Telemedicine in Remote Areas: Possibility of Establishing a Telemedicine System

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Abstract. The COVID-19 epidemic is a severe test for the whole medical industry. Under such a circumstance, healthcare is seeking creative business models. Contemporarily, many countries have developed telemedicine, which is an innovative way of consultation brought by digitalization to healthcare. It has developed more rapidly under the spread of COVID-19. Popularizing telemedicine is a perfect method to deal with the epidemic, which can be specified with telediagnosis, teletherapy, and telemonitoring. Since patients in remote districts also long for professional medical services, this paper intends to explore the possibility of building a medical institution to provide telemedicine for patients living in remote areas. Besides, this paper discusses the application of each function and its limitations. Though telemedicine brings more chances for the patients who have a distance to the medical institution, high quality equipment and funds are needed to support the run of telemedicine. However, the implementation of 5G can improve the performance of telemedicine, especially in the latency of telesurgery. Overall, though building a medical station that supports telemedicine is challenging, there are particular populations have demand on it. These results shed light on guiding further exploration of digital updating for medical industry.

Keywords: Telemedicine, Telediagnosis, Teletherapy, Telemonitoring, 5G & IoT.

1. Introduction

Telemedicine may have existed in ancient times, ancestors used bonfires to remind of the outbreak of epidemics [1]. Since the 20th century, telemedicine has been defined as the delivery of healthcare and the exchange of healthcare information across distance [2]. On account of the COVID-19, the demand for telemedicine increased dramatically, as it can avoid the contact between the COVID-19 patients and other patients. However, not only patients who have infected with the COVID-19 can receive online consultations, but other departments have also opened telemedicine services. This means that during the epidemic, more patients can receive treatment and reduce cross infection.

Although telemedicine cannot be considered as a treatment plan for all patients, it has great significance in some treatment plans. For some specific chronic diseases, telemedicine is more efficient than ordinary treatment. When it comes to students with asthma, telemedicine can alleviate symptoms and improve their ability to against adverse weather [3]. Students spend most of their time in school, and telemedicine can enable students to combine learning with effective and systematic treatment. Since the treatment process of chronic diseases is long, telemedicine can reduce the loss of time and money for patients. In addition, when people receive telemedicine, it is easy to implement if there are any changes in the following treatment. On the other hand, the elderly have a high incidence of infecting chronic diseases, and many countries suffer from an aging society. It is estimated that the number of people over 80 in the world will multiply by three between 2020 and 2050 [4]. Therefore, the popularization of telemedicine can reduce the pressure of aging on healthcare services.

Healthcare has developed more rapidly on account of the invention of digital technology, which means that the service scope of telemedicine has also been expanded. In the existing literature, imaging equipment that has high clarity is necessary for the telediagnosis of dentistry. With the constant updating of intelligent devices, photos taken from mobile phone cameras can also be used as a diagnostic basis, but it still has defects in the face of complex dental diseases. In Fairweather's research [5], teletherapy is welcomed by patients and their families for Speech-language therapy.
Teletherapy allows patients in remote areas to take treatments with low intermittence from doctors, therefore it is a great choice for patients who live in the area with backward medical services. Brahmbhatt and Cowie pointed out that telemonitoring has great potential in the management of heart failure [6]. Although existing monitoring equipment makes it easy to obtain patients’ physical data, it still has barriers on decision-making and processing after obtaining data. In the future, this barrier may be broken by artificial intelligence to help people make relatively timely decisions.

This article aims to explore the possibility of building a medical station to support telemedicine in remote areas. By reviewing existing literature, the development of telemedicine along with the demand of telemedicine in remote areas will be discussed. Finally, the limitations of building such a medical station will be introduced, and some suggestions will be given.

2. Overview of the Telemedicine System

Telemedicine provides the possibility that patients can also receive medical services at a distance. The demand for telemedicine significantly increased during the epidemic period because of the dramatic increase in the number of patients [7]. Many patients cannot receive high-level medical services in remote areas, therefore they are trying to look for better medical treatment in the cities with more advanced scientific and technological development, which also leads to an overload of the staff of a hospital. In addition, this phenomenon is more popular in some developing countries and regions with poor science and technology.

Therefore, it may be helpful to establish a medical station that can facilitate people to receive high-quality services to satisfy the needs of patients in suburban areas. In this medical system, patients receive telediagnosis at first, followed by remote treatment that is performed by professional doctors. Finally, they are monitored through IoT technology to detect their physiological data and judge whether further treatments are needed according to the state of patients based on the remoting diagnostic results. Since 5G has been successfully invented, it can be implemented to strengthen telemedicine.

2.1. Telediagnosis

Telediagnosis is identifying body signals through sensors and biometric systems, and finally diagnosing what disease does the patient have. At present, it is reported that oral diseases and Parkinson's diseases are the diseases that widely apply telediagnosis. Telediagnosis of oral diseases is extremely dependent on equipment and requires imaging devices that have high clarity to help doctors judge patients’ condition. According to academic statistics, the average age of patients applying for telediagnosis is 51.76 years old, and their average distance from the nearest medical institution is close to 100 kilometers, even one of the patients is 500 kilometers away from the nearest one [8]. It demonstrates that telediagnosis is popular among the elderly, and the service scope of telediagnosis is wide, thus it is beneficial for patients who live far away from the medical institution. The incidence of Parkinson's disease increases with age. While in the telediagnosis of Parkinson's disease, the required sensors are specified.

In Gopinath’s research, the telediagnosis for Parkinson's disease needs to rely on the subcutaneously implanted sensors to obtain data and diagnose according to the algorithm designed in advance. There is a certain demand for telediagnosis, which is composed of a variety of technologies. The demand is magnified in specific populations, including the elderly and people living in remote areas. In addition, telediagnosis can work better by implementing the Internet of Things, which is valuable in managing all the devices [9].

2.2. Teletherapy

Compared to traditional healthcare, teletherapy enables patients to receive more constant and stable medical services. There are loads of ways to complete telemedicine, nevertheless, as one of the most challenging forms of teletherapy, telesurgery will be discussed in this section. Telesurgery
generally refers to the surgery performed by doctors through controlling the surgical robot connected to the wireless network and doctors have no contact with patients during the whole process [10, 11]. Choi et al. concluded that one of the limitations of telesurgery is latency, which may be affected by network fluctuations and server overload [10]. In this case, telesurgery has been stuck in the initial stage. In addition, safety and cost equivalently affect the development of telesurgery.

The uncertainty of the surgery will increase as the duration of the surgery becomes longer. The uncertainty of surgery will not only raise the risk of surgery, but also increase the psychological pressure on doctors. Currently, the telesurgery is a costly treatment on the grounds that the surgical system is limited. In addition, the DaVinci surgical system almost monopolizes the market of robotic surgery [12]. Among several lately launched surgical platforms, Senhance has been proven to be able to compete with the DaVinci surgical system [13], where a typical sketch is illustrated in Fig. 1. Compared with the DaVinci system, Senhance requires lower cost. In the future, the research and development of more competitive surgical platforms can help balance the ecology of market of telesurgery.

![Figure 1. A sketch of the robotic platform for surgery.](image)

Whereas the implementation of 5G technology can reduce the delay to less than 1ms and improve the reliability to 99.99%. Thus, 5G technology can extend the distance between the output devices and the input devices by maintaining low latency of the surgery. Furthermore, monitors and cameras are the important facilities for observing the surgery process and machine operation. Their imaging clarity will greatly affect the success rate of surgery. If the imaging is not clear, patients may be injured accidentally. Furthermore, 5G technology allows telemedicine equipment to equip with 4k or even 8k monitors and cameras, which undoubtedly improves the clarity and the probability of success of the surgery.

2.3. Telemonitoring

In telemonitoring, the Internet of Things is the most essential technology. The Internet of Things can combine many information sensing devices with the network, regardless of time and place, to achieve information exchange between the devices and the network. The Internet of Things is widely used in various monitoring systems in healthcare, for instance, the physical data monitoring of applications that are related to healthcare in intelligent devices and monitoring of ward environment in the hospital. The monitoring of timely updated physical data is most suitable for patients with chronic diseases, besides, the pensioners are the people with a high incidence of chronic diseases.

Aging has become a common phenomenon in many countries, and the aging social structure has affected many countries. The Internet of Things is helpful in medical services for the elderly. The Internet of Things can not only reduce the burden of aging on medical services, but also enhance the standard of medical services [14]. However, the demand of the elderly for medical services is high because the elderly's body system will be affected by aging. The application of Internet of Things technology means that doctors can even monitor the health of the elderly from a distance, making it possible for the elderly to receive telemedicine, which reduces the pressure of aging on medical institutions.
Personal Healthcare Device (PHD) is instrumental in the medical system of the Internet of Things. As shown in Fig. 2, the wearer's biomedical signals can be detected and tested by it, subsequently, the data will be stored in the server [15]. Then, physician can evaluate the health level and prevent the occurrence of diseases based on these physical data. It is a considerate function for the elderly, especially those with chronic diseases. Moreover, if there is any abnormality, early detection can provide better treatment for the patient. Additionally, for the elderly with heart disease, their blood oxygen level and heart rate need to be always paid attention to. The monitoring system based on the Internet of Things can fairly help doctors detect these two data without distance limit, which is more beneficial to the elderly living in remote areas.

![Figure 2. A sketch of the working flow for PHD management server.](image)

The telemonitoring can also be used to control the environmental figure of hospital wards. The environmental data will be sensed through sensors and uploaded to the server through the network, which means that medical staff can directly obtain data and subsequently adjust the overall environment of the ward according to the needs of patients. Generally, indoor humidity and harmful gas will affect the patient's recovery. Moreover, Santos pointed out that body temperature is a critical indicator to check whether people are infected with various infectious diseases, and human body temperature will also be affected by environmental factors [16]. Furthermore, the high temperature environment will cause doctors to make wrong judgments about the patient's temperature. In general, the comfortable room temperature is around 22 °C, and the humidity of the room has a range from 30% to 65%. However, the most comfortable environment index may vary for different person, both genders and regions will affect this value. Therefore, it is necessary to monitor the ward environment for better recovery of patients.

3. Limitations

The emergence of telemedicine has changed the pattern of the medical industry and indicates the progress of the medical industry in the digital society. Although telemedicine will bring patients persistent and unvarying medical services, it is limited by three aspects, namely, equipment, funds
and demands [17]. Firstly, the demand for telemedicine in different disease areas varies greatly. The demand for telemedicine for patients with chronic diseases is urgent as telemedicine can overcome the long-term and consistent medical services that the treatment of chronic diseases required. Patients with non-chronic diseases may have minor demand for telemedicine. However, no matter what kinds of disease people get infect with, the demand of telemedicine will be expanded when the infected people are the elderly and those far away from telemedicine institutions.

Nevertheless, due to the spread of the COVID-19 epidemic, a great number of patients have to accept telemedicine to avoid contact with COVID-19 patients. On this basis, the popularity of telemedicine has gradually expanded. Further, in general, telemedicine needs the support of high-quality equipment, e.g., the imaging facilities have great clarity is required in the telediagnosis of oral diseases as well as in the monitor of telesurgery. Among the existing mobile phones, there are many devices that have clear imaging capabilities.

In the future, with the update of cameras, more portable devices can support telemedicine. On top of that, developing telemedicine will cost a great deal of money since it requires high-quality equipment, advanced operating systems and advanced digital technology. Additionally, building a medical institution that supports telemedicine requires distinctive equipment to deal with different diseases. Up to the present, telemedicine technologies for different diseases may be developing independently. However, in the future, it is possible to develop integrated devices, which can meet the different needs of patients.

4. Conclusion

To sum up, a large number of service industries have innovated themselves, and the medical industry is no exception. Telemedicine is an inspired model in the medical industry and has expanded its popularity during the pandemic period. With the aim of enabling patients who are far away from medical institutions to enjoy high-quality medical services, this paper attempts to explore the possibility of the construction of a medical institution supporting telemedicine, which can carry out telediagnosis, teletherapy and telemonitoring. Although telemedicine can bring convenience to both patients and doctors, the equipment and funds it asked are still challenged. Though the popularity of telemedicine in various disease fields is different, telemedicine is expected to popularize in the future with the progress of technology. After 5G technology is applied to telemedicine, it is committed to expanding the scope of telemedicine services and solving some limitations of telemedicine. For instance, 5G solves the problem of latency in telesurgery. Some limitations of telemedicine have also been put forward and suggestions have been given. Therefore, the idea of building medical institutions is feasible, because there is a demand for patients living in remote areas, but a large amount of capital investment may cause the burden of the government.

References


