Research on the Opportunities of 5G Technologies in transforming the Access and Quality of Healthcare Systems

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Abstract: Today's healthcare system faces serious challenges and inefficiencies despite numerous efforts to ameliorate the problems. Fortunately, technologies emerged as efficient solutions in driving the progress of improving the system, and much attention and hope have been given to the newest generation of networks—5G. This is attributed to the fact that the healthcare industry explored and implemented many use cases, but extensive implementations were hampered by the deficiencies of existing technologies. This paper summarizes the potential of 5G in transforming the healthcare system through the use of secondary data. By presenting two specific use cases under the current 4G network and the future 5G network, virtual consultation, and remote patient monitoring, it concludes that 5G has more potential to resolve the challenges by offering some unique features that are particularly beneficial to healthcare, such as high-speed data transfer rate, ultra-low latency, high bandwidth, better connectivity and capacity. The significance of this paper is that, under the COVID-19 pandemic, use cases that are delivered remotely are of urgent attention for the healthcare industry to develop. 5G offers immense improvements to the existing solutions in the 4G framework, including healthcare delivery convenience, medical resource optimization, and patient value growth.

Keywords: Covid-19, Opportunities, 5G, Healthcare Systems

1.Introduction

1.1 Research background

The term "5G" is the fifth generation of wireless technology. Though it is nascent at this stage and not ubiquitous, it emerges as a promising solution in various fields. It is mainly characterized by its high bandwidth, low latency, and high data transfer rate. Healthcare is one of the areas that receive numerous attention in the era of 5G due to many of its strained deficiencies like soaring healthcare costs and a lack of medical resources and access in the system. Although cutting-edge technologies are created to address these problems in the healthcare system, 5G stands out as a catalyst for all other technologies when integrated and can generate opportunities to transform key aspects of healthcare.

1.2 Literature review

Li lays out the potential benefits of 5G in the healthcare system and briefly presents some of the applications of 5G and its concomitant technologies like the Internet of Things (IoT), big data, Artificial Intelligence (AI), Augmented Reality (AR), and Virtual Reality (VR) [1]. The two presented cases are the integration of VR technology in rehabilitation training and the area of telemedicine. They both existed years ago but are not fully developed in the era of 4G, mainly due to limited bandwidth and data transmission speed. The paper also envisions a new healthcare model resulting from the maturation of 5G, which is called self-determination medicine. It will enhance the autonomy of patients given the improved ability of computers to process massive amounts of data, which enables patients to participate in the treatment system that doctors currently dominate. The high reliability and low latency of 5G will provide secure communication and an interactive network in which patients can build an individual health ecosystem.

West shows how 5G differs from its previous generations (3G and 4G) in several characteristics and discusses emerging applications of 5G in healthcare [2]. The paper demonstrates that connected medicine will provide people with quality care through improvements in diagnostics and treatment. More importantly, it emphasizes the role of 5G in transforming the digital integration of the healthcare system and how it brings patients closer to real-time health services. It also provides numerous

concrete examples of the 5G impact on medical access, cost, and quality. It finally gives recommendations on future advancements of 5G and the challenges that need to be addressed for the achievement of 5G to become a reality rather than a hope.

Latif, Qadir, Farooq, and Imran published the first paper that discusses how 5G, combined with other technologies like AI, big data, and IoT, will enable a significant future healthcare transformation [3]. The paper enumerates various challenges in the current healthcare system, and relevant data support each. It then highlights how these technologies can address this issue, followed by introducing specific 5G-enabled use cases and the unique capabilities of 5G in enabling the technologies to achieve their intended goals. It also presents a concrete case study describing the economic benefits of 5G-enabled healthcare in each technology, in which cost savings or reductions in healthcare are tremendous.

Mishra, Vikash, and Varma demonstrate the working principle and critical features of 5G and the limitations of existing technologies [4]. They focus on e-healthcare and propose a 5G architecture for it with the taxonomy of 5G. Moreover, they provide a comparative analysis of 4G LTE and 5G and deduce that 5G is more efficient at performing healthcare use cases and generates more security and data privacy than 4G LTE. This is an important discovery because most scholars cite data privacy and security as doubts or challenges for 5G implementation. The analysis that they perform could resolve this concern for the future of 5G.

The abovementioned scholars and other articles that this paper relies on providing insightful knowledge of the benefits of 5G and how 5G differs from 4G or its previous generations. They show that 5G is capable of integrating existing technologies and helping them achieve their maximum benefits to the healthcare system. Some use cases heavily rely on the unique capabilities of 5G. All of this information is essential and valuable for this paper. However, most of them mention each specific use case briefly in a paragraph and distribute more attention to explaining the technologies.

1.3 Research framework

For people to familiarize themselves with the use cases and how they have the potential to transform the current healthcare system, this paper intends to give a detailed description of two 5G-enabled use cases. First, it presents the main challenges in the healthcare system nowadays and discusses two solutions: virtual consultation and remote patient monitoring. Then it provides key features of 5G in comparison with 4G. To highlight the superior capabilities of 5G, it shows how some of the essential features of 5G can empower the use cases and maximize their intended results, which are limited by the deficiencies of 4G.

2.Methods

This paper relies on secondary data through literature research. The sources are mainly academic journals, industrial reports, and websites. It analyzes and synthesizes critical contents of the useful sources for this research. It distinguishes 5G from 4G in several characteristics and compares the two use cases in the two networks separately.

3.Results

As it stands today, the healthcare system faces several challenges that, if not addressed, will place a significant burden on both healthcare professionals and patients. First, the increasing cost of healthcare services, even in countries that offer universal insurance coverage, prevents a certain number of populations from accessing healthcare services. Second, a lack of medical resources means that, as the population continues to grow and age, the ratio of patients to doctors becomes imbalanced and leads to a shortage of healthcare professionals. There will be an anticipated 12.9 million healthcare workers shortage by 2035 [5]. Therefore the demand for healthcare far outpaces the supply and will contribute to longer waiting times for patients. There is also a lack of healthcare infrastructure, especially for people living in rural areas. It is difficult to transport necessary

equipment to their local hospitals, which creates constraints on the availability of treatment. Lastly, a lack of universal access denotes that not everyone has equitable access to healthcare services. Those who are financially disadvantaged or living in isolated areas have limited access. These deficiencies are most challenging for people with chronic diseases and the elderly. Both are seen as vulnerable populations in the healthcare system. The increases in chronic diseases have become the most dominant burden globally. They are affecting people over the world regardless of their ages and locations. The population is also aging quickly, resulting in a larger number of older adults globally. According to WHO, the total population globally over 65 years old was 702.9 million in 2019 and is expected to reach 1549 million by 2050 [6]. These vulnerable populations rely more heavily on the healthcare system because they consume more resources and visit healthcare facilities more often. Therefore, special attention should be given to these populations to improve the system more efficiently.

The prevalence of chronic diseases and aging population drive the demand for telehealth. Moreover, under the COVID-19 pandemic, healthcare delivery methods under telehealth have become extremely important and prevalent, useful when social distancing is required. They are not only helpful for alleviating the burden of these vulnerable populations but also tremendously efficient in addressing other challenges in the system mentioned above. This form of healthcare delivered remotely is already feasible in the 4G context, one of which is called virtual consultation. It is the process of patients consulting a healthcare professional over an audio or video call. The healthcare professional examines the patient through the call or video conference and then suggests the medications or treatments [6]. This innovation offers both convenience and freedom for patients and healthcare professionals without compromising the quality of care. Many patients who are in need of treatment reside too far from the necessary healthcare facilities, making it difficult and costly to get the treatments. This is especially true in rural or underdeveloped areas, where healthcare facilities and transport infrastructure is limited. If they choose not to get the necessary treatment due to the constraints, it will lead to increased emergency treatments and higher mortality rates [7]. Moreover, a typical in-person visit costs about $150 for an individual. In contrast, a virtual visit only costs $50, potentially increasing the patient turnout rate as virtual care is more cost-effective [8]. An example of implementing this solution is an enterprise called Babylon Health, which provides 24/7 access to a healthcare professional through virtual consultation [7].

Another solution that is considered and in the development process by the healthcare industry is remote patient monitoring, which enables healthcare professionals to track and manage patients' conditions faster and more efficiently. It works by placing patients with different types of sensors or wearable devices enabled by IoT technology to monitor a patient's physiological conditions remotely [4]. They allow patient data like body temperature, blood pressure, and heart rate to be continuously monitored and transmitted through cloud-based platforms. Data are collected, and reports are generated after a selected period and sent to the healthcare professionals. The data give insights that help them understand patients' conditions more thoroughly and make adjustments or improvements accordingly. Many of the issues in treating patients with the chronic disease could be reduced or resolved through this method. For example, patients suffering from chronic diseases such as cardiovascular disease, diabetes, and cancer benefit from this technology since remote monitoring devices can track vital signs and glucose levels and transmit the information to healthcare professionals [2]. This technology helps healthcare professionals detect possible problems early and provide treatments to patients proactively, largely preventing emergencies. This kind of monitoring is also useful for elderly populations, many of whom lack mobility and have difficulty traveling to healthcare facilities. Healthcare professionals can constantly track their health by monitoring data like food intake and exercise, which helps improve efficiency and gives older adults a sense of comfort being treated at home. Many organizations that currently deploy this technology include the Michael J. Fox Foundation, which uses wearable devices to track the tremors associated with Parkinson's disease, and Diabetacare, which provides all-day monitoring and support for people who have diabetes [2,7].

The benefits and examples of the two use cases demonstrated above show that the healthcare industry is already exploring them in the 4G context. Nevertheless, several constraints in the 4G network exist, such as low data transmission rate, security concerns, and limited connectivity that prevent large-scale adoption and successful implementation of virtual consultation and remote patient monitoring. Moreover, there are often breakdowns in service when many users in the same area try to access these services simultaneously. More devices on the network will create more demand for connections, which 4G will be unable to support. In contrast, 5G offers the unprecedented potential of moving the two use cases a big step forward through its unique and powerful characteristics.

4.Discussion

5G represents a quantum leap from its predecessor, 4G, in several aspects. First, its data transmission speed is 100 times faster than 4G [9]. However, 5G is not simply faster than 4G, and other key features enabling 5G to make a difference are worth noting. The most powerful and distinguished characteristic of 5G is its ultra-low latency. Latency refers to the time it takes for the network to process a request[9]. Under the 4G network, the request processing time is usually 50 to 80 milliseconds, which is sufficient for email and web surfing [2]. However, the goal of 5G is to reduce the time interval to a few milliseconds, which is at least 50 times faster than 4G [2]. Low latency offers a pronounced advantage in delivering healthcare to patients in that it enables 5G to move large datasets quickly and perform intensive work without lag. The lower the latency, the more 'real time' the experience of the event. Another important characteristic of 5G is its huge increase in bandwidth, which allows data to travel at 100Mb/s, which is 10 times more than 4G, and reach up to 20Gb/s at peak rates, which is 20 times more than 4G [7]. Moreover, 5G promises ultra-reliable and secure connectivity through new capacities like network slicing technology and encryption of data in motion [7].

Virtual consultations are already being developed and utilized in the 4G context, with some of them exploring the use case through high definition (HD) video. Its benefits are forecasted to be huge [7]. For example, according to a study, virtual consultation may save primary care physicians an average of five minutes per appointment and free up 47.8 million hours in the primary care workforce in Canada by supplementing one patient visit per year with virtual healthcare [6]. However, one of the limitations of the 4G network is that HD video meeting requires super-low latency. If the request processing time is not fast enough, the user experience will decrease. Though 4G may meet the performance requirements for the use case in a lab environment, it does not provide sufficient consistency to stream HD video without degradation of video quality in the real world [7]. As a result, the 4G network would not be competent enough to implement this use case adequately. As virtual consultations become prevalent, and healthcare professionals need dependable and high-quality videos to analyze patients' conditions and make more relevant recommendations, it is important to implement the use case through 5G. 5G-enabled virtual consultation will significantly decrease "did not attend" rates and waiting time for patients, thus improving patient turnover. According to predictions by STL Partners, there will be 2.8 million patient visits and 929 million missed appointments without 5G in 2030, but 5G is expected to bring 79.4 million extra patients treated in 2030 [7].

The remote patient monitoring with 4G also meets the necessary performance requirements and generates considerable outcomes. For example, after creating a Diabetes Telehealth Network with remote care management in Mississippi, cost savings were $339,184 for 100 patients enrolled in that project [2]. However, when this solution is rolled out to a larger amount of patients in more regions, the 4G network may not provide the necessary scale and reliability for healthcare professionals and patients. A great strain will be put on the capacity of the 4G network if the number of connected devices significantly increases because 4G supports only 4,000 devices per square kilometer while 5G can support up to a million devices [10]. The significance of 5G becomes pronounced as the use case adoptions increase. First, 5G has 100 times more capacity than 4G to connect with IoT wearable

devices, making 5G more reliable for collecting and transmitting vital patient information [11]. In this way, 5G allows healthcare professionals to gather patient data more real-time and make more informed decisions for better outcomes. With the ultra-low latency of 5G, healthcare will be delivered more efficiently and on time. This is especially important in times of emergency, where a delay of even nanoseconds can exacerbate the situations. Furthermore, data transmission like images and files required by remote patient monitoring is bulk in size. It will take significantly less time if 5G is implemented due to its high data transmission speed and high bandwidth. In addition to the existing benefits enhanced by 5G, 5G can also provide independent advantages like supporting two-way communication. Healthcare professionals will be able to respond and adjust data rather than just receiving them [6]. One of the most salient results of implementing remote patient monitoring through the 5G network is the reduced number of patients staying overnight in hospitals, which helps to free up bed space. According to estimations by STL Partners, there will be 4.2 million extra bed days available in 2030 under 5G-enabled remote patient monitoring [7].

Nevertheless, the availability of a 5G network is currently only limited to some urban areas in a few countries. In order to fully benefit from 5G, telecommunication providers must build a more extensive infrastructure to address the coverage issue. They will initially target major cities, but much of the value from the solution relies upon ubiquitous coverage, reaching those in more isolated areas. More importantly, the healthcare industry must partner with the telecommunications industry to generate value from 5G in order to fully profit 5G and the benefits it could offer. Healthcare professionals, the government, and application developers must actively accelerate 5G adoption. They should clearly articulate their requirements and specify how operators should deploy 5G to achieve those healthcare needs.

5.Conclusion

5.1 Findings

The major challenges that need to be fixed in the healthcare system are the rising cost of healthcare services, a lack of medical resources, and a lack of universal access to the system. The prevalence of chronic disease, the elderly population, and the COVID-19 pandemic aggravate the problems and pressure on the healthcare system. Virtual consultation and remote patient monitoring are two use cases that can effectively alleviate the problems by delivering healthcare services online. They significantly reduce various costs associated with healthcare services, free up healthcare professionals, and provide equal access for people living in rural areas. They also revise the trend in the healthcare system from reactive care to proactive care by providing consultation and monitoring constantly. Though the use cases can be delivered with the current 4G network, the forthcoming 5G infrastructure will provide new ways to tackle the challenges faced by the current 4G solution through its higher bandwidth, lower latency, extended security and reliability. The 4G network does not provide consistent and reliable performance in sending and streaming HD video in a virtual consultation. It cannot transfer large data files in remote patient monitoring. Once 5G standards are set and coverage is widespread enough, 5G will act as a catalyst for adoptions by drastically improving user experience and lowering existing hurdles with current connectivity solutions. Though there exists constraints currently that might prevent the healthcare industry from leveraging 5G's capabilities, it is still exciting to see the future development of 5G and its subsequent impact on the healthcare industry.

5.2 Limitations

This paper discusses the possibilities of 5G in transforming the healthcare system through virtual consultation and remote patient monitoring due to emerging healthcare trends of increasing chronic patients, the elderly population, and the COVID-19 pandemic. However, the lack of primary data constitutes the major limitation of this paper. It presents the findings only through research in secondary data, partly because the topic of 5G is still at the stage of development. It is more advisable

to survey healthcare professionals and the telecommunications provider to gather primary data when 5G-enabled use cases are implemented on a larger scale.

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