

Telemedicine and COVID-19 Pandemic: Valuable Lessons for Future Implementations

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Abstract—Telemedicine has gained significant momentum during the pandemic. Telemedicine offers a way for people to access medical care without having to physically visit a healthcare facility, which can be especially important when in-person visits may not be safe due to a highly contagious virus. One major benefit of telemedicine is that it allows for the continuation of healthcare services while also helping to reduce the spread of COVID-19. By providing virtual consultations and treatments, telemedicine helps to limit the number of in-person visits. This is critical to reduce the risk of exposure to the virus and prevent healthcare facilities from becoming overwhelmed. Telemedicine has also helped to address some challenges that have arisen as a result of the pandemic. For instance, by using telemedicine, healthcare providers can reduce the need for PPE and maintain a safe distance while still providing necessary medical care. Despite the many benefits, there are also some challenges and limitations. For example, not everyone has access to the necessary resource to participate in telemedicine. Additionally, some medical procedures and treatments may not be suitable for telemedicine, requiring in-person visits. Moreover, it is important to consider the ethical issues that it raises and to work toward solutions that address these concerns. This can involve measures such as ensuring that telemedicine is available and accessible to all who need it, protecting patient privacy and confidentiality, and ensuring that telemedicine is used in a way that provides the highest quality and most appropriate care for patients.

Index Terms—telemedicine, telehealth, virus, COVID-19, pandemic

I. TELEMEDICINE: HISTORY, CURRENT STATE, AND PANDEMIC IMPACT

TELEMEDICINE itself is not a new term. In fact, telemedicine has a relatively long history. In 1879, an article in the *Lancet* discussed the possibility of using the telephone to decrease the frequency of unnecessary visits [1]. Telehealth has also been used in clinical settings for decades. In 1906, the electrocardiogram's inventor published an article on the telecardiogram [2]. Since the 1920s, radio has been utilized to provide medical advice to shipboard clinics [3].

A clinician diagnosing a patient over the radio was depicted on the cover of *Science and Invention* magazine in 1924, and within the magazine was envisioned a handset that would enable the video examination of a patient over a distance [4]. In the 1940s, radiology photographs were sent 24 miles between two districts in Pennsylvania through a telephone line in the world's first example of electronic medical data transfer [5]. In the 1950s, Canadian radiologists expanded on this technology by establishing a

teleradiology framework that was employed in and around Montreal [6]. In 1959, the University of Nebraska employed two-way interactive television to send neurological examination results to medical students across campus [7]. In 1967, the School of Medicine of the University of Miami collaborated with the local fire department to relay electrocardiographic rhythms to the local hospital via radio transmission [8].

Plenty of existing studies have shown evidence that telemedicine is beneficial [9]–[12]. Telemedicine enables access for populations in rural areas to medical specialists, potentially saving a significant number of lives [13], [14]. Not only that, telemedicine is proven to be cost-efficient [15], resource-effective (especially in a limited resource setting) [16], and even might be able to help healthcare institutions to minimize the consequences of no-show patients [17].

In the last decades, we have seen rapid development of telecommunications technologies, some of which enable us to communicate through audiovisual media in a low-latency real-time manner regardless of the actual distance between users' locations. On the other side, the growth of healthcare worker and medical facilities are not enough to accommodate the population growth, especially in developing and under-developed countries. Considering the rapid advancement of wireless technologies and the lack of adequate medical resources, it is expected that telemedicine has spread and been widely adopted worldwide. However, despite its long history and experiences, the progression of telemedicine adoption is relatively slow [18].

At the end of 2019 (or the beginning of 2020, for many countries), COVID-19 rapidly spread among populations. Its massive infection rate and unknown severity-fatality rate and pathophysiology have overwhelmed many governments around the world. During its peak infection rate, thousands of cities worldwide were in short of healthcare resources. COVID-19 has put an additional burden on the already heavily loaded medical facilities. In the later stage of the pandemic, it is known that COVID-19 has produced relatively mild symptoms and caused no life-threatening conditions in most cases. Additionally, most of the COVID-19 cases, especially the ones that occurred in healthy young-adult patients, can be cured with adequate home-based self-care treatments. Considering these conditions, many stakeholders published regulations for telemedicine care for mild-to-medium COVID-19 cases in the hope that the already limited in-site healthcare resources can be allocated to patients with higher priorities.

Actually, this situation has brought momentum to the relatively slow penetration of telemedicine applications. Because of the COVID-19 situation, stakeholders as well as healthcare service providers have been given no choices

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other than developing and implementing telemedicine systems.

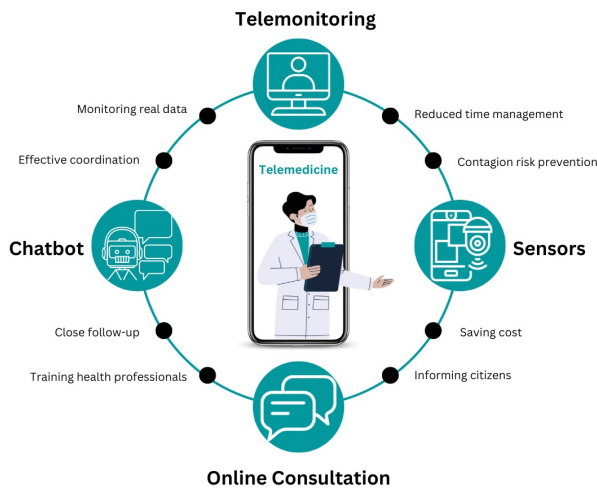


Fig. 1. Telemedicine practice during the COVID-19 pandemic.

II. TELEMEDICINE DURING PANDEMIC

As aforementioned, the pandemic has forced many parties to develop and implement telemedicine systems. When this paper was written, there were literally tens of thousands of research manuscripts about telemedicine and the COVID-19 pandemic, proofing that telemedicine and the COVID-19 pandemic have become hot research topics. During the pandemic, COVID-19 patients can use telehealth services to access necessary and essential health services thanks to the philosophy of telemedicine. This innovation has proven to be a crucial part of COVID-19 mitigation, particularly for patients in remote areas [16], [22], [23].

The disease's rapid progression poses a significant challenge to the entire world. Healthcare providers and governments are struggling as the standard capacity for public care is exceeded. Social distance measures are one of the most important strategies for reducing and mitigating the spread of the epidemic. In this circumstance, telemedicine can be utilized to provide support to healthcare systems, particularly in the areas of public health, prevention, and clinical practices [19]–[21]. In this matter, telemedicine can take several forms (see Fig. 1), including:

- **Telemonitoring:** Using devices that measure and evaluate patient health information such as vital signs (i.e., blood pressure, pulse, oxygen level, and respiratory rate) which is then reported to the healthcare facilities. If the measured conditions become severe, the healthcare provider can easily admit the patients to the hospital. In addition, telescreening can also be conducted via self-assessment using the appropriate healthcare questions and self-reporting for COVID-19 symptoms experienced by the users.
- **Sensors:** GPS, oxygen level sensor, blood pressure sensor, pulse meter, respiratory rate sensor, and even ECG sensor can be found in an embedded device

(i.e., smartphone, smartwatch, etc.). By using this device, people can assess their healthcare conditions. On the other side, the stakeholders can detect the crowd through the GPS tracker and map the locations that have a high risk of virus contagion.

- **Online consultations:** Telehealth enables patients to interact with professionals regarding their symptoms and their health conditions. The physicians are then able to give advice to relieve the patient's situation and prevent it from being worsened. The results of these consultations can even be used as medical triage assessments.
- **Chatbots:** Chatbots can accompany patients under isolation, preventing them from feeling afraid and lonely. Moreover, chatbots can offer recommendations and FAQs regarding the COVID-19 disease.

COVID-19 has given significant momentum to telemedicine development [24]. During the pandemic, lots of countries worldwide have implemented telemedicine. For instance, in China, an Emergency Telemedicine Consultation System was established by the national telemedicine center to serve their citizens through the telemedicine-enabled response network and outbreak alert [25]. This effort is supported by major private sectors such as ZTE and China Telecom who have provided 5G technology support to China's hospitals [26].

In South Korea, the SNU hospital began to operate a telemedicine service for COVID-19 patients staying nearby the virus outbreak epicenter [27]. In Singapore, the government established a telemedicine and tracing system that enables GPS tracking of people under quarantine, allowing the government to map the transmission chains [28]. A similar situation has happened in the US and many European countries during the pandemic. In the US, The COVID-19 pandemic has significantly altered the healthcare delivery pattern. In the context of a drop in in-person patient visits, many health professionals are beginning to use telemedicine for the first time, prompted in part by regulatory changes that broaden public and private insurance reimbursement for a broader range of telemedicine services [29]. Growth in commercially insured telemedicine use offset roughly two-thirds of the drop in the frequency of in-person visits during the pandemic [32]. In a study conducted with a total of 2927 German healthcare professionals to investigate their perceptions of telemedicine during the pandemic crisis, it was revealed that telemedicine has wide acceptance among medical workers amidst the increased telemedicine utilization during the pandemic [31]. However, the study notes that technical and regulatory barriers must be overcome in order to integrate telemedical structures into routine care.

Although currently, Spain has no nationwide regulation enabling telemedicine services [33], [34], the use of telemedicine services has increased during the pandemic. For example, in the Spanish region of Catalonia, authorities in public health have deployed a follow-up system in primary care that uses telephone calls to monitor patients' symptoms and, if they worsen, accommodate them to revisit the health center [35].

In summary, telemedicine practice during the pandemic offers various advantages (see Fig. 1), such as:

TABLE I
SEVERAL STUDIES OF THE ETHICAL AND LEGAL ASPECTS OF TELEMEDICINE.

First Author	Publication Year	Object of Investigation	Legal and Ethical Implications
Kotsopoulou [36]	2015	Electronic therapy	Informed consent Confidentiality, security, and privacy concerns Redundancy (failsafe system) 4 bioethics principles: beneficence, nonmaleficence, autonomy, justice
Ho [37]	2018	Self-monitoring devices	Questionable reliability of healthcare monitoring devices User-operator relationship Might increase the user's anxiety regarding their health condition
Botrugno [38]	2018	Telemedicine	Lack of legal regulations regarding telemedicine Informed consent Patient privacy and data protection Inter-nations policies Regulations for medical devices
Kluge [39]	2018	Telemedicine	Ethical conduct for health informatics professionals Legal codes for health informatics professionals Health informatics professionals certification and standardization
Crico [40]	2018	Health status monitoring	Lack of cross-border legal regulations for health data management
Hoyle [41]	2019	Telemedicine	Health information use from ethical perspective

- Reducing the time management overhead for diagnosis, treatment, and quarantine.
- Minimizing the risk of COVID-19 contagion.
- Saving cost for scarce medical resources (e.g., personal protective equipment (PPE)). In addition, telemedicine supports better allocations of scarce medical materials for patients with higher priorities.
- Enabling an effective and efficient way for the stakeholders to provide information regarding COVID-19 to their citizens. On the receiving side, the citizens are able to obtain the required information easily.
- Enhance the effectiveness of medical professional training. Especially considering that COVID-19 is a “new” virus with an unknown pathophysiology.
- Providing a way for a close follow-up by real-time monitoring while the patients are quarantined at home.
- Allowing effective coordination among medical professionals in different locations.
- Enabling real-world data monitoring in a real-time manner.

III. ETHICAL ASPECTS OF TELEMEDICINE

Telemedicine has become an increasingly popular and important tool for delivering healthcare services. While telemedicine offers many benefits, including increased access to care, convenience, and reduced risk of transmission of infectious diseases, it also raises a number of ethical issues that need to be considered. In Table I, we have summarized several studies that have been conducted regarding ethics and legal challenges in telemedicine implementations.

One ethical issue related to telemedicine is the potential for unequal access to care [42]. While telemedicine can provide access to care for people who live in rural or remote areas or who have mobility issues, not everyone has the necessary technology or internet connection to participate in telemedicine appointments. This can result in a digital divide, where some people have access to telemedicine and others do not, leading to disparities in healthcare access and outcomes.

Telemedicine practice has also sparked concerns regarding informed consent [43]–[45]. Whether for the health

information transmissions or the medical interventions, the operators should obtain patients' informed consent. Since there is no face-to-face meeting between patients and the operators in the telemedicine framework, informed consent principles are at risk of being neglected. Therefore, a strong legal policy regarding this matter should be regulated to ensure the patients' rights to informed consent. It is also important to make sure that healthcare professionals are always aware that they are not working as “medical automans” and that there is always patients' right to informed consent.

Another ethical issue is the potential for lack of privacy and confidentiality in telemedicine appointments [24], [46]. Telemedicine involves the transmission of sensitive personal and medical information over the internet, which can be vulnerable to hacking and other forms of cyber-crime. This raises concerns about the protection of patient privacy and the confidentiality of medical information.

Furthermore, telemedicine practice is vulnerable to clinician malpractice and liability [43], [47]. To tackle the risk of malpractice, patients and clinicians should always be able to identify with whom they are interacting in the telemedicine framework. Even so, the malpractice risk is not automatically diminished. In the in-person visit settings, there is always a risk of misdiagnosing which leads to ineffective, incorrect, or even dangerous interventions. However, the causes of this situation can be identified easier in the in-person visit settings: clinician's malpractice or simple natural error for which the clinician has no responsibility of it. In the telemedicine setting, however, the difficulty is elevated. Not only does not being able to physically assess the patient's conditions, but the physician also cannot fully monitor the patient's situation and behavior. In a case where poor outcomes were produced in a telemedicine setting, it is rather hard to find the parties who are responsible for blaming. Hence, if not carefully considered, this situation might provide a serious risk, not only for the patients but also for the healthcare professionals.

In addition, telemedicine raises questions about the quality and effectiveness of care. While telemedicine can be an effective way to deliver healthcare services, it may not always be the best or most appropriate form of care.

For example, certain medical procedures or treatments may not be suitable for telemedicine, requiring in-person visits.

From a legal perspective, it is obvious that a worldwide standardized regulation is needed to ensure patient safety. However, as far as the authors are aware, there are no legal-bonded regulations that exist and are world-widely accepted, at least until when this paper was written. To guarantee patients' safety and fairness, as well as to increase patients' confidence, fair regulations regarding telemedicine practice should be carefully made.

Overall, while telemedicine offers many benefits, it is important to consider the ethical issues that it raises and to work towards solutions that address these concerns. This can involve measures such as ensuring that telemedicine is available and accessible to all who need it, protecting patient privacy and confidentiality, and ensuring that telemedicine is used in a way that provides the highest quality and most appropriate care for patients.

IV. LIMITATIONS OF CURRENT TELEMEDICINE

Telehealth has become an increasingly popular and important tool for delivering healthcare services. While telemedicine offers many benefits, including increased access to care, convenience, and reduced risk of transmission of infectious diseases, it also has a number of limitations that need to be considered.

One major limitation of telemedicine is that it requires access to technology and a reliable internet connection. Not everyone has access to the necessary technology or internet connection to participate in telemedicine appointments, which can result in a digital divide, where some people have access to telemedicine and others do not. This can lead to disparities in healthcare access and outcomes [48], [49].

Another limitation of telemedicine is that it may not be suitable for all medical procedures and treatments. Some medical conditions or treatments may require in-person visits or the use of specialized equipment that cannot be provided remotely. In these cases, telemedicine may not be an effective or appropriate form of care.

Telemedicine can also be limited by the availability of healthcare providers who are trained and experienced in providing care remotely. While the use of telemedicine is growing, there may not be enough healthcare providers with the necessary skills and expertise to meet the demand for telemedicine services.

In addition, telemedicine may not be as effective as in-person visits for certain types of care. For example, it may be more difficult for a healthcare provider to assess a patient's physical symptoms or to provide certain types of treatments remotely.

In short, while telemedicine offers many benefits, it is important to recognize its limitations and use it in a way that is appropriate and effective. This may involve using telemedicine in combination with in-person visits or other forms of care, and ensuring that patients have access to the necessary technology and internet connection to participate in telemedicine appointments.

V. FUTURE OPPORTUNITIES IN TELEMEDICINE AFTER THE PANDEMIC

The use of telecommunication and information technologies to provide clinical health care from a distance has gained significant attention and adoption in recent years, and it is likely that its use will continue to grow in the future. There are many opportunities for the future development and use of telemedicine, which have the potential to benefit both healthcare providers and patients.

One major opportunity for the future of telemedicine is the potential for increased access to care. Telemedicine allows people to receive medical care from a distance, which can be especially beneficial for those who live in rural or remote areas or who have mobility issues. By increasing access to care, telemedicine has the potential to reduce healthcare disparities and improve outcomes for underserved populations.

Another opportunity for the future of telemedicine is the potential for improved convenience and efficiency. Telemedicine can save patients time and effort by eliminating the need to travel to a healthcare facility, and it can also help to reduce wait times and improve the overall patient experience. For healthcare providers, telemedicine can also improve efficiency by allowing them to see more patients in a given time period.

In addition, the future of telemedicine may include the development of new technologies and approaches to healthcare delivery. For example, virtual reality and other immersive technologies have the potential to revolutionize the way that healthcare is delivered, allowing for more interactive and engaging telemedicine appointments.

In summary, the future of telemedicine holds many exciting opportunities for improving healthcare access, convenience, and effectiveness. While there are also challenges and limitations to consider, the continued development and use of telemedicine have the potential to transform the way that healthcare is delivered and improve outcomes for patients and providers alike.

VI. REMARKS AND CONCLUSION

Telemedicine has gained significant attention and adoption during the COVID-19 pandemic. Telemedicine offers a way for people to access medical care without having to physically visit a healthcare facility, which can be especially important during a time when in-person visits may not be safe due to a highly contagious virus.

One major benefit of telemedicine is that it allows for the continuation of healthcare services while also helping to reduce the spread of COVID-19. By providing virtual consultations and treatments, telemedicine helps to limit the number of people who need to visit hospitals and clinics in person. This can help to reduce the risk of exposure to the virus and prevent healthcare facilities from becoming overwhelmed.

Telemedicine has also helped to address some of the challenges that have arisen as a result of the pandemic, such as the shortage of PPE and the need for social distancing. By using telemedicine, healthcare providers can reduce the need for PPE and maintain a safe distance from their patients while still providing necessary medical care.

In addition to its practical benefits, telemedicine has also proven to be a valuable tool for addressing the mental health needs of people during the COVID-19 pandemic. The stress and isolation caused by the pandemic have had a significant impact on people's mental health, and telemedicine has provided a way for people to access mental health care from the comfort of their own homes.

Despite the many benefits of telemedicine, there are also some challenges and limitations to consider. For example, not everyone has access to the necessary technology or internet connection to participate in telemedicine appointments. Additionally, some medical procedures and treatments may not be suitable for telemedicine, requiring in-person visits.

Overall, telemedicine has played a vital role in helping to provide healthcare services during the COVID-19 pandemic. While it is not a replacement for in-person care in all cases, it has proven to be a valuable tool for reducing the spread of the virus, addressing the challenges of the pandemic, and providing access to healthcare for those who may not otherwise have been able to receive it.

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