



# 5G technology for healthcare: Features, serviceable pillars, and applications

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## HIGHLIGHTS

- 5G refers to wireless network technology and has opened up new healthcare possibilities in innovation and expanded access to treatment.
- 5G technology is a prerequisite for the interconnection of everything in smart healthcare.
- This article studied the 5G, smart principal features and serviceable pillars of this technology for healthcare.
- Paper also identifies and discuss significant applications of 5G for healthcare.
- In future, 5G will helps people for proper control over their health.

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## ABSTRACT

5G refers to wireless network technology and has opened up new healthcare possibilities in innovation and expanded access to treatment. 5G is a unified, powerful air interface built with increased capacity to support next-generation user experiences and services. 5G technology is one of the essential technologies for societal digital transformation, and it is also a prerequisite for the interconnection of everything in smart healthcare. Promoting and implementing 5G smart healthcare can reduce inconsistencies in allocating medical resources and expedite medical advancements. This article studied the 5G and its need in healthcare. Smart Principal Features and Serviceable Pillars of 5G Technology for healthcare are discussed briefly. Finally, identify and discuss significant applications of 5G for healthcare. 5G promises to give people more control over their health. With the implementation of 5G, we will most certainly witness the introduction of new medical technology, allowing patients to test and monitor their health from the comfort of their homes. The combination of 5G and Artificial Intelligence (AI) will result in a network of smart devices that connect and, as a result, will broaden the backdrop for decision-making. It also creates new potential for the growth of the internal medical ecosystem. 5G network connection and coverage may be limited in areas with tall and broad trees and buildings. In the future, network operators and medical device makers will collaborate more in smart medical care.

## 1. Introduction

The fifth generation of mobile networks can transform almost every industry. Remote network-related operations, such as online sales demos or cloud-sharing of huge files, will become faster and more efficient with

5G. Businesses will benefit from increased productivity and sales by using this technology. Furthermore, 5G will open up new avenues for innovation throughout the Internet of Things (IoT). Driverless cars, virtual and augmented reality, artificial intelligence, remote-controlled machinery, and other innovations will provide a competitive advantage to

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firms eager to embrace new technologies.<sup>1–3</sup> The introduction of 5G technology can revolutionise healthcare delivery by increasing speed and capacity while decreasing latency. This strong network has enormous potential in the field of healthcare. As more organisations launch or extend their telehealth solutions, a high-quality video powered by 5G might assist patients and clinicians in establishing a rapid and precise connection.<sup>4,5</sup>

5G is expected to help a growing network of IoT devices and other wearables for remote patient monitoring in healthcare. 5G provides dependable connectivity, allowing staff to remotely make rapid health care decisions for more patients. It will be crucial for transmitting big pictures and may open the way for imaging instruments like X-rays and MRIs to function remotely.<sup>6,7</sup> While most hospitals have skilled surgeons on staff, they do not have every surgical specialisation. They frequently consult with specialists who have specific skills. Experts have used video and audio in certain medical disciplines to assist the surgical team throughout the procedure. As medical technology develops, more and more procedures rely on technology. With a 5G connection, the same information the surgical team sees may be live-streamed in real-time to the supporting expert team. The specialists will advise the team in real time during the surgery.<sup>8–10</sup>

With internet-enabled secure data sharing for many healthcare institutions, patients benefit from improved care networks involving doctors, pharmacists, social workers, caregivers, and others to communicate essential health data through the internet. 5G enables distant healthcare practitioners to employ communications technology to improve patient care.<sup>11,12</sup> Medical practitioners may share real-time data and discuss it with patients and peers via video conferencing. In addition, diverse healthcare teams can collaborate in medical consulting and planning to tackle complex health problems. Thus, to enable this long-distance telemedicine system to run smoothly, the 5G network provides the required bandwidth and low latency to transfer big video and picture data. At the same time, users communicate with each other through video conferencing.<sup>13,14</sup>

The healthcare business may benefit greatly from artificial intelligence and machine learning. AI can assist in diagnosing illnesses such as cancer, heart disease, skin blemishes, and others. AI systems can reach results much faster, making diagnostics more accessible to the general population. Furthermore, machine learning is one method of making medication more customised. Because each person responds to the same therapy differently, algorithms can assist in simplifying statistics gathering and identifying which factors suggest a patient will have a particular reaction to a specific treatment.<sup>15–17</sup> The potential for adopting 5G in Healthcare is promising. 5G technology can be a true driving force in the global expansion of the healthcare business. It can build a new progressive healthcare system step by step, beginning with better data storage, assuring traceability, expanding the availability of medical services, and other alternatives. It allows consumers to download data faster, has more bandwidth, and manages more connected devices with less time lag.<sup>18–20</sup>

As 4G technology advances to 5G, a single 5G connection is likely adequate for communication. As a result, more and more home healthcare solutions will connect using 5G. Hospitals will utilise wireless technologies to check patients' health problems after being discharged remotely. Smartwatches are beneficial for regularly monitoring the wearer's health problems.<sup>21,22</sup> Another significant advantage of 5G is sharing big pictures and data. It can also aid in developing augmented and virtual reality tools for teaching in complex medical settings. The demand for 5G connections coincides with considerable development in the wearable technology business. Fitness watches and other wearables are popular among consumers. The introduction of 5G wearable devices can enable clinicians to collect real-time data from forecasting poor health occurrences and creating precise, personalised patient treatment plans.<sup>23–25</sup>

This paper consists of 10 sections. Section 1 introduces the 5G technology and briefly about the paper. Section 2 discusses the need for 5G in healthcare. Primary research objectives are provided in section 3. Section

4 explains the principal smart features of 5G technology for healthcare, and section 5 discusses the serviceable pillars of 5G technology for healthcare. In section 6, significant applications of 5G technology for healthcare are identified and discussed. Section 7 provides a discussion regarding this study. Section 8 discusses the significant challenges of 5G, and section 9 provides the future scope. Finally, section 10 provides the conclusion of the paper.

## 2. Need for 5G in healthcare

In healthcare, there is an increase in the number of gadgets and technologies that offer better, more efficient services, transforming healthcare facilities into smart hospitals. 5G provides seamless connectivity, eliminating the need to move between in-building Wi-Fi and mobile networks, and enables the merging of several incompatible IoT radio networks into a single network. When the technology is fully employed, patients will receive treatment sooner and have greater access to otherwise unavailable specialists. 5G connections can increase experts' abilities to reach these underserved patients without needing physical presence.<sup>26–28</sup>

Wearable monitoring devices give continuous insight into essential health indicators such as heart rate and blood pressure. 5G connection can significantly improve the healthcare industry's capacity to offer patients a continuum of care. 5G-based sensor node infrastructure is recommended for simply and comfortably monitoring patients' health. A surgeon can operate robotic equipment remotely, which is beneficial for performing patients' medical procedures. Telesurgery or robotic surgery needs a dependable network, mainly when a surgeon receives haptic input. The success of remote robotic surgery is increasing using 5G network technologies. It has enormous potential to create an online virtual healthcare facility where doctors can operate on patients anywhere.<sup>29–32</sup>

## 3. Research objectives

The healthcare IT sector is constantly looking for new ways that sophisticated technology may improve healthcare delivery. With the advent of new 5G technologies, the healthcare industry's IT services and apps have become more linked than ever before, with the best implications for healthcare professionals and patients. 5G brings up completely new possibilities for telehealth.<sup>33,34</sup> This technology allows patients to communicate electronically with physicians and other healthcare professionals via real-time video or live chat. 5G's high speed allows for more effective long-distance healthcare delivery. This is because data transfer from remote areas may occur in near real-time. As a result, doctors and experts can swiftly and correctly diagnose, treat, and monitor patients situated hundreds or even thousands of kilometers away. Adding a high-speed 5G network to current infrastructures can rapidly and safely transfer massive data files of medical imaging, improving access to treatment and care quality.<sup>35–37</sup> The primary research objectives of this article are as under:

- RO1.** - to study the 5G and its need in healthcare;
- RO2.** - to discuss the Smart features of 5G Technology for Healthcare;
- RO3.** - to brief about the Serviceable Pillars of 5G Technology for Healthcare;
- RO4.** - to identify and discuss significant applications of 5G for Healthcare.

## 4. Smart principal features of 5G technology for healthcare

Advanced healthcare practices seek proper and interconnected network facilities to enable quality patient services. Fig. 1 explores the different aspects and principal features of 5G technology for healthcare practices. Various features and technologies promote the 5G scenario for

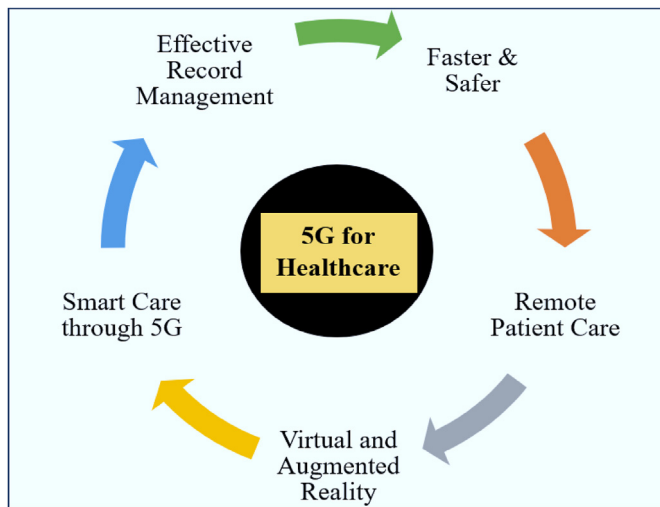


Fig. 1. Features and tools of 5G for healthcare practices.

healthcare practices: wireless communications, fast and accurate connective trends, virtual and augmented reality, remote surveillance, remote tracking, patient data support, etc. The 5G technology further supports healthcare practices more effectively and impactfully.<sup>38–40</sup>

5G enables healthcare professionals to offer therapy to chronically sick patients in real time across the fastest network possible. Patients with chronic illnesses can maintain autonomy and improve results using dependable, always-on mobile personal emergency response devices. More medical devices will be available to patients as technology advances, allowing them to test and monitor their health from the comfort of their homes.<sup>41,42</sup> This healthcare technology calibrates, collects, and validates data from trustworthy sensors. This data can be subsequently transferred for analysis to a range of medical and healthcare specialists. Integrating several patient Internet of Medical Things (IoMT) devices and sensors enable clinicians to give their patients a total health picture, resulting in a customised health treatment regimen.<sup>43–45</sup>

The healthcare industry remains flexible to fully capitalise on the surge of innovative applications offered by 5G networks. Physicians and patients have primarily interacted face-to-face in medical offices, hospitals, homes, and care facilities for hundreds of years. Today, however, medical technology and speedier networks of 5G are altering the face of healthcare. The development of wearable health gadgets to monitor vital signs has been most evident. Health institutions are increasingly adopting telehealth technology to treat patients to keep patients and medical personnel safe. As a result, the global telemedicine market is expanding rapidly. Medical gadget manufacturers are scrambling to meet demand.<sup>46–49</sup>

5G wireless technologies propel telemedicine and other healthcare services to new heights. As a result, the expansion of home healthcare, remote patient monitoring, robotic surgery support, and smart city infrastructure will be accelerated. Patients and healthy people alike will notice a direct influence on their well-being and accessible healthcare resources. Home healthcare is becoming more popular as the population ages.<sup>50,51</sup> While staying or recovering at home is more convenient, there are safety issues when an outpatient or older person lives alone. Some technological elements contributing to this are broad cellular network availability, ease and speed of implementation, and substantially enhanced bandwidth. 5G can also support large-scale IoT and smart city infrastructure.<sup>52,53</sup>

The Internet of Medical Things (IoMT) -based gadgets, when combined with remote monitoring, telemedicine, and robotic surgical technologies, can change how healthcare practitioners maintain patients' health cheaply. Medical practitioners can monitor, inform, and receive real-time data to detect a medical problem before it gets critical. 5G

technology is the greatest thing to rely on to keep everything running correctly.<sup>54,55</sup> With the aid of IoMT, this cellular network technology has revolutionised healthcare by improving the quality and efficiency of wearable medical equipment. Artificial intelligence has enormous potential to enhance the diagnosing process, design the best therapy for specific patients, and predict postoperative problems. A massive quantity of data is required to reap the benefits of AI. Healthcare firms with a 5G network may use AI tools to provide the best treatment.<sup>56–58</sup>

A 5G network with low latency and incredible bandwidth can speed up the entire process. The more innovative healthcare device technology becomes, the more medical gadgets patients will be helpful to. Patients can use such devices to monitor their health from the comfort of their homes. Sensors in these specialised gadgets will generate data. Healthcare experts can send and analyse these sensors to better access and treat data. Paramedics may transfer patient data immediately from the ambulance and link an experienced professional to give emergency care online using high-speed 5G. Furthermore, continuous remote patient monitoring will allow people with chronic conditions to call doctors as soon as possible. Doctors will be able to check the status of their patients no matter where they are.<sup>59–62</sup>

As the Covid-19 pandemic has increased the demand for medical services, the concept of remote connection between physicians and patients has grown more significant than ever. Telemedicine applications, chatbots, and robots are utilised to gather data, treat patients, and diagnose, which is critical during a lockdown. With higher network speeds, 5G enables clinicians to communicate with patients remotely without worrying about network failures, blackouts, or delays. 5G also allows seamless communication by integrating medical devices into a single network. Patients who are more active in health monitoring are more likely to adopt healthy lifestyles, increase treatment results, and lower healthcare expenditures.<sup>63–66</sup>

### 5. Serviceable pillars of 5G technology for healthcare

Several base and service structures have been revealed where 5G culture was found to be super classical and effective in the healthcare domain. Fig. 2 exemplifies the pillars and supportive grounds through which 5G technology becomes more powerful for healthcare structures. The availability of a high-class network and 5G connectivity features also fulfil the need for advanced healthcare facilities. There are four pillars or enablers that signify the 5G implementation. These are; care for patients, well-equipped healthcare professionals, supportive and caring healthcare units, and government bodies. These pillars provide the basic structure for implementing 5G technologies to deliver the perfect quality healthcare services.<sup>67–70</sup>

The increasing connectivity demands of healthcare providers are addressed by 5G. These include faster speeds, reduced latency, higher connection density, and the ability to ensure the quality of service. 5G can be a significant connection enabler for better healthcare scenarios

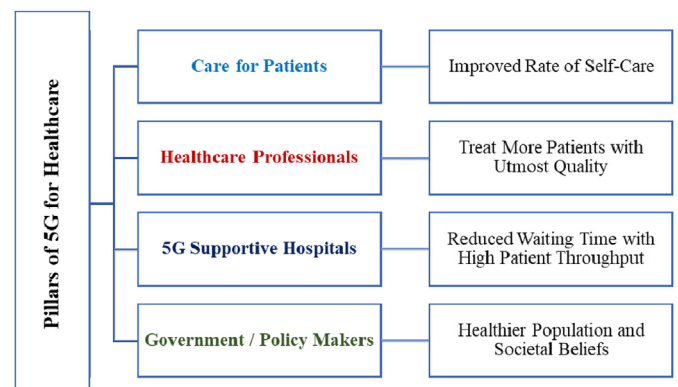


Fig. 2. Supportive pillars of 5G technology for healthcare.

supplied by IoMT, robots, AI, and the cloud. These technologies create massive amounts of warnings and data, which might overwhelm healthcare professionals' capacity to use them<sup>71–73</sup> efficiently. VR and wearable sensors may be utilised for home-based rehabilitation, video consultation, and real-time transfer of pictures, videos, and healthcare-related information from clinical-grade equipment, providing patients with faster and more accurate remote diagnosis and guidance. The speed and data capacity of 5G can enable remote care and treatment by integrating tools and equipment that efficiently support seamless communication and real-time operations regardless of location.<sup>74–76</sup>

Recent advancements in connected-health technology have enabled healthcare providers to enhance cooperation and communication while enabling new care-delivery models that make treatment more accessible, such as remote patient monitoring, virtual care, robots, and telepresence. Faster connection speeds change doctor–patient interaction by incorporating technical communications into medical treatment. Patients wear remote medical sensors from the comfort of their own homes, relaying vital signs to healthcare specialists. This enables doctors and caregivers to monitor various vitals, manage treatment plans dynamically, and conduct a consult or intervention via webcam. With the introduction of 5G networks, this current medical trend will be taken to the next level, providing a significant economic boost to the medical sector.<sup>77–79</sup>

The availability of mobile applications and platforms may deliver on-demand medical information more quickly by utilising 5G and can even be used in instances such as patient admissions to make these procedures more efficient. Because of the improved speed of 5G, telemedicine can be enabled on mobile devices. It will expand its reach and make these services available to more patients. As a result, patients will receive treatment rapidly, and physicians and other experts will interact more effectively. Paramedics will transmit pictures, data, and comprehensive information, which helps prepare physicians for treatment using 5G technology.<sup>80,81</sup> Similarly, high-quality video connections may enable paramedics to administer emergency care or examine and diagnose patients at the scene with the help of an online professional. Furthermore, the improved capabilities of 5G may enable disaster response organisations to implement predictive analytics, machine learning applications, and artificial intelligence systems.<sup>82,83</sup>

Before introducing 5G technology, remote monitoring was restricted by networks' ability to manage such massive volumes of data. Hospitals and practitioners could not obtain the real-time data required to improve patient and preventive care and make more timely healthcare choices. Remote monitoring may be significantly enhanced with 5G technology, which promises reduced latency and higher capacity, therefore improving patient care and providing healthcare practitioners with the data they want in real-time. 5G has low latency to offer real-time information, such as live HD video. Its high bandwidth allows doctors to communicate with patients or the elderly and send and analyse massive data sets. Its dependability and security improve communications within hospitals and other healthcare settings.<sup>84–87</sup>

5G systems provide improved mobile broadband, dynamic low latency, larger bandwidths, device-centric mobility, concurrent redundant and dependable device-to-device connections, and shared spectrum. 5G connection tackles various constraints through higher bandwidth use and an intelligent network that can segregate and prioritise life-critical activities, such as sizeable machine-to-machine communication and computing necessary for remote tactile surgery. These disruptive technological solutions contribute to a larger linked healthcare ecosystem, which necessitates data gravity and attracts more technology and software solutions. This enhanced healthcare data governance and regulation, including classification of the patient and associated healthcare data, security, collection, storage, transfer, retention, and deletion.<sup>88–90</sup>

Enhanced augmented reality (AR) and virtual reality (VR) use advanced imaging technologies and spatial computing applications. 5G technology can assist clinicians in simulating more complicated medical situations and supporting less intrusive operations. More complex training settings can help medical school students and residents learn to

care for patients safely.<sup>91,92</sup> The wearable gadget may gather information about the wearer and communicate it with healthcare providers remotely using Bluetooth to link with a 5G device such as a smartphone. In many situations, patient monitoring throughout the day offers a more accurate picture of the patient's state than much hospital-based equipment. Because of these new uses for wearable technology and data transmission, dependable, high-speed connections will be critical to the medical industry's future.<sup>93,94</sup>

As 5G technology becomes more widely used, the potential for healthcare applications becomes limitless. The proper strategy, tactics, and technology can assist providers in making the most of this promising technology in the following years. Patient data must be kept centrally for patient applications to transform hospitals into data centers and doctors into data scientists. Patients will have online access to a centralised repository of medical records, allowing them to readily manage the quality and efficiency of their care. 5G will improve access to prediction algorithms, ranking patient data in order of emergency with more precision and convenience. 5G network provides companies with better customisation and total control over their connectivity. It allows company executives to implement uniform networking strategies across the firm. 5G networks provide facility smartness by delivering significantly improved mobile connection that promotes digital transformation.<sup>95,96</sup>

## 6. 5G technology applications for healthcare

A 5G network, with its high speed and super capacity, is a significant element. This technology enhances the viewing experience by offering 360-degree video and enabling cordless live streaming. It helps medical practitioners to extensive experience throughout their training and when treating or operating on patients. Healthcare practitioners may use IoT devices to monitor patients and collect data that can subsequently be used to make healthcare more customised and preventative than ever before. Chronic illnesses can be controlled, and healthcare costs lowered using a real-time remote health monitoring system. They may quickly obtain the data they want in real-time and treat their patients appropriately. Patients will be able to communicate data throughout the 5G network swiftly. This eventually allows patients to utilise patient portals more efficiently, examine test results and pictures, access remote care, and locate care plan information. This shift to remote care will be aided by 5G, providing more dependable connections to transfer patient data. This will make it easier for healthcare practitioners to make data-driven healthcare choices<sup>97–101</sup> remotely. Table 1 discusses the significant applications of 5G for healthcare.

The advent of 5G has catalysed the implementation of many innovative technologies that require more network power and lead to revolutionary new medical solutions. Healthcare workers not only deal with a large quantity of patient data, but this data is also sensitive and must be maintained securely. 5G will revolutionise how gadgets and networks communicate and safeguard mission-critical communications, enabling doctors to provide remote health care. The patient experience will be significantly impacted by adopting 5G technology. Introducing 5G technology will enhance remote monitoring systems and telemedicine capabilities. Preventative care will see significant gains as a result of 5G. Physicians can transfer files to an expert much faster using 5G's speed. They may then utilise AI technology to help them diagnose patients based on images.<sup>102–104</sup>

As the number of linked devices and networks increases, 5G will offer advantages and disadvantages in network and data security. Healthcare companies must assess the risks and vulnerabilities associated with the availability and access to patients' health data. Technology is at the core of inpatient and outpatient monitoring and tracking, from locating a hospital room for an arriving patient to transporting patients about and between rooms and diagnostic treatment areas to keeping an eye on a heart monitor. The rise of 5G is set to exponentially accelerate all that data and open up channels of connection in entirely new ways, both within and beyond the hospital's boundaries. It will alter how healthcare

**Table 1**  
5G technology applications for healthcare.

S.No	Applications	Description
1	Digital transformation	5G can promote various improvements, including digital transformation across all industries, including healthcare, due to its higher data download rates, reduced latency, and dependable connections. 5G technology can create a solid basis for innovation by enabling the interaction of health sensors, algorithms, and smart devices and more efficiently and cost-effectively supporting remote monitoring. 5G technology can support various applications, including virtual reality and remote surgery, enabling hospital management systems. With real-time information, patients undergo a thorough examination using 5G-connected diagnostics equipment. This results in reduced physical contact, lowering the danger of Coronavirus transmission and allowing doctors to serve more patients.
2	Data transfer	A 5G network sends data files swiftly between doctors and hospitals, decreasing the time required to transport them through typically underpowered traditional wired networks. Because doctors can send and consume medical data faster than ever before, whether at home or in the office, 5G implies more prompt diagnosis, opinions, treatment beginnings, and modifications. The transition to 5G provides a long-term answer to the ever-increasing demand for bandwidth. Healthcare professionals may remotely monitor patients and collect real-time data for preventative treatment and other specifically tailored healthcare solutions using 5G-enabled wearable gadgets.
3	Remote patient monitoring	5G will enhance home healthcare, remote patient monitoring, and surgical procedures. This technology will improve the way crises are handled in smart cities. Critical information will be available in near real-time, allowing teams to react much faster and provide better treatment. Machine learning, artificial intelligence, and robots will play a more significant part in increasing accuracy. 5G can alleviate the healthcare business's challenges while accelerating the industry's digital transition. It benefits patients with chronic diseases who have previously had several medical tests and find it difficult to travel to a doctor located thousands of miles away.
4	Large medical imaging files transfer	Adding a 5G network to an existing healthcare infrastructure can aid in the quick and dependable transfer of big medical imaging files. The doctor gets the report with a fast network when a patient's test is completed. As a result, doctors obtain what they need for future therapy more rapidly, improving overall patient care. Patients no longer need to drive long distances to see a doctor. Healthcare treatment may now be provided remotely using telemedicine. 5G network has made it more secure and smooth. It provides real-time, high-quality mobile video. As a result, people may consult doctors outside of their usual locations, and doctors can interact more effectively among themselves.
5	Telehealth	Telehealth enables chronically sick people to receive necessary treatment when they cannot leave their homes to visit their doctors. Telehealth applications increase substantially as 5G offers ultra-fast bandwidth with reduced latency. The network footprint of the healthcare business expands year after year, implying that an increasing number of healthcare services and applications rely on fast network speeds. 5G technology aid in transforming archaic hospital

**Table 1 (continued)**

S.No	Applications	Description
6	Security process	healthcare systems into smart hospitals capable of providing remote healthcare services to patients worldwide. Whether in healthcare or elsewhere, businesses must plan to adjust their security processes to keep sensitive data secure while implementing 5G. Shortly, 5G promises to be a key accelerator for developing innovative technology. Healthcare is one of the areas that has been waiting for 5G to begin bringing about the improvements it is meant to bring about. 5G enables connections to support the data transmission required by healthcare professionals. So, shortly, telecom software solutions for healthcare will become an attractive growth market, promising to realise long-planned medical advances.
7	Improve responsiveness	5G technologies have greater bandwidth than 4G technologies, resulting in quicker Internet connections and large-scale device communication systems. 5G technologies give improved responsiveness, which means reaching many network-connected devices. As a result, 5G is projected to be a driving factor in the growth of the Internet of Things, allowing healthcare to construct sophisticated networks of smart medical equipment. Thus, 5G is a speedier network that allows for quicker data transfers and the efficient connectivity of many devices. 5G technology can sustain communication and calculate data quickly. This offers new medical possibilities, including using artificial intelligence in real-time decision-making and other sophisticated technologies to improve patient care.
8	Quick data transmission	Processing speed is critical in contemporary medicine, yet some medical data, such as imaging images, are significant. 5G enables significantly quicker data transmission, allowing physicians to get rapid, high-quality image files generated by MRI, CAT, or PET scans, which are essential for swift decision-making. As a result, 5G enables quick data transfer between physicians and hospitals, assuring accurate diagnosis and treatment. Improved data availability and the capacity to handle it in real time will benefit the whole healthcare system.
9	Patient care service	5G is improving the seamless delivery of patient care services in the hospital. Compared to existing connectivity services, 5G allows quicker and richer data exchange and more complicated data processing at the network's edge, at the point of care. In emergency scenarios, such as remote ambulance diagnosis and real-time health data transfer, real-time data sharing might be critical when teleconsultation is the only choice. 5G is a game-changer for healthcare enterprise services that require more content-rich clinical collaboration and communications and a dependable infrastructure for apps and devices. 5G can improve skill development in the medical field by increasing access to simulation activities, including VR and haptics, in the education process and delivering realistic, real-time remote tutoring at the greatest resolution.
10	Deliver high speed	5G offers healthcare professionals and can deliver high-speed, life-saving services outside their physical boundaries. These include data advantages such as sending large digital diagnostic files like MRI results. 5G is anticipated to change how healthcare practitioners communicate with one another and their patients, from quicker tests and diagnostic findings to telemedicine, remote

(continued on next page)

**Table 1 (continued)**

S.No	Applications	Description
11	Helps real-time surgical procedure	monitoring and surgery, robots, and other applications. 5G is a new wireless network that is primarily cloud-based. Healthcare systems can use 5G to allow mobile networks to conduct telemedicine visits, substantially expanding the reach of these programmes. It also allows physicians and other staff members to work more efficiently and effectively. 5G can help with real-time surgical procedures. This allows hospital-based physicians to give treatment recommendations to remote locations and field personnel, another 5G use case early and present. It is expected to enable remote surgery eventually and treatment utilising robots, support augmented and virtual reality and remote clinical care, and wearables for mobile field assistance. In such cases, highly trained and experienced senior practitioners can assist remote and rural medical workers from a single and centralised location.
12	Support medical devices	5G will support various medical devices, including smartphones, smartwatches, smart scales, and other measuring devices. Biosensors and trackers implanted in our clothes and accessories will give meaningful feedback and alert us to early symptoms of health change. 5G telecommunications offers greater bandwidth, reduced latency, and the possibility to include cloud and network-connected gadgets. As a result, the IoT will connect more complicated networks, while other systems require enormous data transfer volumes, such as driverless vehicles, robotic surgery, and critical infrastructure monitoring.
13	Quality of life	Healthcare is a critical service area with far-reaching consequences for the quality of life, which can be assisted by 5G, which may play a positive role in delivering improved services. Research and partnerships in technological enablers and academics are conjuring up new applications and services within the healthcare business. Connected wearables and IoT technologies, such as remote patient monitoring tools, improve patient health insights. This allows patients to obtain care more quickly and enables collaboration among physicians, employees, and experts from any place. Patients and physicians must be confident that they can rely on the internet services they access and use and the numerous gadgets that access their surroundings. They must also have faith in the everyday computer interactions in their settings, such as software upgrades, communications, and other routine activities.
14	Innovation	Its ultra-high capacity and low latency will distinguish 5G. As more 5G applications become available, innovation will become increasingly essential in the realm of 5G. Such variation in creativity will need the underlying technological architecture to be nimble, on-demand, open, and continually developing. High-quality 5G connection technologies can increase medical professional cooperation by cooperating on scans to diagnose patient care better. The possibilities of smart, data-driven algorithms in healthcare will grow in tandem with the growth of health IoT networks and devices. Using AI software to evaluate real-time patient data supplied to cloud platforms would be easier and more reliable with 5G infrastructure.
15	Remote surgery	5G also lays the groundwork for sophisticated applications such as remote surgery by specialists utilising robotic arms linked by communications networks. These applications can also provide new income streams for

**Table 1 (continued)**

S.No	Applications	Description
16	Resolve health issues	operators, who play a critical role in allowing this innovative application of contemporary network technology. 5G technology will undoubtedly be deeply integrated with medical care. This technology will make medical care more feasible in hospitals and private clinics. Wearable medical gadgets have been demonstrated to be beneficial in assisting different risk groups in resolving health issues and improving patient prognosis. Patients and physicians may benefit from more significant functions if their connections are smoother with 5G. This technology can aid in the faster transmission of critical data. 5G can provide continuous broad coverage for emergency vehicles, allowing patients to realise that “getting aboard the ambulance implies entering the hospital. Remote specialists can conduct remote surgical therapy for patients at local hospitals using medical robots and high-definition audio and video systems.
17	Improve the ability of healthcare worker	Implementing 5G in Healthcare can significantly improve healthcare workers' communication and cooperation. 5G increases physicians' capacity to connect with patients and complement their expertise by removing several difficulties. With 5G's faster speeds, there is no limit to the quantity of data that healthcare practitioners may transfer instantly via digital channels. This is especially beneficial when high-resolution pictures, such as x-rays, are used in the diagnostic procedure. The additional bandwidth provided by 5G also allows for more significant usage of networks without sacrificing speeds, which is essential for IoT adoption. Medical IoT solutions enable healthcare companies to continuously gather and analyse patient data in real-time.
18	Enable public safety	5G-enabled technologies will enable public safety organisations to create realistic crisis scenarios for training and testing. 5G deployment provides more incredible options for companies, and IT teams to improve security and battle hackers. 5G cellular technology has become more widely available. It offers increased bandwidth and data rates, reduced latency, and the potential to bring practical IoT to many devices. 5G implies enormous advances in patient care, results, and experiences. Customers use smartwatches and phones to measure exercise, diet, heart monitoring, blood pressure, and glucose levels.

practitioners exchange crucial information and their patients.<sup>105–107</sup>

## 7. Discussion

5G promises a new health ecosystem capable of meeting the requirements of patients and healthcare providers accurately, efficiently, conveniently and cost-effectively. 5G networks are set to change all essential components of healthcare throughout the world. Healthcare businesses may employ machine learning technologies to deliver the best treatment possible in the hospital or clinic by moving to high-capacity 5G networks. 5G networks can allow accurate real-time data transfer, ensuring the quality and dependability of medical data via AI systems. 5G and AI will reduce barriers to hospital interconnection, enabling improved diagnosis and treatment experiences to be exchanged between large and small hospitals. AI enables clinicians to assess specific patient statuses in real time, enhancing diagnosis and healthcare delivery regardless of the patient's location. This saves money, shortens treatment time, and gives the end-user more options. Clinicians must understand their complexities and dynamic changes, which can be time-consuming

and error-prone owing to visual strain.

The applications of 5G influences physicians learning by allowing them to use more sophisticated augmented and virtual reality apps. VR application helps teach medical students about stroke physiology and diagnostics. Students use a VR headset and are immersed in a virtual world where they engage with a patient to determine whether they show symptoms. Students can witness how persons suffering from a stroke might be impacted by asking them to lift their arms. 5G enables apps that offer clinicians rapid and reliable access to big files like medical records and images but also gives more coverage. Due to their potential to digitally change the learning experience, virtual meeting programmes like Zoom, Microsoft Teams, and Google Meet have increased client subscriptions.

The next generation of the internet and 5G will strongly influence each critical stakeholder in healthcare, providers, payers, and pharmaceutical firms. With 5G networks, healthcare authorities can enhance efficiency and results by using new technologies such as IoT to maximise the benefits of decreased latency, resulting in better patient care with fewer delays. This enables quicker and more reliable video connections, proactive care based on medical equipment input, and large-scale patient data analysis to enhance overall health results. These impacts can substantially impact healthcare professionals' capacity to interact with their patients, monitor their health, and give medicines and lifestyle advice at crucial times to guarantee optimum efficacy.

Patients can now access tailored treatments by using 5G and IoT technology. The monitoring capabilities keep patients updated on personal health patterns, such as rising blood sugar levels, which may signal pre-diabetes. This early warning system can discourage or prevent many significant health events. These technologies also help many people recuperate after a medical event. Faster networks provide real-time data tracking customer product preferences and in-store purchasing patterns using 5G. This data enables businesses to offer a more tailored customer experience by sending targeted emails about the most substantial discounts. Due to COVID-19 health limitations, 5G has helped families and friends to stay connected through various digital channels with patients unable to meet their loved ones in person.

Using 5G networks will experience tremendous development throughout the digital era. The long-term consequences will improve the healthcare sector, including more efficient ways to care for patients, aid healthcare workers, and, eventually, save many lives due to the beneficial influence of technology advancements. 5G research and development has cleared the way for a robust new communication standard that connects billions of devices and sensors to the internet. The quicker network speeds and larger bandwidth of 5G not only save time and money for organisations, but in the case of the healthcare business, this upgraded technology has the potential to save lives.

## 8. Challenges of 5G

The biggest drawback of 5G is that it only has local availability and has patchy worldwide coverage. Only urban regions will benefit significantly from the 5G network, while rural areas may only see coverage for a few years. Also, the costs associated with installing tower stations are significant compared to other networks. The introduction and implementation of 5G will take years since testing, trialling, and installing 5G towers are costly. While 5G operates quickly at high speeds, it will not have the same range as 4G. Moreover, large structures and trees may obstruct the frequency of the 5G network, which will cause several issues. Because of this, providing coverage with additional towers takes longer and costs more money. Rain can also interfere with 5G coverage, which requires additional protection. While having the potential for higher download speeds, experts predict that 5G technology will have a lower upload speed than 4G and 4G LTE.<sup>108–111</sup>

Another drawback of 5G technology is that it impairs cellular devices by shortening their lives and depleting their batteries. A 5G connection on the phone will cause a significant power drain, significantly reducing

battery life. So, in order to safeguard the battery from harm and other issues, producers must invest in innovative battery technologies. Another negative aspect of 5G technology is that it makes cybersecurity more vulnerable to attack. However, the absence of encryption during connection also makes 5G-enabled devices a more accessible target for cyberattacks and data theft. One of the issues with 5G is cybersecurity since hacking will happen. The increase in bandwidth makes it simple for thieves to grab the database. Also, the software it employs makes it subject to assaults. Attacks are likely when 5G connects to more devices. Due to the absence of encryption in 5G, hackers would be able to organise their assaults more effectively, which will significantly harm businesses.

## 9. Future scope

In future, 5G technology will provide remote support of excellent healthcare while limiting patient exposure by eliminating in-person visits to doctors and healthcare facilities. Patients who cannot go to their healthcare professionals will visit them via natural-feeling telepresence devices using 5G. Consequently, a wireless network can supply vital healthcare treatments for chronically ill or confined patients. 5G has the potential to alter the infrastructure of Healthcare IT completely. 5G technology will become more feasible and provide a digital revolution for healthcare. Healthcare companies must assess their infrastructure and equipment to remove potential barriers and plan for a 5G future. This technology can transform patient empowerment and home health care entirely.

5G networks will lay the groundwork for businesses to track consumer behaviour, personalise marketing plans, provide better services and deliveries, improve operational efficiency, empower employees through seamlessly connected devices and accessibility, and eventually lead to predictive analytics and better decision-making for a sustainable and profitable future. 5G technology will enable physicians and other medical practitioners to do their jobs more successfully and do things they could not do previously. AI and machine learning will be essential to the success of 5G in healthcare. Massive volumes of data will be sluicing over the network from electronic health records, wearables, imaging files, and shortly's massively linked healthcare paradigm. 5G will improve the command and management of beyond-line-of-sight drones and other uncrewed vehicles, allowing public safety personnel to respond faster and acquire more situational awareness during emergencies.

## 10. Conclusion

5G networks bring up new options for healthcare delivery. Rather than transporting patients to a doctor for treatment, 5G networks may connect patients and physicians worldwide. By combining more medical equipment with IoT, doctors will monitor patients without expensive inpatient treatment. Digital imaging may be transmitted anywhere globally for analysis, increasing access for patients distant from health care providers and decreasing the cost. The healthcare business has a complicated regulatory framework and profoundly ingrained legacy systems, which have historically delayed the adoption of new technology. However, healthcare may see the most significant changes and may benefit from several elements of 5G technology. 5G can enhance patient monitoring and care at home and the efficiency of practices and hospitals. Wearable devices transferring patient data through 5G networks necessitate the development of technology that ensures safe and secure communications. The medical industry may draw on cross-industry experience by selecting solutions that have proved effective in other sensitive areas, including data centres and consumer electronics. This helps the expert supervise a necessary surgical procedure using high-quality pictures and minimal latency to provide quick feedback. In the future, with a high-capacity 5G network, remote robotic-assisted surgery will be easily possible.

## Declaration of competing interest

None.

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