



A Review of the Effectiveness of Telemedicine Technologies

Olivia Andreea Marcu¹, Radu Fodor^{2*}, Mihai-Ştefan Muresan^{3,4}

¹*Department of Preclinical Disciplines, Faculty of Medicine and Pharmacy, University of Oradea, Oradea, Romania.*

²*Doctoral School of Biomedical Sciences, Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania.*

³*7th Surgery Department, 'Iuliu Hatieganu' University of Medicine and Pharmacy, Cluj-Napoca, Romania.*

⁴*Medicover Hospital, Suceagu-Cluj, Romania.*

ABSTRACT

The exchange of medical information through information and communication technologies is called telemedicine, which provides access to medical services at the patient's homes. This service is easily available for people who live in remote areas or people who have chronic diseases and need long-term care. The purpose of the present study was to evaluate the effectiveness of telemedicine technologies. To provide medical services, telemedicine has become an effective method in health care and education in health fields. It has various implementations in different countries in the form of surgery, nursing, genetic counseling, pharmaceutical care, home care, rehabilitation, psychology, Cardiology, radiology, dentistry, pathology and dermatology, remote ophthalmology, and audiometry all used to treat injuries. In this article, some telemedicine implementations in various fields have been introduced in recent years and their effectiveness in preventing deaths, treating diseases, and reducing costs have been investigated. The use of telemedicine can be a practical solution in the field of diagnosis and treatment of various diseases to overcome time and space limitations. This technology has also maximized self-control and management of clinical symptoms by motivating patients and providing screening programs and improving health status.

Keywords: Telemedicine, Communication technologies, Medical information, Medical services.

HOW TO CITE THIS ARTICLE: Marcu OA, Fodor R, Muresan MS. A Review of the Effectiveness of Telemedicine Technologies. *Entomol Appl Sci Lett.* 2023;10(2):25-31. <https://doi.org/10.51847/zmWyZ4cpPs>

Corresponding author: Radu Fodor

E-mail ✉ dr.radu.fodor@gmail.com

Received: 10/03/2023

Accepted: 16/06/2023

INTRODUCTION

Telemedicine is the provision of health care services using information and communication technology in situations where health care professionals and the patient are not present, and the safe transmission of medical information through sound, image, prevention, diagnosis, treatment, and follow-up of the patient's condition [1-4]. This technology has moved health care from clinics and hospitals to the home and has provided the possibility of transmitting relevant information in various formats such as text, audio, or image [5, 6]. Since this technology is based on the principle of "regular monitoring of physiological symptoms", any change in the

clinical symptoms of patients can be a warning about the deterioration of their condition, so using remote medical technology to evaluate and monitor clinical symptoms can reduce the rate hospitalization and death of patients [5, 7-9].

In many developed countries, with the increase in chronic diseases and the aging of the population, the demand for medical care has also increased, and on the other hand, the demand for people to transfer health services from hospitals to patients' homes has also increased. Such cases have made these countries face new challenges in providing health services [10-12]. With the rapid development of information and communication technologies (ICT), telemedicine methods have become an option to solve these challenges [13-

15]. Telemedicine reduces the limitations of distance and provides access to medical services at the homes of patients, especially those who live in remote areas. Telemedicine is also used in emergencies and health care related to chronic diseases [16-18].

In this method, different applications such as video conferencing, e-mail, smartphones, wireless devices, and other communication methods are used to transfer information. For example, providing advice to the patient through video conferencing, sending images related to the patient's condition, remote monitoring of vital signs, and telephone consultation centers with nurses are considered in the field of telemedicine [16, 19, 20]. Presently, telemedicine has become an effective method for providing medical care as well as distance education and in the form of various implementations such as Telenursing, Telerehabilitation, Teletrauma care, Telecounseling, E-learning, Teleradiology, Telepharmacy, Teleaudiology, Telepathology and teledermatology, Teleophthalmology, and Teledentistry are used [11, 21-24]. For this purpose, in this review article, the applications of telemedicine in recent years have been introduced, and then the extent of their impact on the treatment of diseases, prevention of deaths, and cost reduction have been examined.

Applications and implementations of telemedicine

In this section, some successful telemedicine implementations that have been used in recent years in developed countries are introduced:

In the last decade, caring for middle-aged people with cognitive impairment has become a huge challenge that telemedicine has come to help. Currently, an intelligent system called TSH has been introduced to help these patients, which prevents the occurrence of situations that endanger the lives of patients, especially patients with Alzheimer's. This system includes a set of hardware and software that maintains and processes information related to the patient. This system is monitored by people such as nurses, relatives, or family doctors to help the patient when the system announces the possibility of danger [25]. In one implementation, researchers used video conferencing in genetic counseling. In this study, patients performed their genetic counseling in a clinic or development center and communicated with a genetic counselor through

video communication. The examination of this method showed a high level of patient satisfaction, and most of the patients after using this method wanted to use the remote genetics method instead of face-to-face counseling. In addition, the results showed that remote genetics is a useful tool for routine consultations and disease assessment of children with suspected genetic conditions [26].

In another implementation in Sudan, a remote communication system was provided to facilitate telemedicine operations. In this system, all local health centers and mobile clinics were connected to the capital hospital. The model included a web-based telemedicine system that provided basic services for remote consultations via video conferencing. This system has been very useful for facilitating communication between nurses and doctors, health workers and nurses, and doctors and patients [27].

In another study, a remote health service model was presented to help people with cardiovascular diseases who are at risk. In this model, a wearable monitoring system and a clinical warning system were introduced. The monitoring system monitors the patient's condition, and in emergencies, a warning is sent to the central server through the alarm system and wireless technology, so that experts can come to help the patient. The results have shown that this service increases the patient's freedom of action and reduces the risk of death [28].

In another study, a home telemedicine system was implemented to measure blood pressure. With the help of this system, the patient's blood pressure is sent to the center through the Internet. The data received in the center is stored and then processed using the software. Related doctors also access the patient's information on the Internet using a username and password and view the results measured over time and monitor the patient's health. This system can be accessed at any time [29].

In a research conducted on the use of telemedicine in the treatment of tinnitus, the researchers concluded that the use of an online audiometry system can be effective in various stages of the treatment process for tinnitus sufferers; Among the applications of this system are the initial observations of the initial evaluation, diagnosis, and optimization of therapeutic tools, long-term monitoring of

patients, and online support. The online audiometry system can be managed personally and saves time and money in medical care. However, it should be said that currently, performing the analysis in the online audiometry system requires an audiologist, because although many clinical examinations can be done remotely, it is necessary to make the final diagnosis by an expert [30].

In 2013, another example of a telemedicine system was implemented in a hospital setting, which focused on monitoring the rehabilitation of patients with neurological disorders. In this method, the patient and doctor can interact with each other through web-based applications. The results of this study also showed that this method reduces the time the patient stays in the hospital without reducing continuous monitoring [31]. Also, another tool called M-health has been introduced, which is expected to provide higher quality in people's health. This tool is based on mobile phone technology and includes an application capable of medical diagnosis. This program receives personal information and displays the results of medical tests online to the user. In addition to facilitating the work of doctors and medical centers, this practice plays an important role in the lives of users, because they can check their health status at any time and place. One of the important goals of these systems is to provide personal attention and motivate users [32].

In Lushan, China, after the April 2013 earthquake, teams developed a wireless portable telemedicine system at a hospital located in the earthquake zone and attended to a large number of injured. The system was connected to other hospitals with specialist rescue teams and rescue ambulances to enable remote medical consultation for special care, emergency treatment, orthopedics, brain surgery, slow surgery, biliary system, and other telehealth services. Specialists used to diagnose and treat the injured and were in contact with other specialists. Using this system, many patients were treated remotely [33]. A similar implementation was also carried out in Sudan and reported similar results [27].

Other researchers also believe that telemedicine is suitable for the rehabilitation of patients with cerebrovascular diseases and neurological defects. They have introduced technologies that

increase the possibility of controlling r-tPA (Recombinant tissue plasminogen activator) for qualified patients [34, 35].

Examining the effectiveness of telemedicine

Ekeland *et al.* evaluated all telemedicine implementations that had been carried out until 2010 and measured their effectiveness [36]. The results of this survey showed the following: 64% of the implementations indicated that telemedicine in diseases, especially chronic diseases, can be implemented well and has positive effects. These effects are in the form of increasing the effectiveness of treatment, increasing the efficiency of providing health services, and increasing the usability of the service. Also, the evidence showing the efficiency and effectiveness of telemedicine in studies related to teleradiology (especially neurology applications), telemedicine in mental health, the transmission of echocardiography images, teledermatology, and care for Chronic diseases is remote. 36% of the implementations also indicated that the effectiveness of telemedicine in some diseases is limited. For example, the therapeutic effect of remote cardiac monitoring in preventing cardiac arrest had not been established until then. Some implementations also showed that telemedicine did not have a very positive effect on asthma care.

Moreover, 91 percent of all these implementations acknowledged that telemedicine has reduced costs. It has reduced the patient's use of the hospital and increased the patient's satisfaction and quality of life. Many cases, such as teleradiology, provide time and cost savings and sometimes clinical benefits by avoiding travel and associated delays. Studies of home care and monitoring applications also show compelling evidence of cost reductions.

While in remote dermatology, despite the many benefits for patients, there are additional costs for hiring and employing medical care providers [36, 37]. In another systematic study regarding the role of information and communication technology in the management of depression and the diagnosis of its effect, the results of the review showed that there is not enough evidence about the effect of information and communication technology in the management of depression, however, there is a hypothesis that video conferencing It has the same results as

face-to-face treatments and Internet programs can improve depression symptoms like in-person treatments [38].

In a research that was conducted on the subject of telemedicine to help pregnant women, the results showed that counseling with pregnant women has a therapeutic effect and also reduces costs [39].

In another study, the effect of providing medical services at home on veterans with diabetes was investigated, and the results of this study indicated that patients are more satisfied and incur fewer treatment costs due to fewer visits to medical centers [40]. Also, the results of another study show that the use of telemedicine has had a positive effect in reducing mortality and remote disease management of patients who have had cardiac arrest. In this method, the patient's information is sent to the doctor through a communication system, and the doctor controls the important changes and takes the necessary measures if a risk is detected [41].

In another study, all telemedicine implementations that were carried out until 2011 on children and adolescents with chronic diseases were examined. This research focused on three issues: effectiveness in reducing costs, effectiveness in clinical outcomes, and patient satisfaction. The results of the research showed that telemedicine services for children and adolescents with chronic diseases are cost-effective and satisfactory for patients. Based on this, it can be said that telemedicine is a practical and satisfactory solution for the psychological treatment of children with chronic diseases and their families. Other findings of this study also show that the use of telemedicine provides the same clinical results compared to those who use in-person services [42]. Experts can be sure that the output and quality of service in telemedicine are equal to traditional care and offer such services to patients with full confidence.

Yager *et al.*'s study conducted in 2012 on the effectiveness of telemedicine in children with chronic diseases confirms the aforementioned findings [43]. In 2012, the impact of telemedicine on critical illness mortality was also investigated. In this research, 11 hospital ICUs were examined and the results showed that telemedicine has a direct relationship with the reduction of mortality in the hospital and ICU compared to standard care methods. Also, the duration of

hospitalization is significantly reduced. Young *et al.* have also presented a similar result in this field [44]. In 2012, research was conducted to compare collaborative care based on practice and collaborative care based on telemedicine in the treatment of patients with depression for 18 months. Exercise-based cooperative care is a kind of intuitive exercise that is done with the help of mental health professionals and with the cooperation of family members. On the other hand, collaborative care based on remote medicine is carried out in a virtual environment where mental health experts are also present virtually and at all hours of the day and night. The results of this study showed that the effectiveness of treating patients by remote medicine with the presence of specialists at all hours of the day was higher compared to the practice-based treatment method (with limited presence of specialists) [45]. In another study, all telemedicine implementations aimed at mental health in the elderly population of adults and children were examined. The result of this evaluation also explained that telemedicine is more effective in diagnosis and treatment than personal care [46].

CONCLUSION

Currently, the demand for remote medical services and home care services has increased in developed countries. Medical centers have turned to the approach of providing remote health services. The results of the surveys show that telemedicine in the treatment of many diseases has been equivalent or more effective compared to personal treatments, and in limited cases, its effectiveness has not yet been fully established. Another advantage of this technology is 24/7 access. The use of this service, in addition to being effective in the treatment of diseases and the possibility of long-term access, has also had an effect on reducing costs, and this has caused developing countries to be encouraged to provide telehealth services and using New communication technologies turn to these approaches.

ACKNOWLEDGMENTS: None

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

REFERENCES

1. Brunetti ND, Scalvini S, Acquistapace F, Parati G, Volterrani M. Telemedicine for cardiovascular disease continuum: A position paper from the Italian Society of Cardiology working group on telecardiology and informatics. *Int J Cardiol.* 2015;184:452-8. doi:10.1016/j.ijcard.2015.02.023
2. Maiti S, Rai N, Appanna P, Jessy P. Digital Telescopic Denture-A Viable Treatment Modality of Preventive Prosthodontics: Clinical Report. *Ann Dent Spec.* 2022;10(4):1-4.
3. Sadoughi F, Moulai Kh, Ahmadi Farsani M, Hadian M. Efficacy and effectiveness of telemedicine in the management and monitoring of heart diseases: a systematic review. *Mod Med Inf.* 2018;4(2):51-9.
4. Shahzan S, Paulraj J, Maiti S. Assessment of Anxiety Levels in Children Receiving Dental Treatment Using Rubber Dam-A Randomized Control Trial. *Ann Dent Spec.* 2022;10(4):15-21.
5. World Health Organization. Telemedicine 2009. Available from: <http://www.who.int/goe/survey/2009/figures/en/index1>
6. Singh GP, Attavar SH, Kavuri S. Application of cone-beam computed tomography in diagnosis and treatment of multiple canals-a case report. *Ann Dent Spec.* 2022;10(2):15-8.
7. Lin MH, Yuan WL, Huang TC, Zhang HF, Mai JT, Wang JF. Clinical effectiveness of telemedicine for chronic heart failure: A systematic review and meta-analysis. *J Investig Med.* 2017;65(5):899-911. doi:10.1136/jim-2016-000199
8. Koehler F, Winkler S, Schieber M, Sechtem U, Stangl K, Böhm M, et al. Telemedicine in heart failure: Pre-specified and exploratory subgroup analyses from the TIM-HF trial. *Int J Cardiol.* 2012;161(3):143-50.
9. Verma P, Pandian SM. Prevalence of endodontically treated posteriors in patients undergoing orthodontic treatment-cross-sectional radiographic evaluation. *Ann Dent Spec.* 2022;10(1):1-6.
10. Nebotova LV, Gasanov EAO, Makhsubova SH, Abdullayeva ZA, Shabaev SMSI, Kadiev IA. Methods of Treatment of Hemangiomas. *Clin Cancer Invest J.* 2023;12(2):33-8.
11. Koch S. Home telehealth - current state and future trends. *Int J Med Inform.* 2006;75(8):565-76.
12. Keser G, Altun D, Pekiner F. Assessment of Oral Cancer Awareness Among Medical Professionals Working in Bergama District of Izmir Province, Turkey. *Clin Cancer Invest J.* 2021;10(2):69-77.
13. Khazaei S, Rashedi E, Barati E. Blended learning approaches in medical science: a review article. *Pajouhan Sci J.* 2013;11(1):6-11.
14. Shekarriz R, Hedayatizadeh-Omran A, Amjadi O, Alizadeh-Navaei R, Godazandeh G. Serum level of programmed death-ligand 1 in patients with gastric cancer in Mazandaran Province as a High-Risk Region in Iran. *Clin Cancer Invest J.* 2021;10(1):5-10.
15. Khan TM, Tahir H, Salman M, Ul Mustafa Z, Raza MH, Asif N, et al. General Anxiety Predictors among Frontline Warriors of COVID: Cross-Sectional Study among Nursing Staff in Punjab, Pakistan. *Arch Pharm Pract.* 2021;12(2):40-4.
16. Safdari R, Masouri N, Ghazi Saeedi M, Sharifian R, Soltani A, Shahmoradi L. Wireless and mobile systems in telemedicine. *Iran South Med J.* 2012;15(4):327-38.
17. Alhammad IM, Aseri AM, Alqahtani SA, Alshaebi MF, Alqahtani SA, Alzahrani RA, et al. A review on updates in management and treatment of psoriasis. *Arch Pharm Pract.* 2021;12(1):74-8.
18. Aldahshan AA, Salamah AR, Fayoumi NM, Alkhudaydi SA, M AMK AQ. An overview on post-cholecystectomy syndrome diagnostic & management approach. *Arch Pharm Pract.* 2021;12(4):38-41.
19. Ahmed RM, Elkhader BA, Hassan WB, Elsamani M, Eisa RA. Knowledge and Practices towards Breast Cancer Screening. *Int J Pharm Res Allied Sci.* 2021;10(2):21-8.
20. Alsaffar BH, Daghistani DK, Alshakhouri MH, Alqarni AA, Ghamdi MS, Alqusayar AA. Review on Fixed Prosthesis and its Influence on Periodontal Health, Literature Review.

- Int J Pharm Res Allied Sci. 2021;10(3):89-93.
21. Smith LW. Telenursing. *JAMA*. 2012;307(1):94.
 22. Kasckow J, Felmet K, Appelt C, Thompson R, Rotondi A, Haas G. Telepsychiatry in the assessment and treatment of schizophrenia. *Clin Schizophr Relat Psychoses*. 2014;8(1):21-7A.
 23. Alshammari ST, Turkistani HA, Almatar YI, Alhuraish AM, Hefni ST, Bagabir RA, et al. An Overview on Endodontic Irrigation Solution Role in Management. *Int J Pharm Res Allied Sci*. 2022;11(1):17-20.
 24. Desai S, Mohanachandran P, Singh PK, Devakumar L, Kannan S, Suveer A. Advanced TeleOphthalmology for Blindness Prevention. *Mobile Communication and Power Engineering: Springer*; 2013. p. 9-385.
 25. Latfi F, Lefebvre B, Descheneaux C, editors. Ontology-based management of the telehealth smart home, dedicated to elderly in loss of cognitive autonomy. *Proceedings of the 2007 Workshop on OWL Experiences and Directions*; 2007.
 26. Hilgart JS, Hayward JA, Coles B, Iredale R. Telegenetics: a systematic review of telemedicine in genetics services. *Genet Med*. 2012;14(9):765-76.
 27. Sworo GD, Kam M, Juan EJ. Design of a Telemedicine-based system for Clinic-In-A-Can. In 2012 IEEE Global Humanitarian Technology Conference 2012 Oct 21 (pp. 265-270). IEEE.
 28. Ibrahim F. Remote Health Monitoring Systems for High Risk Patients. *Int J Open Probl Comput Sci Math*. 2012;5(4):124-30.
 29. Nam NP, Tam NH, Loc LG, Van Toi V. Design a System of Home Health Care Telemedicine for Blood Pressure Measurement. In 4th International Conference on Biomedical Engineering in Vietnam 2013 (pp. 286-289). Springer Berlin Heidelberg.
 30. Guitton MJ. Telemedicine in tinnitus: feasibility, advantages, limitations, and perspectives. *Int Sch Res Notices*. 2013;2013.
 31. Martínez-Alcalá CI, Muñoz M, Monguet-Fierro J. Design and customization of telemedicine systems. *Comput Math Methods Med*. 2013;2013.
 32. Alepis E, Lambrinidis C. M-health: supporting automated diagnosis and electronic health records. *SpringerPlus*. 2013;2(1):103-8.
 33. Li T, Chai J. Implementation of telemedicine services in the earthquake disaster relief: the best medical experts provide direct medical service to the affected people. *Zhonghua*. 2013;25(5):262-4.
 34. Morales-Vidal S, Ruland S. Telemedicine in Stroke Care and Rehabilitation. *Top Stroke Rehabil*. 2013;20(2):101-7.
 35. Johansson T, Wild C. Telerehabilitation in stroke care - a systematic review. *J Telemed Telecare*. 2011;17(1):1-6.
 36. Ekeland AG, Bowes A, Flottorp S. Effectiveness of telemedicine: a systematic review of reviews. *Int J Med Inf*. 2010;79(11):736-71.
 37. Hailey D, Roine R, Ohinmaa A. Systematic review of evidence for the benefits of telemedicine. *J Telemed Telecare*. 2002;8(1_suppl):1-7.
 38. García-Lizana F, Muñoz-Mayorga I. Telemedicine for depression: a systematic review. *Perspect Psychiatr Care*. 2010;46(2):119-26.
 39. Magann EF, McKelvey SS, Hitt WC, Smith MV, Azam GA, Lowery CL. The use of telemedicine in obstetrics: a review of the literature. *Obstet Gynecol Surv*. 2011;66(3):170-8.
 40. Barnett TE, Chumbler NR, Vogel WB, Beyth RJ, Qin H, Kobb R. The effectiveness of a care coordination home telehealth program for veterans with diabetes mellitus: a 2-year follow-up. *Am J Manag Care*. 2006;12(8):467-74.
 41. Anker SD, Koehler F, Abraham WT. Telemedicine and remote management of patients with heart failure. *Lancet*. 2011;378(9792):731-9.
 42. Van Allen J, Davis AM, Lassen S. The use of telemedicine in pediatric psychology: Research review and current applications. *Child Adolesc Psychiatr Clin N Am*. 2011;20(1):55-66.
 43. Yager P, Dapul H, Murphy S, Clark M, Zheng H, Noviski N. Comparison of Face-to-Face Versus Telemedicine Patient Assessment in A Pediatric Intensive Care Unit. *Crit Care Med*. 2012;40(12):321-8.

44. Young LB, Chan PS, Lu X, Nallamotheu BK, Sasson C, Cram PM. Impact of telemedicine intensive care unit coverage on patient outcomes: a systematic review and meta-analysis. *Arch Intern Med.* 2011;171(6):498-506.
45. Fortney JC, Pyne JM, Mouden SB, Mittal D, Hudson TJ, Schroeder GW, et al. Practice-Based Versus Telemedicine-Based Collaborative Care for Depression in Rural Federally Qualified Health Centers: A Pragmatic Randomized Comparative Effectiveness Trial. *Am J Psychiatry.* 2013;170(4):414-25.
46. Hilty DM, Ferrer DC, Parish MB, Johnston B, Callahan EJ, Yellowlees PM. The effectiveness of telemental health: a 2013 review. *Telemed E-Health.* 2013;19(6):444-54.