Research Article | **June 2019**

Telemedicine: A Primer (Part 1)

Matthew N. O. Sadiku, Mahamadou Tembely and Sarhan M. Musa

Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX 77446, United States
Email: sadiku@ieee.org; matembely@pvamu.edu; smmusa @pvamu.edu

Abstract— Telemedicine literally means "healing at a distance." The rise of the Internet age and the proliferation of smart devices have brought profound changes for the practice of telemedicine. Telemedicine is now regarded as the use of information and telecommunication technology (ICT) to provide patients with health care at a distance. It is a new fascinating development that enhances the level of medical services. Telemedicine holds the promise of significant changes within the healthcare industry since it offers an opportunity to attract and retain consumers. This paper provides a primer on telemedicine.

Keywords— telemedicine, telehealth, teleeverything, ICT

I. INTRODUCTION

The marriage between information technology and science-based medical knowledge has given birth to telemedicine (also known as telehealth or ehealth). Telemedicine (TM) may be regarded as the transmission of medical images between healthcare centers for diagnosis across distance.

It is an opportunity to meet people where they are at and ensure that they are receiving the care they need. It has been used to overcome distance barriers and to save lives in critical care and emergency situations.

Telemedicine's major goal is to bring medical services to isolated, geographically dispersed, and physically confined persons unable to reach a physician within reasonable time or distance. This new modality of healthcare delivery is gradually finding its way into the mainstream medicine. Telemedicine should now be regarded as an integrated component of the care continuum.

Telemedicine is closely related to telehealth; the two are often used interchangeably. Telehealth is an umbrella term that covers the technologies that provide support for long distance clinical healthcare. Telemedicine, on the other hand, refers to the remote delivery of clinical care through communication technologies. Telemedicine applications and services include email, video, wireless tools, smart phones, etc. Examples of telemedicine include group therapy, nursing interactions, education and training, televisits to community health workers, follow-up visits, management of chronic conditions, medication management, specialist consultation, and medical image transmission [1].

II. CONCEPT OF TELEMEDICINE

Telemedicine refers to the use of electronic information and communications technology (ICT) to provide medical services when distance separates the patient and health practitioner. It allows healthcare professionals to evaluate, diagnose and treat patients at a distance using telecommunications technology. It uses video cameras and monitors to connect the patient and the health care providers.

Modern telemedicine began in the early 1900s in the Netherlands with the transmission of heart rhythms over the telephone. Today, telemedicine is used in a variety of specialties including radiology, neurology, and pathology. It is rapidly expanding to serve millions of people and providing health services for individuals living in remote and rural areas. Telemedicine manifests itself in a number of ways, all of which are centered arounddata transfer and communications.

According to the Center for Connected Health Policy (CCHP), there are four categories for tele use today. In other words, the practice of telemedicine can be broken down into four types of solutions: store-and-forward, patient telemonitoring, real-time telemedicine, and mobile health [2].

- *Store-and-Forward Telemedicine:* This is also known as "asynchronous telemedicine." It is a method by which healthcare providers share patient medical data. It is asynchronous in the sense that the consulting specialist, patient, and primary doctor do not need to all be communicating simultaneously. Store-and-forward solutions enable healthcare providers to forward and share patient medical data with a provider at a different location. All sorts of medical data (e.g. lab results, medical images, bio-signals) can be transmitted across vast distances.

- *Patient Telemonitoring:* This allows healthcare providers to monitor patients' health data from a far, usually while the patient is at home. It allows healthcare professionals to track a patient's vital signs and activities at a distance. It can be used by diabetics and elderly patients.
- *Real-time Telemedicine:* This makes it easy to do a doctor-patient visit anytime, anywhere. Using the method, patients and providers use video conferencing software to hear and see each other. It is popular for primary care, urgent care, follow-up visits, and the management of medications, and chronic illness. This may involve the use of robots and other technologies to allow a medical practitioner to perform a procedure at a certain location.
- *Mobile health:* Mobile health (or mHealth) refers to the practice of medicine via mobile devices such as mobile phones, tablet computers, personal digital assistants (PDAs), and wearable devices. It integrates mobile technology with the health delivery with the promise of promoting a better health and improving efficiency. MHealth services propose healthcare delivery anytime and anywhere overcoming geographical barriers with low and affordable costs. Challenges such as privacy concerns have limited the impact of mHealth, but it has enormous potential to reshape healthcare delivery in the future [3]. Patients are beginning to use mobile technology to monitor and track their health.

III. APPLICATIONS

Telemedicine seeks to improve a patient's health by allowing real time interactive communication between the patient and the practitioner at the remote site. It does not represent a separate medical specialty; it is a tool that can be used by health practioners to extend the traditional practice of medicine to a distant location.

Telemedicine is a "teleeverything" phenomenon as evident in various applications and services which include telehealth, telecare, telenursing, telepharmacy, telesurgery,teleradiology, telepsychiatry, teledermatology, teleconsultations, telenephrology, teleobstetrics, teleoncology, teledentistry, teleaudiology, telerehabilitation, teleophthalmology,teletrauma, teleneuropsychology, telecardiology,telepediatrics, remote monitoring of patients living with chronic conditions, online continuing medical education, and online provision of medical and health information to patients. The frequency of application of telemedicine to the various specialties is given as follows [4]:

- Radiology - 37%
- Emergency Medicine - 22%
- Pathology - 11%
- Cardiology - 9%
- Internal Medicine - 7%
- Dermatology 4%

Some of these are explained in detail below [5].

- T*ele-consultation*: Telemedicine makes real-time medical consultation via two-way videoconferencing. This is provision of knowledge or experience of an expert across distance. It may also involve diagnosis at distance of a patient by a physician at distance (e. g. telecardiology). Provider-to-provider consultation may take place within the same healthcare system. It is estimated that the number of telemedicine consultations will reach 160 million cases by 2020.
- *Remote Clinics*: Governments have taken the lead in setting up telemedicine clinics around the world. This is a new way of providing specialty medical services to people living in remote, usually rural communities. Video clinics have also been reported to be well received by the patients.
- *Online Booking:* Outpatient clinic appointment bookings can improve patient experience. The booking can be done using emails or texting. Appointment confirmation is sent now by text messages rather than the traditional letter.
- *Home-monitoring:* Care services at the home of the patient (e. g. for elderly patients, diabetics) "care at home" Home monitoring may confer improvement in cost-effectiveness and quality of care.
- *Telemonitoring:* Supervision of a patient and his data at distance, who is not in the hospital and/or clinic (e. g. diabetes patients, veterans, patients with heart insufficiencies)
- *Tele-learning*: This involves education and training of patients and/or professionals at distance. Telemedicine can also facilitate medical education by allowing workers to observe experts in their fields and share best practices easily. For example, some trauma centers are delivering trauma lectures to hospitals and health care providers worldwide using video conferencing.
- *Developing Countries:* Telemedicine allows a rapid deployment of healthcare in developing nations. Instead of building and staffing large number of facilities, telemedicine allows clinics to consult at anywhere in the world.

IV. BENEFITS

Telemedicine can transform the future of medicine in both rural and urban settings. The benefits for both patients and healthcare providers have greatly contributed to the rapid spread of telemedicine [6].

- *Convenience*: It is more convenient, accessible care for patients. It is increasingly becoming a tool for convenient medical care. It reduces the cost and inconvenience of traveling.
- *Cost Saving*: It may save money for both patients and physicians. With a full suite telemedicine software, you don't need a physical clinic to practice medicine.
- *Affordability*: The patients need no transportation time or costs. Thus, telemedicine is regarded as a cost-effective alternative to the more traditional face-to-face way of providing medical care.
- *Accessibility:* It has the ability to provide healthcare to a patient, regardless of the patient or provider's location. It is easier for patients to access care when they need it where they are at, whether that's at home, office, school, etc. in a way that traditional care delivery settings cannot.
- *Improves Care Quality:* The quality of healthcare has risen whenever telemedicine is deployed. Telemedicine can provide access to scarce specialist care (shortage of health professionals) and improve the quality of care in rural areas.
- *Shortage of Clinicians*: Telemedicine systems are regarded as a necessary measure to alleviate the shortfall in skilled medical specialists in developing countries [7].
- *Rural Health:* Telemedicine can be of a great help in the remote areas. It connects patient and specialized doctors remotely. It can facilitate the delivery of healthcare services to rural areas. For rural and underserved areas in particular, telemedicine can reduce transportation problem.

V. CHALLENGES

In spite of these benefits, telemedicine is yet to become the go-to place for healthcare.

Challenges related to telemedicine may range from technical limiting barriers to ethical and patient confidentiality concerns.

- *Technical Training and Equipment:* Like most technology solutions, telemedicine requires some training and equipment purchases. Some critics of telemedicine argue that online interactions are impersonal. Many physicians and patients alike still like a "personal touch."
- *License Restriction*: Healthcare providers currently obtain their medical licenses to practice in a specific state. A specialist based in Texas is not legally allowed to treat a patient in Florida. This creates a problem for telemedicine.
- *Limited reimbursement:* Its widespread use has been limited by low reimbursement rates and interstate licensing issues. State legislation determines the restrictions and reimbursement rates for telemedicine services. Telemedicine reimbursement is a major challenge.
- *Malpractice:* There is risk of data breach with any Internet-based service. Can a bad audio connection still make a doctor liable?
- *Cultural barriers:* A majorchallenge is a complex of human and cultural barriers. This may occur from the lack of desire, or unwillingness, of some physicians to adapt clinical paradigms for telemedicine applications.
- *Legal considerations:* These are a major obstacle to telemedicine uptake. These include an absence of an international legal framework to allow health professionals to deliver services in different states or countries.
- *Complexity:* It is regarded as a technology that is hard to use. As medicine and technology have become sophisticated over the years, telemedicine has become complex. Needless to say, telemedicine requires patients to be familiar with the Internet. There is also the problem of incompatibility of telemedicine systems.
- *Privacy and Confidentiality:* In all nations, issues related to confidentiality, dignity, security, and privacy are of ethical concern. Although security, privacy, and confidentiality issues also exist in traditional healthcare, the electronic recording, storage, and retrieval of patient sensitive data in a telemedicine system increase opportunities for infringing on patients' rights. Financial cost also poses a barrier to the adoption of telemedicine in developing countries.

VI. CONCLUSION

Telemedicine refers to the delivery of clinical services at a distance. It is a fertile field that has dramatically altered the face of healthcare in a relatively short amount of time. It is revolutionizing traditional healthcare. If properly designed, implemented, marketed, and used appropriately, telemedicine can enhance the quality of life, independence, and quality of care of many persons with disabilities. More is still expected, especially when it comes to providing telemedical service for developing countries.

As technology continues to improve and decrease in cost, telemedicine will improve research, education, access to care, emergency response, and the delivery of general medicine. Telemedicine will continue to benefit the healthcare system in developing nations in terms of preventive care and disease treatment. As a technology that is transforming the entire healthcare infrastructure, telemedicine is here to stay. More information about telemedicine can be found in the books in [8-14] and the following journals devoted to it:

- *Journal of Telemedicine and Telecare*
- *International Journal of Telemedicine and Applications*
- *Telemedicine Journal and e-Health*
- *Telemedicine Today*

REFERENCES

[1] H. A. Aziz And H. Abochar, "Telemedicine," *Clinical Laboratory Science*, vol. 28, no. 4, October 2015, pp. 256-258.

[2] "Types of telemedicine,"https://chironhealth.com/definitive-guide-to-telemedicine/about-telemedicine/types-of-telemedicine/

[3] M. N. O. Sadiku, A. E. Shadare, and S.M. Musa, "Mobile health," *International Journal of Engineering Research,* vol. 6, no. 11, Oct. 2017, pp. 450-452.

[4] L. J. Moore, "An investigation into the impact of telemedicine on the veterinary practitioner," *Doctoral Dissertation,* Auburn University, 2001.

[5] "Examples of telemedicine,"https://www.dgtelemed.de/de/telemedizin/anwendungsbeispiele.php

[6] "The ultimatetelemedicineguide | What is telemedicine?"https://evisit.com/resources/what-is-telemedicine/

[7] K. I. Adenuga, N. A. Iahad, and S. Miskon, "Towards reinforcing telemedicine adoption amongst clinicians in Nigeria," *International Journal of Medical Informatics*, vol. 104, 2017, pp. 84-96.

[8] A. C. Norris, Essentials *of Telemedicine and Telecare*. John Wiley and Sons, 2002.

[9] A. Kamenca, *Telemedicine: A Practical Guide for Professionals.*MindView Press, 2017.

[10] S. B. Bhattacharyya, *A DIY Guide to Telemedicine for Clinicians.* Springer,2017.

[11] A. C. M. Fong, B. Fong, and C. K. Li, *Telemedicine Technologies: Information Technologies in Medicine and Telehealth.* John Wiley & Sons, 2010.

[12] G. W. Shannon and R. Bashshur, *History of Telemedicine: Evolution, Context, and Transformation*. Mary Ann Liebert, 2009.

[13] A. W. Darkins and M.A. Cary, *Telemedicinae and Telehealth: Principles, Policies, Performance and Pitfalls*. London, UK: Springer, 2000.

[14] R. Wootton and J. Craig (eds), *Introduction to Telemedicine.* London, UK: Royal Society of Medicine, 1999.

ABOUT THE AUTHORS

Matthew N.O. Sadiku (sadiku@ieee.org) is a professor at Prairie View A&M University, Texas. He is the author of several books and papers. He is a fellow of IEEE.

Mahamadou Tembely (matembely@pvamu.edu) received his doctoral degree from Prairie View A&M University, Texas. He received the 2014 Outstanding MS Graduated Student award for the department of electrical and computer engineering. He is the author of several papers.

Sarhan M. Musa (smmusa@pvamu.edu) is an associate professor in the Department of Engineering Technology at Prairie View A&M University, Texas. He has been the director of Prairie View Networking Academy, Texas, since 2004. He is an LTD Sprint and Boeing Welliver Fellow.