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THE IMPACT OF THE COVID-19 PANDEMIC ON THE DEVELOPMENT OF TELEMEDICINE

KEYWORDS
coronavirus pandemic, telemedicine development, medical services

ABSTRACT
The purpose of this paper is to review the current knowledge on the impact of the coronavirus pandemic on the telemedicine development. This work mainly focuses on telemedicine, history of its development, its impact on medicine, and the potential impact of the coronavirus pandemic on the telemedicine development. Telemedicine can be considered an innovative solution and has many development opportunities and to take full advantage of it, the opinions of doctors, paramedics, and patients should be taken into account, remembering to adapt this technology also to the elderly or computer illiterate people in order to make it easier or even possible for them to use. There should also be more research conducted in this area for further investigation of the telemedicine impact on the quality of the offered medical services.

1. INTRODUCTION

The outbreak of the coronavirus pandemic has caused enormous changes in the healthcare system [1–3]. Not only people's attitudes have changed, but also the type of health services provided [1]. As it's known, a pandemic means an epidemic that is spreading across large areas at the same time [3–4]. The impact of SARS-CoV-2 pandemia on Nuclear Medicine is still being widely examined [5–7]. In their paper – Kirienko et. al. [8] focused on Europe. They noticed that the pandemic has reshaped Nuclear Medicine practice. Pandemic affected human resources, diagnostic and therapeutic management of patients, teaching, training, research, and radiopharmaceutical supplies.

In Asia, Hee-Seung et. al. [7] noticed that living in the Covid-19 pandemic has become the new "normality". The success of strategies implemented by governments are not possible to measure because of differences between different countries and communities of different social and economic statuses but the practice of Nuclear Medicine is recovering.

In Africa and Latin America impact of Covid-19 on Nuclear Medicine was more pronounced in Latin America than in Africa [9]. There were a significant decrease in nuclear medicine diagnostic and therapeutic procedures due to pandemic-related challenges.

The impact of the Covid-19 pandemic on emergency physicians in the United States was examined by among the others by Nguyen et. al. [10]. They stated that emergency physicians had greater burnout caused by the Covid-19 pandemic and it may worsen in the effect of psychological stress, isolation, and job dissatisfaction. Their research also showed that many respondents declared inadequate mental health services and resources.

Another study conducted by Antonios et. al. [11] in their paper stated that the pandemic of coronavirus 2019 caused high morbidity and mortality of Cardiovascular diseases and affected patients with pre-existing medical conditions by delaying or deferring outpatient care as the reason of concerns about exposure to the virus. Concerns about exposure to the Covid-19 virus caused the use of telemedicine solutions for reducing that exposure.

2. PANDEMICS OVER THE CENTURIES

As history shows, every century new pandemic outbreaks [12, 13]. Based on the data from the paper written by Morens and colleagues [14] was pretend in form of table (see: Tab. 1), where the history of cases, the year of the pandemic, and the number of deaths caused by it was presented [12, 14].

Table 1. The history of cases, the year of the pandemic, and the number of deaths caused by it [based on 14]

Year	Disease	Number of deaths
430 BCE	Plague of Athens	~100,000
541	Plague of Justinian	30-50 million
The 1340s	Black Death	~50 million
1494	Syphilis	>50,000
Ca. 1500	Tuberculosis	High millions
1520	Hueyzahuatl	3.5 million
1793–1798	American plague	~25,000
1832	2nd cholera pandemic in Paris	18,402
1918	Spanish influenza	~50 million
1976-2020	Ebola	15,258
1981	Acute hemorrhagic conjunctivitis	Few
1981	HIV/AIDS	~32 million
2002	SARS	813
2009	H1N1 swine flu	284,000
2014	Chikungunya	Few
2015	Zika	~1000
2019	SARS-CoV-2	>6.22 million (ongoing)

The authors of [14] also stated that the increasing number of cases and deaths of the Covid-19 disease caused changes in every aspect of work school, recreation, travel, economic well-being, and interactions with friends and family.

That paper also pointed out that disinformations caused increasing anxiety and confusion. They also identified the relationship between increasing population numbers and pandemics [14]. The reason for the outburst of pandemics indicated are humans [12–14].

3. TELEMEDICINE OVER THE CENTURIES

Technology has changed over the centuries [15]. Technological innovations made in the last two centuries led to the emergence of telemedicine [16–18]. It started with devices such as Telegraph, Radio, and Telephone [18–20]. The telegraph was the first device used to deliver medical care. It was mainly used during the civil war for transmissions of messages about wounded soldiers to medical teams. Usage of Radio for medical purposes was mainly for providing medical care for ship crews. Then, devices such as Radio, Telephone, and Television were used [18, 21].

Gerson Cohen made the term „telognosis" which stands for the method of diagnosis using transmitted radiographs by radio or telephone. He also reported a three-year experience in the transmission of radiographs using commercial telephone lines between a clinic in Atlantic City and a hospital in Philadelphia [18].

Briskier declared the first transatlantic transmission of medical data. He transmitted heart sounds and clinical data from New York to Paris and Rome by using radio and radio photo transmission [18, 22]. The years 1970 to 2000 were a big change for telemedicine [18]. Murphy and Bird published their experience of „Telediagnosis" in 1000 patient encounters [18, 22]. Bird was the person who coined the term „telemedicine" [17]. In 1975, with the start of project STARPHC, access to healthcare was provided in Indian reservations [18]. Then, in 1977, Grundy declared the earliest example of synchronous telemedicine to provide critical care access to an underserved population [18, 23]. The development of ARPANET, which was a network established to connect various mainframe computers in the Department of Defense facilities across the USA, made a giant leap because this technology evolved into the modern internet by the late 1990s [18]. The years 2000 to 2020 had rapid evolution in technology [18, 24]. With the development of smartphones, tablets, and telemedicine devices, telemedicine was becoming more and more widely used [18].

4. TELEMEDICINE IN TIME OF A PANDEMIA

The telemedicine-based solutions are helpful in times of a pandemic, especially because of avoiding exposure to the virus [25–28]. In their paper, El Naamani et. al. [29] reported that this became a major force in the health care system. They declared that physicians and patients have displayed high levels of satisfaction with telemedicine. Their paper pointed out possible improvements in health care for underprivileged areas as a result of telemedicine. Their research showed that the most important advantages of telemedicine for respondents were its superior convenience compared to clinic visits, cost-effectiveness, protection against infectious diseases, and shorter waiting time. As the most important disadvantages, responders ranked, as following: technological difficulty, less privacy, feeling that telemedicine requires expensive technology they could not afford, and lastly difficulty in conveying their concerns. They also declared that to overcome these disadvantages, healthcare systems must use healthcare delivery and communication tool to provide and expand access to the patients with the highest level of care.

Acceptance of telemedicine technology among physicians was examined by Garavand et. al. [30], where they examined behavioural barriers in using telemedicine and its technology among physicians. They concluded that the key to the successful implementation of telemedicine is to identificate the most important factors affecting the acceptance of telemedicine from physicians. Telemedicine technology may be hard for using as well for older people.

Aliberti et. al. in their paper [31] focused on how to improve telemedicine for elderly people. They pointed out a few additional challenges for implementation of telemedicine among people older than 65 years old such as lower technological literacy, lack of desire, greater costs, and more sensory, cognitive, and functional limitations. They proposed multi-level options that could make it easier for people over 65 to use telemedicine technology such as assistance from a family with visit preparation and presence during it, training for telemedicine, access to computers and broadband internet, using effective telemedicine platform and more IT and also administrative support.

Another important aspect is paediatric telemedicine. Haynes and Marcin in their paper [32] presented four models of care within paediatric telemedicine. Firstly, there is „provider-to-provider" model of care, which allows communication between two providers and involves real-time video consultations with a paediatric specialist for primary care. Secondly, there are „provider-to-patient" telemedicine services, which allow direct encounters over real-time video from the providers to the patient or family. Then, there are school-based telemedicine services, with allow children to receive care through telemedicine at their local school in the presence of a school nurse or other school personnel. Lastly, there is „ tele-monitoring" with allows collection of the monitoring of patient-generated data. They also pointed to the insufficient amount of research in this field.

5. CONCLUSION

The main purpose of this paper was to review the current knowledge on the impact of the coronavirus pandemia on the development of telemedicine. The coronavirus pandemic has had a huge impact in the field of medicine [25–27]. Its explosion has caused, among others, wider use of telemedicine and irreversibly changed the frequency of its use [28]. Among other things, telemedicine can be used in order to improve the availability of medical care in less accessible areas and help provide medical care in times of pandemic [26, 27]. Telemedicine technology can grow thanks to the improvement in technology and devices. Its use will evolve due to many advantages of this method, but more work is needed to improve its quality, accuracy, and public perception of the field. A very important aspect of its development is the adjustment of telemedicine technology for the elderly or computer-illiterate people to make it easier to use it [29].

For the future research, not only the opinions of patients, but also of doctors and paramedics may be helpful. More research should also be carried out in this area to further investigate the impact of telemedicine on the quality of medical services offered.

REFERENCES

1. Joseph A.O., et al.: *Coronavirus outbreak: Reorganising the breast unit during a pandemic*. European Journal of Surgical Oncology, vol. 46/6, 2020, pp. 1176–1177, doi: 10.1016/j.ejso.2020.04.031,
2. Li H., et al.: *Changes in children's healthcare visits during coronavirus disease-2019 pandemic in Hangzhou, China*. The Journal of Pediatrics, vol. 224, 2020, pp. 146-149, doi: 10.1016/j.jpeds.2020.05.013,
3. Moynihan R., et al.: *Impact of COVID-19 pandemic on utilisation of healthcare services: a systematic review*. BMJ open, vol. 11(3), 2021, pp. e045343, doi: 10.1136/bmjopen-2020-045343,
4. Hambere S., Abhishek B., Sumit H.: *Rapid digitization of healthcare—A review of COVID-19 impact on our health systems*, Int. J. All Res. Educ. Sci. Methods, vol. 9(2), 2021,pp. 1457–1459, doi: 10.6084/m9.figshare.14156417.v1,
5. Annunziata S., et al.: *Impact of the COVID-19 pandemic in nuclear medicine departments: preliminary report of the first international survey*, European journal of nuclear medicine and molecular imaging, vol. 4(9), 2020, pp. 2090–2099, doi: 10.1007/s00259-020-04874-z,
6. Freudenberg L.S., Dittmer U., Herrmann K.: *Impact of COVID-19 on nuclear medicine in Germany*, *Austria and Switzerland: an international survey in April 2020*, Nuklearmedizin-NuclearMedicine, vol. 61(20), 2020, pp. 294–299, doi: 10.2967/jnumed.120.249821,
7. Bom H.S.H., et al.: *Impact of COVID-19 on nuclear medicine in Asia*. In: Seminars in Nuclear Medicine. vol. 52(7), 2022. pp. 25–30, doi: 10.1053/j.semnuclmed.2021.06.001,
8. Kirienko M., et al.: *The impact of COVID-19 on nuclear medicine in Europe*. In: Seminars in Nuclear Medicine. vol. 52(1), 2022. pp. 17–24, doi: 10.1053/j.semnuclmed.2021.06.022,
9. Giammarile F., et al.: *Impact of COVID-19 on nuclear medicine departments in Africa and Latin America*, In: Seminars in Nuclear Medicine. vol. 52(4), 2022. pp. 31–40, doi: 10.1053/j.semnuclmed.2021.06.018,
10. Nguyen J., et al.: *Impacts and challenges of the COVID-19 pandemic on emergency medicine physicians in the United States*. The American journal of emergency medicine, vol. 48, 2021, pp. 38–47, doi: 10.1016/j.ajem.2021.03.088,
11. Antonios L., Chen W., Dilsizian V.: The impact of COVID-19 on nuclear medicine operations including cardiovascular manifestations in the USA. In: Seminars in Nuclear Medicine. vol. 52(1), 2022. pp. 11-16, doi: 10.1053/j.semnuclmed.2021.06.003,
12. Qiu W., et al.: *The pandemic and its impacts*, Health, culture and society, vol. 9–10, 2017, pp. 1–11, doi: 10.5195/HCS.2017.221,
13. Kaur H., et al.: *A review: Epidemics and pandemics in human history*. International Journal of Pharma Research and Health Sciences, vol. 8(2), 2020, pp. 3139–3142, doi: 10.21276/ijprhs.2020.02.01,
14. Morens D.M., et al.: *Pandemic COVID-19 joins history's pandemic legion*, MBio, vol. 11(3), 2020, pp. 1–9, doi: 10.1128/mBio.00812-20,
15. Godin B.: Innovation contested: The idea of innovation over the centuries. *Routledge*, New York 2015,
16. Benger J.: *A review of telemedicine in accident and emergency: the story so far*, Journal of Accident & Emergency Medicine, vol. 17(3), 2000, pp. 157–164, doi: 10.1136/emj.17.3.157,
17. Bashshur R.L., Reardon T.G., Shannon G.W.: *Telemedicine: a new health care delivery system*, Annual review of public health, vol. 21(1), 2000, pp. 613–637, doi: 10.1146/annurev.publhealth.21.1.613,
18. Jagarapu J., Savani R.C.: *A brief history of telemedicine and the evolution of teleneonatology*, In: Seminars in Perinatology, vol. 45(2), 2021. p. 151416, doi: 10.1016/j.semperi.2021.151416,
19. Duplaga M.: *The transition from telemedicine and e-health to Health 4.0*, In: The Digital Transformation of Healthcare. Routledge, 2021, p. 17–30, doi: 10.4324/9781003144403-2,
20. Wootton R., Craig J., Patterson V.: Introduction to telemedicine. *CRC Press*, London, 2017,
21. Field M.J., et al.: Telemedicine: A guide to assessing telecommunications in health care, *National Academies Press*, 1996,
22. Briskier A.: *Heart examination and consultation by radio and radio-photo transmission*. Journal of the American Medical Association, vol. 169(17), 1959, pp. 1981–1983, doi: 10.1001/jama.1959.03000340013003,
23. Dorman T.: *Telemedicine*, Anesthesiology Clinics of North America, vol. 18(3), 2000, pp. 663–676, doi: 10.1016/s0889-8537(05)70185-1,
24. Us Y.O., et al.: *Green transformations in the healthcare system: the covid-19 impact*, Health Economics and Management Review, vol. 1(1), 2020, pp. 48–49, doi: 10.21272/hem.2020.1-04,
25. Mcmaster T., et al.: *Current and future use of telemedicine in surgical clinics during and beyond COVID-19: A narrative review*, Annals of Medicine and Surgery, vol. 66(4), 2021, p. 102378, doi: 10.1016/j.amsu.2021.102378,
26. Portnoy J., Waller M., Elliott T.: *Telemedicine in the era of COVID-19*, The Journal of Allergy and Clinical Immunology: In Practice, vol. 8(5), 2020, pp. 1489-1491, doi: 10.1016/j.jaip.2020.03.008,

27. Ortega G., et al.: *Telemedicine, COVID-19, and disparities: policy implications*, Health policy and technology, vol. 9(3), 2020, pp. 368–371, doi: 10.1016/j.hlpt.2020.08.001,
28. Colbert G.B., Venegas-Vera A.V., Lerma E.V.: *Utility of telemedicine in the COVID-19 era*, Reviews in cardiovascular medicine, vol. 21(4), 2020, pp. 583-587, doi: 10.31083/j.rcm.2020.04.188,
29 El Naamani K., et al.: *Telemedicine during and post-COVID 19: The insights of neurosurgery patients and physicians*, Journal of Clinical Neuroscience, vol. 99(8), 2022, pp. 204–211, doi: 10.1016/j.jocn.2022.03.006,
30 Garavand A., et al.: *Acceptance of telemedicine technology among physicians: A systematic review*, Informatics in Medicine Unlocked, vol. 30(1), 2022, p. 100943, doi: 10.1016/j.imu.2022.100943
31 Aliberti G.M., et al.: *Perspectives of primary care clinicians in Massachusetts on use of telemedicine with adults aged 65 and older during the COVID-19 pandemic*, Preventive medicine reports, vol. 26(10), 2022, p. 101729, doi: 10.1016/j.pmedr.2022.101729,
32 Haynes S., Marcin J.: *Pediatric Telemedicine: Lessons Learned During the COVID-19 Pandemic and Opportunities for Growth*, Advances in Pediatrics, vol. 69(3), 2022, pp. 1–11, doi: 10.1016/j.yapd.2022.04.002.