishing of telemedicine. This section follows closely the works of Sosa- Iudicissa, Wootton, and Ferre-Roca (2000) and Mahen, Whitten, and Allen (2001) among others.

Telemedicine technologies can be traced to the pre-electronic era. For example, wealthy families commonly sent urine samples to their doctors, who would use a urine chart to arrive at a diagnosis (Sosa-Iudicissa et al., 2000). This would be an early example of pathology. Teleprescribing was practised before postal services were established and there are well-documented examples (Jurin, 1726). The development of postal services in the mid-nineteenth century facilitated prescription by post: a sick person would write to an eminent physician enclosing his medical history. The physician's reply would include a diagnosis, directions for a regimen and a prescription (Porter & Porter, 1989).

Telephony that became widespread in the late nineteenth century was used for medical work from the beginning. It is still widely used for this purpose. However, the telephone can be used for other purposes than simple voice communication. The first trans-telephonic "electrical stethoscope" was demonstrated in England in 1910 (Brown, 1910), which was used to amplify the sounds from a stethoscope and transmitted them through the telephone network. Similar devices are still in use today to permit a physician to carry out remote auscultation using low-cost equipment. Other medical uses for ordinary telephone network include transmission of images and ultrasound images via a computer modem (Shaint, Cheng, & Greenbaum, 1996) and also the use of fax machines (Rollger, Irving, Broere, & Tranmer, 1997). Internationally, there has also been mounting interest in call centres and their use of modern telecommunications for the purpose of medical triage (Lancet, 2001). These initiatives originated mostly in the US in response to the need to reduce escalating healthcare costs (Fries et al., 1993). However, they became widespread in the early 1990s as part of a broader strategy by many US healthcare organisations to implement demand-management strategies focused on improving consumer health knowledge and preventing unnecessary use of expensive health resources.

These services, staffed largely by registered nurses, often act as gatekeepers for access to emergency healthcare services and provide telephone triage, recommending appropriate levels of care supplemented by advice on self-care and information about provider availability. In countries with large public healthcare

systems, such as the UK and Canada, gatekeeper functions are performed mostly with existing primary care services. Thus, potential indirect benefits such as improvement in service access and availability (especially after-hours) have made telephone triage a rational and popular policy initiative. The largest whole-of-population approach to date has been implemented by NHSDirect in the UK. This service began in 1997 and currently about 65% of the England has 24-h access (DOH, 1997). In the US 100 million people are estimated to have access to telephone triage, while in Ontario, Canada, the ministry of health and long-term care has instituted a similar approach for a population of more than 10 million people (Turner et al., 2002). In 1966, Australia followed the US, the UK and other developed countries in promoting the use of nurse-led telephone advice services. The core of these services is very similar: nurses follow computer-driven protocols to give advice about a wide range of problems related to acute minor illness (Roland, 2002).

Turner and colleagues reported the operation of a nurse-led telephone advice service in Australia, HealthDirect in Western Australia (Turner et al., 2002). The service has been widely used, with over 300,000 calls being received during the first 2 years of its operation. It operates from a dedicated call centre with 33 full-time-equivalent operational staff (48 nurses) and is available to the whole state, 24 h a day, 7 days a week. The 10 most frequently used guidelines of the service covered more than half of all the calls to HealthDirect, and more than half of callers were advised to contact their general practitioners. As in other countries, most callers were young adults or parents calling on behalf of children. There is some concern that the increasing use of telephone advice may disadvantage elderly and ethnic people, who found it less easy to use the telephone.

Healthcare planners are clearly interested to know whether these services will reduce the demand for existing healthcare services. Turner and colleagues found that HealthDirect has reduced telephone calls to hospital emergency departments. In the UK, a reduction in the number of calls handled by the emergency department staff coincides with the introduction of NHSDirect (Munro, Nicholl, O'Cathain, & Knowles, 2000).

In the early 1900s, radiocommunications were used for providing medical services to Antarctica (Sullivan & Lugg, 1995). The potential of radio to provide medical advice for seafarers was very quickly recognised, and by the 1920s most of the maritime nations had established services (Goethe, 1984). The Italian service, CIRM, for example, treated over 35,000 ship-borne patients by radio in its first 60 years of existence (CIRM, 1995). The growth in long-distance air travel in the second half of the century brought about a new medical problem: the provision of medical advice to passengers of the aircraft. In-flight medical incidents, which require professional assistance occur at a rate of about 1 in 50,000 passengers carried (Bagshaw, 1996). In cases where there is no doctor on-board, airlines maintain an on-call service by which aircraft captain can obtain radio medical advice from the ground (Sosa-Iudicissa et al., 2000).

The first use of close-circuit television, that is, interactive video communication in healthcare occurred in the 1950s, when the Nebraska Psychiatric Institute used a two-way interactive television system for telepsychiatric clinic consultations with Norfolk State Hospital, 112 miles away. This link was developed for educational, specialised treatment, and consultation between specialists and general practitioners (Wittson et al., 1961). Another experimental project became active in 1959, when a Canadian radiologist used images transmitted by coaxial cable for a diagnostic consultation (Jutras, 1959). In the late 1960s, a teledermatology demonstration project linked a polytechnic from Logan International Airport in Boston to Massachusetts General Hospital. Using an interactive audio-video system, physicians were able to deliver services by using gray scale screens to communicate relative degrees of erythematic (Murphy & Bird, 1974). The introduction of low-cost computing and digital communication has led to the development of videoconferencing. This has been used for telemedicine, for example, teleconsulting, initially with room systems and more recently with desktop systems (Grisgsby & Allen, 1997).

The recent development of mobile phones has allowed mobile telemedicine and research includes the transmission of slow-scan video pictures from ambulances (Curry & Harrop, 1998; Harrop & Curry, 1998). Wireless techniques also include the use of satellite communications. One of the uses of telemedicine in the third world was the use of low-cost satellite system to enable Internet access for healthcare workers. It linked urban medical centres to remote clinics and practitioners in nine African nations, the Philippines, and three countries in the Americas. The system provided e-communications and CD-ROM availability via the HealthSat satellites (LEO satellites, for a fraction of the cost of geostationary satellites (Groves, 1996; Ferguson, Doarn, & Scott, 1995; Garshnek, Hassel, & Davis, 1997).

Using off-the-shelf hardware components and a specially developed high-end wavelet-based interactive video communication software system, satellite networks for various applications of interactive telemedicine have been designed and developed. Based on the successful generic advanced low-cost trans-European network over satellite several projects such as medical assistance for ships; disaster emergency logistic telemedicine advanced satellite system; and Euro- Mediterranean Internet-satellite platform for health, medical educational and research are being currently realised (Graschew, Roelofs, Rakowsky, & Schlag, 2002; Saleman, 2002).

The National Aeronautics and Space Administration (NASA) was also central in the early development of telemedicine. Concerned about the effects of zero gravity on the physical conditions of astronauts, NASA had an early need to monitor vital signals during space missions. Fuelled by its successes, NASA supported the establishment of a comprehensive test-bed system known as space technology applied to rural Papago healthcare, this programme was incubated on the Tohono Odham reservation in Arizona. The programme tested satellite-based

communications designed to provide both the reservation and astronauts with a wide range of medical services (Fuchs, 1979).

NASA was also a pioneer in distributing advanced telemedicine technology following the devastating earthquake that struck Mexico City in 1985 (Garshnek, Hassell, & Davis, 1997). NASA maintained its interest in disaster assistance through telehealth technology. In 1988, NASA conducted the first international telehealth programme, known as space bridge now called space for Russia, to provide medical consultation to earthquake victims in Armenia. This programme was based on technology originally developed for astronauts (Garshnek, 1991; Llewellyn, 1995). Consultants used satellite-based communication to deliver one-way video, voice, and facsimile medical care from four medical centres in the US to a health centre in Yerevan, Armenia, in the areas of psychiatry orthopaedics, neurology, infections disease, and general surgey (Garshnek & Burkle, 1999; Nicogossian, 1989).

It is observed that the appearance of telemedicine solutions is usually associated with the need of addressing a particular unfulfilled necessity in terms of medical services, in the context of a nation healthcare system. The trend towards telemedicine comes from the rich, developed and industrialised countries. In developing countries, there is also a growing interest in the possibilities that telemedicine and telecare can offer in the context of their particular conditions of scarce human and material resources.

An important number of international initiatives have promoted the development of telemedicine at different levels. In Europe, important efforts have been made at the level of understanding the scenarios for the deployment of telemedicine solutions, and into the research, development, and testing various tools and resources. These efforts date back to the late 80s, under the auspices of the European community initiatives, advanced informatics in medicine and later on health telematics (Sosa-Iudicissa, 1991-1994; Laires, Ladeira, & Christensen, 1995; van Goor & Christensen, 1992).

Also at the international level, WHOand some of its branches analysed the potential of health informatics and telemedicine and provided guidance to member countries (WHO, 1997) and also its health-for-all policy for the 21st century: "health telematics".

A major worldwide initiative in this field has been the creation, under the auspices of the ITUBDT to look into the prospects of telemedicine and developing countries, which has since been adopted in October 1997 (ITU-BDT, 1997).

A technical implementation of Columbia university's informatics for diabetes education and telemedicine (IDEATel) project has been presented (Starren et al., 2002). The focal point of the intervention is the home telemedicine unit (HTU), which provides four functions: synchronous videoconferencing over standard

telephone lines, electronic transmission of fingerstick glucose and blood pressure readings, secure web-based messaging and clinical data review, and access to web-based educational materials. Providing these functions through HTU requires tight integration of six components: the HTU itself, case management software, a clinical information system, web-based educational materials, data security, and networking and telecommunications. With more than 400 HTUs installed, IDEATel has demonstrated the feasibility of large-scale home telemedicine.

Finally, nowadays, there are a very large number of patients who need specific health support at home. The deployment of broadband communication networks is making feasible the provision of homecare services with a proper quality of service. Guillen and colleagues presented a telehomecare multimedia platform that runs over integrated digital network and Internet protocol using videoconference standards H.320 and H.323, and standard TV set for patient interaction (Guillen, Arredondo, Traver, Garcia, & Fernandez, 2002). This platform allows online remote monitoring of electrocardiogram, heart sound, and blood pressure. Usability, affordability, and interoperability were considered for the design and development of their hardware and software components. The evaluation of technical and usability aspects were carried forward with 52 patients of a private clinic and 10 students in the university. Their results show a high rate in the global perception of users on the quality of images, voice, and feeling of virtual presence.

3. Internet-Based Telemedicine System Architecture

The main objective of this system is to provide efficient and convenient methods for the remote rural healthcare workers and physicians located at the cities to collaborate with one another over patient cases. It also allows the rural healthcare workers to send the patients' demographic and clinical data, X-rays and ultrasound images through the IP-based wireless telemedicine network for consultation and diagnosis of any patient's illness. This allows for a circumstance for patient's case diagnosis and consultation remotely. Others are to reduce healthcare delivery cost without loss of quality, increase the access to expert-supported healthcare services based in hospitals located in larger cities and mitigate the isolation of rural health workers by bringing them in regular contact with the physicians in the urban city hospitals.

This system consists of four major modules. These are Administrative, Consultations, Referral and Monitoring modules. The Administrative module consists of four sub-modules, which allow nurses to add/update patient demographic data, admit/discharge management, admission of drugs/injection for the patient and add payment made by the patients. The addition/update of patient's multimedia information sub-module is handled solely by the physicians and the remote rural health workers.

The major objective of this module is to improve the workflow of healthcare practitioners, both clinically and administratively. In essence, this will provide support for clinical and administrative services, investigation of request, result retrieval, diagnosis, treatment, drug prescriptions, etc. All the functions of this module will contribute directly towards on-the-ground support of medical practitioners, thereby allowing more accurate and informed diagnosis, more effective treatment and enhanced level of healthcare. The need for the transformation of patient data into an electronic format is driven by the necessity of obtaining patient's medical history during contact with a medical professional. This process often consumes a substantial portion of the practitioner's time, especially during episodic encounters with patients possessing a potentially complex case history. New information must also be recorded and integrated in an organised manner before an appropriate diagnosis can be attained and treatment administered. Ensuring the availability, accuracy and completeness of medical records will therefore be of great value to medical professionals.

3.1 Consultation Module

Bringing the benefits of the expertise of hospital-based specialists to the rural populace has been the goal of telemedicine systems. This system provides a store-andforward approach mechanism to enable consultation between the remote health workers and the specialists on any particular patient's cases. This approach is typically for non-emergent situations, when a consultation and diagnosis may be made in the next 24-48 h and sent back. This makes use of check boxes to include pertinent patient data such as a subset of his health history, clinical data, X-rays and ultrasound images which the rural health worker wants to transmit over the IP-based wireless telemedicine network to the queue server where the specialist could have them and respond accordingly. The rural health worker uses the check box of the consultation form to attach the pertinent patient's data to be forwarded to the appropriate specialist in the urban city. The consultation could also be between general physicians and specialists within urban cities on any complex situations. This is done with the objective of enhancing and extending basic work processes.

Apart from the stored-and-forward approach as stated above, an interactive two-way remote consultation and diagnosis between the patients in the remote rural areas, remote rural health workers and specialists in the urban cities is supported by using H.323 standard over an IP-based telemedicine wireless network. Using videoconferencing technology and specially adapted medical tools and devices interfaced to the computer, the remote specialist can see his patient, talk with the remote rural health worker, hear heartbeat through remote stethoscope, see images from ear through otoscope, nose, and throat or skin conditions or make some other remote measurements of vital signs through a device such as Tandberg's HealthCare System III (Tandberg, 2003). The interactive two-way remote consultation and diagnosis videoconferencing terminal is made up of a digital camera (to capture local live video), a display unit (to display remote video), a

microphone (to capture local audio), and speakers (to play remote audio). In addition to these obvious components, a videoconferencing terminal also includes medical digital devices, a codec, a user interface (a videoconferencing application software) and a computer to run on. Both the video coded and medical digital device are connected through the computer to the wireless telemedicine network. Multimedia data is transported over the wireless telemedicine network from remote rural location to the specialist in the urban cities in a real-time manner for consultation and diagnosis and the result of diagnosis is forwarded back in a real-time manner with prescriptions and the rest. The system is easy to follow, and provides step-by-step instructions for the medical health workers. The system does require the medical workers have minimal competence to use the system and this will be achievable through an intensive training.

Public telemedicine centres could be located within urban cities, where full interactive two-way remote consultation and diagnosis between remote patients in the public telemedicine centres and the specialists happen, to take care of immediate and emergency healthcare cases. The videoconferencing terminals are the same as the above. This approach also could be initiated in the Nigerian higher institutions in order to augment the institution's health services by allowing nurses in these institutions to consult with specialists. The system could also be initiated in correctional institutions, where the costs and danger of transporting prisoners to the hospitals can be avoided. However, the system is very patient-ready, easy to follow, and provides step-by-step instructions for the patient and does require that the patient to have minimal competence to use the system and in handling the medical equipment at his disposal.

Using videoconferencing techniques, it is possible to obtain a patient's medical history, diagnose patient, educate patient, and make prescriptions among others. The above scenarios mean that the patient does not have to travel to urban cities to see specialist, and in many cases, receive access to specialty care where none has been available previously. This also opens up new possibilities for continuing education for isolated or rural health professionals, who may not be able to leave a rural practice to take part in professional meetings or educational opportunities.

Home healthcare is common to many people's healthcare routine across the world, a situation whereby home-bound patients could communicate daily with specialists. An Internet-based telemedicine system in Nigeria has the capability to support a very large number of patients who may need specific health support at home. This is achievable through an interactive two-way videoconferencing that runs over ISDN or telephone line and Internet protocol using videoconferencing standards H.320 and H.323 and a TV for patient's interaction. The videoconferencing terminal setup in a patient's home consists of patient's existing TV set and remote control, an interface to TV, which also housed conferencing application software, and medical digital equipment. The multimedia data is transmitted through USB and RS323 ports to the telemedicine network. The video screens are very patient-ready, easy to follow, and provide step-by-step

instructions for the patient. The system does require the patient to have minimal competence to use the system and in handling the medical equipment at his disposal. Using this approach, it is possible to obtain patient's medical history, examine the patient for immediate healthcare, make remote measurements of vital signs, educate the patient and make some prescription if need be.

3.2 Referral Module

Referring a patient to another physician or another hospital is one of the most common transactions in healthcare. When a patient is referred, a subset of his record that is pertinent to that the referral is transmitted to the appropriate specialists or hospitals through the IP-based telemedicine network. This system provides a mechanism by which physicians can compose a package of referral information from the patient record and submit the same to the appropriate server queue. The process automatically processes the submission in order to select the appropriate specialists or hospital for the patient's condition based upon the information available.

The basic component of the Internet-based healthcare system's infrastructure is presented in Fig. 1. This includes a user interface made of access devices at the remote rural areas and urban cities, a high-speed, highly reliable and scalable regional network and content management gateway. This approach allows users to access the system through the Internet and a common content management gateway, which in turn takes request for any services from the users (physicians and other health professionals) and passes it to the appropriate backend systems.

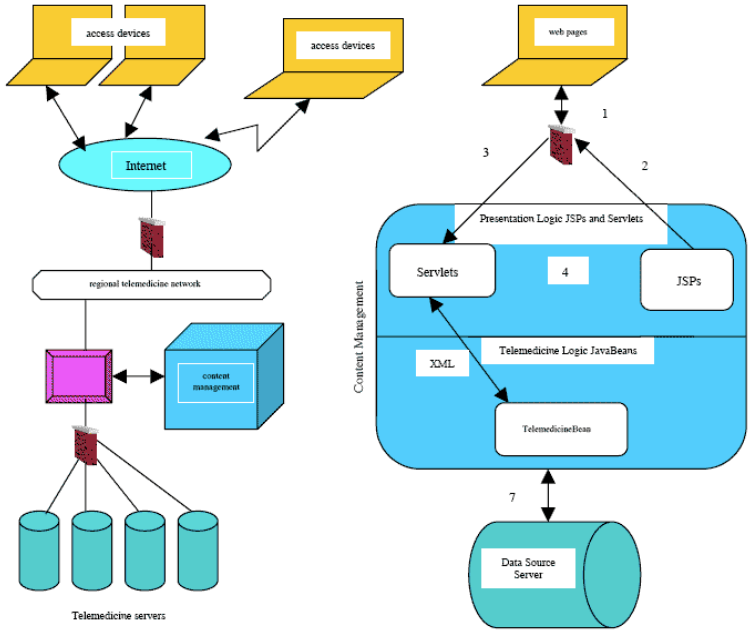

Figure 1: Proposed Internet-based healthcare system Infrastructure in Nigeria (click image to see larger view).

The common content management gateway provides a single point entry to the system via a URL. Once a user logged on, JSP presents the main module of the system to the user. Based on the user's selection and successful authentication, JSP presentation logic redirects the user to submodules or forms to perform the task selected by the user. Furthermore, a servlet provides the presentation logic for processing the service request, for example, submission of a form to register a new patient or update an already existing patient health history. This is invoked by the action of the user. It uses XMLTransform's methods to convert the HTML form data into XML documents. This conversion provides for structured data format that would be recognised by the backend systems in the hospitals.

After the data conversion, the servlet then invokes the TelemedicineBean. The Telemedicine- Bean provides a set of operations for JSPs and servlets to use when accessing the system. The servlet invokes, for example, the add/update method of the TelemedicineBean to add/update patient data into the appropriate backend system. In case a patient is to be referred, a form where the physician will specify the referral information from the patient data and others is presented. After the submission of the completed form, a servlet is invoked and it converts the HTML form data into XML document. This in turn invokes the TelemedicineBean referral methods to transmit and queue up the patient information into the appropriate queue server where the appropriate physician could have access to them. In both cases, it dynamically creates and returns to HTML page with the results of operation specified by the user to the browser.

4. Challenges and Implementation Issues

While Internet-based telemedicine system in Nigeria certainly has promises, there are a number of challenges and implementation issues, which may hinder it from delivering its promises to the citizenry. Therefore, to successfully implement and deploy the above system, the following challenges and implementation issues must be addressed.

4.1 Organisational and Cultural Inertia

Most government entities are not known for their efficiency or willingness to adopt changes. Organisational bureaucracy and lack of clear communication channels or collaboration culture are some of the difficult problems to resolve before this system can become successful. Organisational and cultural changes often are more difficult than technological changes.

4.2 Security and Privacy

Developing an Internet-based telemedicine system allows the exchange of patients data electronically among physicians and hospitals. These exchanges make security one of the highest priorities, that is, allowing healthcare professionals to have access to patients data while also ensuring that their privacy

becomes a necessity. Security and privacy have different implications. Privacy is a matter of policy decisions, while security has to do with the tools to implement the policy. Internet security involves the applications of both non-technical and technical counter-measures. The non-technical means of pursuing Internet security include formulating a corporate security policy and educating and training users about that policy. On the other hand, major technical measures consist of access controls, authentication, encryption, firewall, audit, anti-virus tools, and self-assessment. Current e-commerce security technologies such as digital certificate, data encryption, and public key infrastructure methods could be adopted in securing the system presented in this paper.

4.3 Technology and Information Change

Most government entities are not taking advantage of existing information technology opportunities and most existing information systems are inadequate to meet the requirements of the new models of healthcare being deployed in the context of health-reform initiatives. Besides the common perception among physicians that health information systems are mostly a source for scientific and technical information, often public health authorities have a view of clinical-administrative information systems that they are obsolete and frozen in a "statistical-epidemiological" archetype, designed for the collection of numerical data representing only counts of events and mostly generating only highly aggregated statistical data and time series related to mortality, morbidity, and to service utilisation and coverage. Those information systems have very little practical interest to direct-care professionals and unit managers and are far behind in providing the logistical and longitudinal individual client-based data required to operate and manage the sort of healthcare models being deployed in many countries.

Worse still, most public health authorities are totally oblivious to the broad variety of possibilities offered by modern information and communication technologies to manage clientbased data, support operations, and mine large databases. Indeed, the health sector has not applied the range of options provided by information and telecommunication technologies effectively and health has been conspicuously under-represented in national technologydevelopment policies and plans.

As a counterpoint to the passiveness of the public sector, private providers and health groups recognised that a "different" type of information system and data elements are required to run their organisations and survive in a competitive environment driven by increasing consumer demands and expectations and to deliver personalised evidence-based services. Besides using information technology resources to boost productive specialisation (such as allowing the efficient use of diagnostic services and consultations, maintenance of integrated records, reduction in the number of specialists, and attainment of economies of scale by linking to national and international markets), there are many new areas

of application that are rapidly gaining ground and reducing care costs while improving the continuity and quality of care. The lack of involvement of government at all levels in the use of information technology is worrisome. This may hinder the deployment of the system if government at all levels continues with this kind of lukewarm attitude towards information technology.

4.4 Lack of IT Funding and Human Resources

Some government units (local, state, and federal) are affluent, but most are not. IT spending often is not a priority and one of the most significant barriers to telemedicine implementation is cost. The start-up costs for telemedicine infrastructure are high. Despite a dramatic reduction in per-unit cost over the past years, start-up investment and maintenance costs of a telemedicine network are still high. Also, technology becomes obsolete quickly. Pressure on the appropriate government will surely increase as more people realise the benefits of telemedicine. This will prompt government to set aside a large sum of money for the implementation of the system. Furthermore, IT personnel often lack resources for training and reeducation to update their technical skills. A lot of training is needed to be carried for the health workers in Nigeria if this system is to work. Many of the health workers have never touched computer in their life and are afraid of coming near one; hence the need for a thorough training for the health workers.

Lack of telecommunication infrastructure at the remote rural areas may also be a barrier to this system. In many rural areas, no telecommunication infrastructure is present. To overcome this problem, radiocommunication equipment could be used to connect the remote rural areas to the regional network.

5. Conclusion

Telecommunication technologies are being used to change the healthcare industry in unprecedented and irreversible ways. These technologies are enabling delivery of healthcare to remote patients and facilitating information exchange between generalists and specialists. For many decades now, the use of advanced telecommunications and information technologies has been investigated in an effort to improve healthcare. In this paper, an Internet-based telemedicine system is developed for Nigeria. The establishment of this system is to enhance citizen's equality in the availability of various medical services and clinical healthcare, which are currently being enjoyed by the citizens living in the urban cities where well-equipped hospitals and scarce experts are distributed. It is also to support consultations among physicians over patients' cases and thereby improving the quality of healthcare services in the remote rural areas and provide a secure access to remote patient data. The system is still under development but the author intends to refine the system to enable private hospitals to participate in the consultations and extend the system to include home-based healthcare.

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