

Telemedicine: Definition, Benefits And Limitations

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ABSTRACT

Advances in information and telecommunication technology have brought about new opportunities and capabilities to the delivery of health care services, but these are not without limitations and threats. Telemedicine encompasses any medical activity involving an element of distance and telecommunication in doctor-patient interaction. It may serve as a valuable tool for providing much needed medical services to underserved rural areas in resource poor countries. It allows better utilization of scarce medical personnel and resources and promises to enhance continued medical education of young doctors, nurses and other health care practitioners in rural areas, both in training and in established practice. A practical, cheap "store and forward" electronic mail-based communication may be used to send patient data with image file attachments for expert consultation any where in the world. Issues of major concern in telemedicine are related to security and confidentiality of patient data. The cost of establishing telemedicine in resource poor countries must be balanced against need for drugs, medical equipment and training. There is need for national and international central control bodies to license and supervise telemedical practice. This paper reviews aspects of telemedicine including its clinical applications, cost effectiveness and limitations.

INTRODUCTION

Although telemedicine has been practiced for over two decades, the majority of its applications have been in developed countries compared with developing countries. Healthcare systems in most resource-poor countries are characterized by a concentration of curative and specialist health services in urban areas and limited access to basic health in the largely rural population^{1,2}.

Medical education and medical practice including diagnosis of illness, management of patients and running of health services are information and communication intensive. The inability of developing countries to provide adequate medical services is clearly related to the lack of capital, facilities and systems. Roads and transportation are inadequate and difficulties in transferring patients needing expert service are often encountered.

There is an acute shortage of medical specialists in many developing countries. In sub-Saharan African countries, there are on average less than 1 physician per 10,000 populations, compared with 20 in some developed countries, and 14 countries do not have a single radiologist^{3,4}. Millions of people in resource-poor countries

dermatologists, and pathologists. Specialists are concentrated in few major cities and in tertiary health institutions mostly located in the cities. Specialists usually decline employment in rural hospitals because of lack of basic amenities such as electricity, water supply and adequate housing and poor remuneration. Small hospitals with some basic equipment for investigation and treatment are run by a few general practitioners, general physicians and at times a surgeon, often supported by rural healthcare workers and nurses. These rural hospitals, which serve most of the population, are isolated from specialist support and ongoing training by poor roads, scarce and expensive telephone services and lack of library facilities.

These realities constitute a major threat to health and to help address some of these inequalities, the UN Secretary General Kofi Annan has proposed the setting up of 10,000 telecenters for health information in developing countries, to help bridge the healthcare gap between the rich and poor⁵. Specialities that lend themselves well to telemedicine include teleradiology, telecardiology, teledermatology and telepathology⁶.

Telemedicine offers the potential to alleviate the severe shortage of medical specialists in resource-poor areas and is an effective means of improving access to, and quality of medical care at lower cost. In particular, telemedicine may be seen, as a valuable tool for providing much needed medical services to underserved rural health facilities which serve most of the population. It promises to enhance continued medical education of our young doctors, nurses and other health care practitioners in rural areas, both in training and in established practice^{3,4,5}.

As computers and Internet access become more common and cheaper, telemedicine is likely to become a popular mode of exchange of medical knowledge and expertise. Currently all 54 African countries have some internet connectivity, and wireless networks are reducing connection costs^{2,5,6}. In Nigeria, every major city in all state capitals has internet cafes that are accessible to the public. This article, based on extensive literature review aims at discussing the clinical applications, cost effectiveness and limitations of telemedicine with special emphasis on developing countries.

What is Telemedicine?

Telemedicine can be broadly defined as the use of information and telecommunications technologies to provide medical information and support health care services at a distance^{7,8,9}. In a general sense the term covers any form of diagnostic or therapeutic medical activity or consultation carried out at a distance. In telemedicine applications, multimedia data are exchanged, including text, still images,

audio and video. Approximate synonyms for telemedicine include "telehealth", "on-line health", "e-health" and "telecare".

How does Telemedicine work?

With telemedicine diagnosis and therapy are performed by an expert at a remote location from a patient whose data (text or images) are transmitted electronically. Unfortunately, although telemedicine has been practiced for decades, the majority of the applications have been in developed countries. Throughout the world but particularly in resource poor countries, health care professionals generally lack knowledge about the possibilities and limitations of the information technology. They are often asked to use computer systems they have limited appreciation of, and could enhance their practices via better use of information resources. Telemedicine may be interactive or non-interactive. In its simplest and basic form telemedicine involves exchange of information on patients between medical professionals through telephone or by fax. In developing countries telephone services are unreliable and expensive and facsimile (fax) communication also depends on telephone.

Interactive Telemedicine

Originally telemedicine involved real-time interactive specialty consultations via video conferencing technology and made its debut about 4 decades ago in Nebraska, U.S.A where it was mostly used to support neurologic and psychiatric services²⁰. It became popularized through the early 1990s and principally involves direct real-time interaction between the participants during consultation. Interactive telemedicine requires fast network access, specialist equipment and suitably trained personnel, which may not be affordable in resource poor countries.

E-Mail-based (Store-and-forward) Telemedicine

This is the most common form of non-interactive telemedicine^{11,12}. The electronic mail is one of the most popular applications of the Internet used for communication. It is cheap compared with telephone, fax or courier or traditional postal services. However, the e-mail is only suitable for asynchronous communication, without direct real-time interaction between the participants. Electronic mail in addition to sending text messages may be used to transfer multimedia and privacy enhanced messages including still images, video and audio in a store-and-forward fashion. Clinical photographs, pathology and radiology and ultrasound images may be exchanged. The message is composed, attachments made, saved and forwarded to the recipient. It reduces the time that specialists have to spend waiting for a connection to be made and actually reviewing the cases as is the case with interactive telemedicine. Teleradiology, telecardiology, teledermatology, telepathology and teleophthalmology are some of the specialties with extensive telemedicine practice^{21,22,23}. Medium- to high-resolution digital cameras can capture different types of diagnostic images, such as radiographs, computed tomography and ultrasound scans including echocardiography, ECGs, pathological images and clinical photographs. The digitized image can be attached to an e-

mail with case history and sent for teleconsultation^{13,24}. Large image files such as X-rays may be compressed into JPEG format before transmission. Remote expert consultation is used mostly for diagnosis of rare pathologies or difficult differential diagnoses and provides continuing education for the referring physician.

Web-based Telemedicine

The World Wide Web (WWW) is another popular application on the Internet that facilitates access to information available at sites distributed throughout the world^{14,15}. This permits access to formatted pages and graphics of knowledge databases including journal, teaching materials and evidence-based medical and clinical information. Challenges common to medical education in Africa include lack of current textbooks, limited library and laboratory facilities, and shortage of teachers. Web-based medical communication allows better utilization of scarce medical personnel and resources and promises to enhance continued medical education of our young doctors, nurses and other health care practitioners in urban and rural areas, both in training and in established hospital practice. Apart from medical education, clinical research especially those involving multiple centers can be coordinated through web-based applications. Clinical trials apply e-mail to coordinate and communicate with remote sites involved in the trial and Web sites databases is appropriate for multicenter data collection, disease registries and for electronic medical record systems. Presently real-time and "store and forward" telemedicine, often involves a specialist or referral center, usually teaching hospitals as the monitor site, while nurses and general practitioners run the on site practice. It is the onsite healthcare provider that takes final decision on the management of the patient.

Cybermedicine

Cybermedicine is a variant of web-based telemedicine in which the clinician establishes his practice on the web and performs teleconsultation, telediagnosis, and teleprescription for remote patients. The online physician is entirely responsible for the diagnosis and treatment of the remote patient that consulted his services. Cybermedicine raises far much more ethical and legal issues than the other types of telemedicine¹⁶.

Other Applications of Telemedicine

Apart from remote /rural areas, telemedicine may be the only alternative on spacecrafts, submarines, ships, planes, high altitude and in battlefields and prisons^{14,16}. Real-time remote monitoring of physiologic parameters of astronauts has been in use by the United States National Aeronautics and Space Administration (NASA) since the 1960s. Similar technology has been used to monitor athletes in training and mountain climbers. Physiologic variables such as core temperature, pulse, respiratory rate, blood pressure, pulse oximetry data and electromyographic activity can be recorded, stored and transmitted in real-time for data analysis and intervention.

Real-time and store-and-forward remote monitoring of home health care and disease management have become appealing with increasing frequency of chronic diseases

such as congestive heart failure, diabetes mellitus, chronic lung diseases and the need to reduce cost from prolonged or repeated hospitalization and home care visits^{17,18}. Home-based monitoring devices connected to specialized computer modems can now reliably measure and transmit patient data such as blood pressure, heart rate and blood glucose level. Transmission of such data by ordinary telephone is practical and patients with limited education can successfully use these technologies. Some of these monitoring systems may require web-sites to link patient and physician, nurse or other personnel, while others automatically store, forward and analyze transmitted data and alert patients and physicians to abnormal findings or provide web-based information to support self-care; otherwise data are archived. Other systems are more interactive and require regular telephone calls by a nurse. These technologies which are mostly used in developed countries are appealing because they are considered relatively inexpensive, increasingly convenient for patients and care providers and have the potential to cut cost of care while improving outcome.

Security and other Issues in Telemedicine

Telemedicine has been shown to have both clinical and cost effectiveness, and it holds the promise of improving access to health care particularly in areas where there are geographical barriers and of reducing cost. Although the positive aspects and potentials are impressive, it is not without limitations and risks²⁰. The amount and accessibility of data stored in databases will increase as computer networks are popularized. Improved accessibility may be a threat to privacy and confidentiality of patient data. Typical internet e-mail systems do not provide adequate security and confidentiality for clinical data. Confidentiality is violated when data pass to wrong or unauthorized users, either on purpose or accidentally, within or outside an organization. Although passwords may be used to ensure only authorized users, they may be obtained by illegal ways, by copying or trying different passwords until the correct one is found. Cryptographic techniques, which make data illegible by means of secret encoding, are increasingly being used to transmit patient data and some incorporate user identification at their terminals using magnetic cards or chip cards. Secret encryption where the sender uses a key or password to encrypt data is a standard e-mail approach commonly available and the receiver uses the same key to unencrypt the data. "TeleMedMail"²¹ is free telemedicine software that provides a simple unified approach to organizing clinical data and images, transmitting them by e-mail. It provides JPEG or wavelet compression, encryption for security and can link to electronic medical system if available.

The issue of cost of information technology and telemedicine remains paramount and crucial for resource poor countries and emphasizes the need to use non-proprietary technology to transmit data.

CONCLUSION

Telecommunication technologies clearly have a potential to improve the desperate shortage of medical information and expertise in Africa. A wide spread use of telemedicine services could allow universal health access

and consequently facilitate solutions to principal health problems connected with infectious diseases, paediatric cardiology e.t.c. It is hoped that as physician disinterest is overcome, and as they become more comfortable with e-mail, the Internet and other computer uses, and as telemedicine vendors and advocates devise more convenient and affordable technology, telemedicine will be popularized in resource poor countries. However, important questions regarding the medical and cost-effectiveness of remote health monitoring and other issues related to telemedicine applications including security of patient data should be further evaluated as research clarifies their benefits, limitations, and costs. Furthermore, the cost of establishing telemedicine in resource poor countries must be balanced against the need for drugs, medical equipment and training.

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