Applications of 5G networks for Healthcare: best practices for European Society

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Abstract

The 5G standard will be a new milestone in the development of modern video communications, especially in areas where ultra-high video expansion is required, such as medicine. Over the past few years, the field of e-Health has experienced substantial growth and advancement. The adoption of technology in the health sector has become a common practice across all Member States in the European Region. These investments are aimed at achieving health system reform, introducing innovative healthcare methods, and providing efficient means of accessing and exchanging health information. This article discusses the new 5G network and the scope of this technology. The application of the new network in the medical field is analyzed. It is established that fast and reliable communication will soon allow not only to conduct video consultations but also to remotely manage complex operations. The report's main findings suggest that there is a growing interest in e-Health and that actual advancements are being made in the integration of technology solutions for enhanced public health and healthcare service delivery. Furthermore, the report also examines the potential impact of 5G networks on human health.

Keywords

5G, technology, network, medicine, health, e-Health

1. Introduction

E-Health describes the use of information and telecommunication technologies to perform a wide range of functions that affect the public health sector. E-Health includes Internet-based products, systems, and services [1]. This includes tools for health service leaders and professionals and personal health systems for citizens. For example, medical information networks, electronic medical records, telemedicine services, health portals, and many other ICT tools help prevent disease, diagnose, treat, and monitor the health and lifestyle of citizens.

Despite the fact that electronic medical services are available in Europe, they are not yet popular in real medical practice. One reason is a lack of understanding of their benefits. The experience of developed countries shows that the most common obstacles to the successful implementation of e-Health programs are insufficient information about the role of e-Health in health care and the lack of operational and support policies. Therefore, it is important to actively promote existing good solutions and the benefits associated with them, while developing quantitative methods for assessing the benefits of e-health. e-Health technology is an integral part of the EU strategy implemented within the

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framework of the i2010 initiative [2], which covers actions related to various areas, including public health, facilitating the migration of citizens between EU member states, and health systems assessment.

The e-Health initiative is developing in at least three main directions:

- *research and technological development*. There are plans to introduce Plan C to support e-Health for 17 years. Within their framework, over 500 million euros were allocated to finance research projects;
- *politics*. EU Member States are committed to sharing best practices and best practices to create a pan-European e-Health space and thereby dramatically improve the quality and accessibility of healthcare services while stimulating growth in this promising new sector. The European plan for electronic health protection [3] is even more important than the plan of the European Union in 2010.
- *application development and deployment*. The results of research and pilot projects on e-Health are used for the practical implementation of new applications. A pan-European eTEN program has already been launched to test their performance in the ever-expanding e-Health demonstration systems [4].

There are a lot of other research projects devoted to the investigation of different technological solutions, that can be used for the e-Health applications. One of the widespread and rapidly growing solutions is 5G networks. Therefore, the main purpose of this article is to analyze the possible use of 5G in the EU e-Health ecosystem.

2. 5G networks development for the needs of e-Health

The global telecommunications industry is on the brink of unveiling the fifth generation of mobile communications. As with previous iterations, 5G is poised to revolutionize not just telecommunications, but also various other sectors of the economy. This cutting-edge technology boasts numerous impressive advantages over its predecessors.

5G technology, which is set to replace the 4G standard in the next few years, significantly expands the functionality of fourth-generation mobile networks: it is 100 times faster and a thousand times more powerful. This will create mobile networks that provide much higher performance and reliability and a much lower delay in signal transmission (or delay time), which minimizes power consumption and allows you to connect devices en masse.

The introduction of 5th-generation networks in the long run can transform our perception of the world and lead to the transformation of society [5, 6]. With the upcoming fifth-generation standard, we can anticipate a surge in mobile network capacity and faster data transfer speeds. Moreover, this development will pave the way for new possibilities in utilizing mobile communications and the creation of innovative digital services.

The latest 5G mobile technology boasts impressive characteristics, as outlined in Figure 1. These include:

1. A peak speed of 20 Gbps when transmitting from the base station to the mobile device, with up to 10 Gbps in the opposite direction.
2. Practical speeds of 100 Mbps per subscriber or more.
3. Spectral efficiency in 5G networks that is 2-5 times better than previous generations. Specifically, 30 bits/s/Hz on the line down and 15 bits/s/Hz on the line-up.
4. Improved energy efficiency by 2 orders of magnitude, which enables IoT devices to operate for 10 years without requiring a recharge.
5. Shorter radio interface delays, with a duration of just 0.5 ms for super-reliable interconnection URLLC services and up to 4 ms for ultra-wideband mobile services eMBB.
6. Subscriber speeds of 500 km/h.
7. The ability to connect up to 1 million devices per square kilometer.

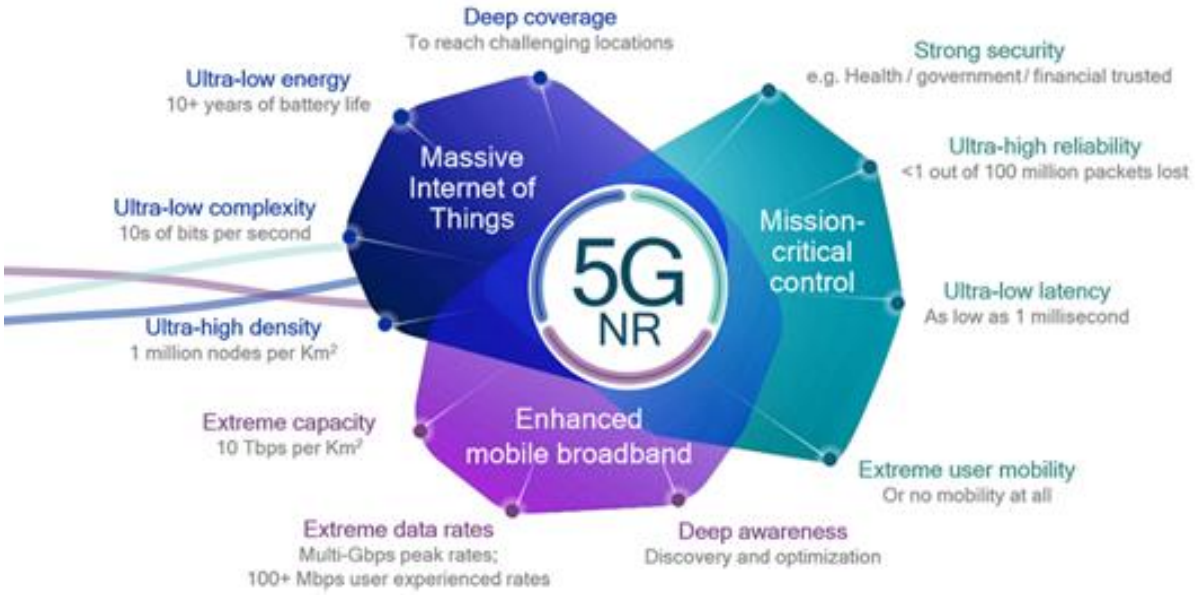

Figure 1: Characteristics of 5G technology

The fifth-generation connection provides benefits for many areas of activity, including the manufacturing sector, transport, and other industries. The 5G network offers solutions to critical issues such as remote management of infrastructure and the city's economy, medical procedures, and transport. In addition, the new generation of telecommunications will open up new opportunities in industry, agriculture, manufacturing, medicine, education, entertainment, and more - all of which will be based on 5G.

This theory is confirmed by practice in other countries, where 5G is actively implemented. The technology allows you to create a large number of connections - up to a million per square kilometer. The network provides high reliability and low signal delay. As a result, 5G provides the ability to provide smart solutions for factories, homes, and city streets.

3. Background work

Studies have provided evidence of the advantages of using e-Health [7, 8, 9]. The use of e-Health applications has facilitated the coordination and integration of care among healthcare professionals [10], allowing for enhanced opportunities [11] for digital data sharing, communication, and consultation [12] at a distance. This has led to reduced healthcare utilization costs [13]. In addition, individuals seeking medical care can now easily overcome the challenges of accessing healthcare [14]. They can benefit from better monitoring, continuity of care, and self-management, thanks to e-Health. Additionally, e-Health has made it more practical for patients to live independently at home.

It is becoming increasingly recognized in both developed and developing countries that e-Health is a crucial tool for reducing discrimination based on lack of access to information and addressing matters that affect personal and community health. However, implementing e-Health within or between institutions requires proper planning, supported by clearly defined policies, rules, and recommendations at the institutional, jurisdictional, and global levels. Without such policies, problems can arise during the e-Health planning cycle, leading to failure to achieve desired goals. This can result in an accidental widening of the gap in health and knowledge levels between different segments of the population, creating a digital divide and increasing health inequities. In developed countries, insufficient information about the role of e-medicine in healthcare, a lack of operational and support policies, unproven cost-effectiveness, and a lack of clinical supporters are the most common obstacles to the successful implementation of e-medicine plans.

Typically types of electronic medicine, in the literature, a lot of applications are induced, such as, to be built, even to go for training, the inclusion of additional assistance in the planning and practice for patients with multiple disabilities [15, 16, 17]. We have seen choters of categories on the basis of these

basic functions, and for encouraging visitors, and brush to respect the versatility of options in electronic medical service [18, 19], we have adopted the chronicity of the concept of adaptation to the CC. Help in the electronic medical service (eCCM) [20]. Type of electronic medical service with ICT tools [21], how to get involved in the offensive areas: remote consultation, monitoring, and monitoring; that municipality; management of health protection and analysis of the data about health [22].

4. Using 5G technologies for healthcare

The use of 5G technologies can contribute to the development of health care. New-generation technologies can offer a lot to modern medicine: from higher communication speeds to smart computing and augmented reality. The fifth-generation network can revolutionize the medical industry [23]. Thanks to advanced communication technology, patients in remote areas who require urgent surgical care no longer need to travel to clinics or hospitals in larger cities. They can now receive assistance in local hospitals or clinics, and if necessary, an urgent video call with a specialist can save the patient's life. These new technologies have also proved useful in the diagnosis and monitoring of patients with chronic illnesses.

The pandemic is a new solution that combines 5G with COVID-19, 5G functions for remote diagnosis and care of coronavirus patients, and non-contact temperature measurement using robots.

As shown in the example (Fig. 2), the quality of the entire healthcare system can be improved by implementing digital technologies in all healthcare processes.

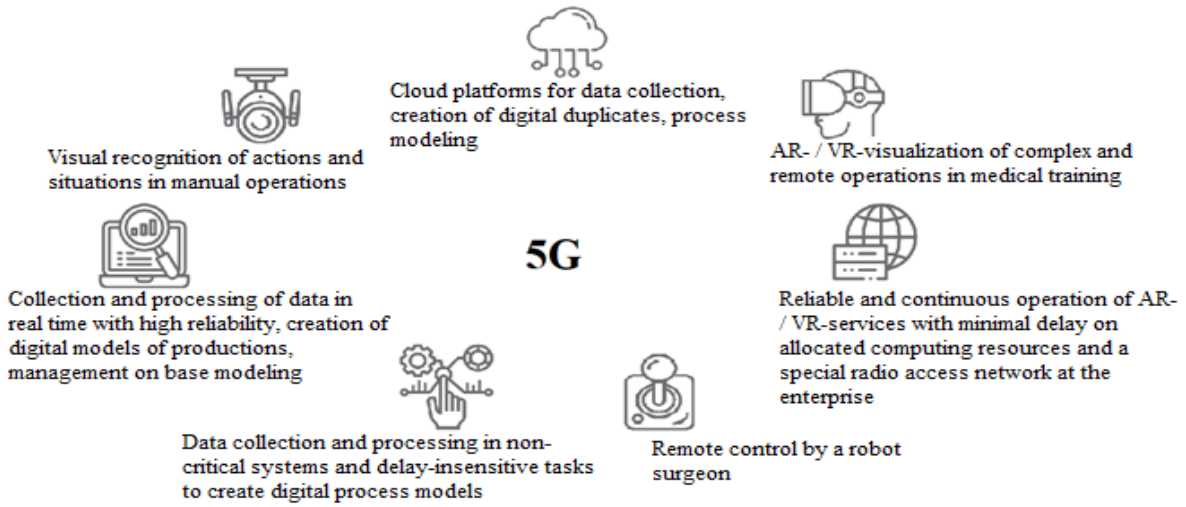

Figure 2: Options for using 5G technology in the medical industry

The basis of digital medicine is the Medical Information System (MIS), which can quickly and easily access all medical data about patients, a large amount of relevant medical information, and computer equipment that allows you to remotely diagnose, consult and care for patients. Such systems can help remotely perform important parts of clinical work, process online diagnostic data, conduct electronic medical monitoring of patients, use aggregate data to prevent and prevent disease and respond quickly and effectively to emergencies. The use of specialized devices that collect and transmit biological and medical indicators from sensors on patients, along with intelligent machine analysis of this data, has made clinical and outpatient care more accessible and effective in diagnosing and evaluating treatments [10].

Remote medicine is not just an interesting innovation, in many cases, it can be the only salvation. For example, with the development of fifth-generation networks, sailors, being in the middle of the ocean, will also be able to receive qualified medical care directly on board [24].

Today, the speed of service delivery often becomes crucial in choosing a clinic. We do not like to wait for the afternoon under the doctor's office and are ready to start treatment as soon as the results of

the examination are ready. 5G can help here too. For example, MRI scans are very large files that often load very slowly. With the fifth generation, the request and receipt of MRI data can occur almost instantly. As soon as the patient leaves the device, the result of the study will be sent to the doctor and the patient [25].

4.1. Remote consultations

Eventually, online counseling with a stable connection can increase the percentage of people who seek medical attention. The transition to 5G technology will allow the instant transmission of huge amounts of information. High-definition video and augmented reality, remote ultrasound scanning, and sound technologies improve the quality of transmitted patient information. It now helps to quickly and accurately assess the patient's condition and the effectiveness of prescribed treatments and can be diagnosed remotely in the future.

Because the new network will provide high-speed transmission, doctors can easily and quickly send images obtained during the biopsy at an average speed of 1 GB per second. This allows colleagues in different buildings of the hospital complex to quickly review the results of tests and diagnose in the shortest possible time. Previously, the process took longer because doctors had to move between buildings to get the results of the examination [26].

4.2. Remote surgery

Low latency and high data rates in 5G networks [26] allow patients to perform full-fledged operations in other hospitals. With the deployment of 5G networks, doctors will even be able to perform operations at a distance, connecting to special robotic surgeons. For example, a brain tumor specialist from New York will be able to perform a complex operation in Beijing from his own office. Instant communication is critical here.

In March 2019, China demonstrated to the world scientific community its first remote operation with the support of a 5G network involving robots [27]. The three-hour surgery was performed at Beijing General Hospital. The patient suffered from Parkinson's disease and was operated on by Lynn Gippi, a well-known and experienced neurosurgeon. Lin Zhipi is located in Sanya, 3,000 kilometers from the capital. (Fig. 3) [28].

Figure 3: The first remote operation with 5G network support

Korean telecommunications giant KT and Samsung Medical Center announced in January 2020 the launch of official testing of 5G-based IT solutions in healthcare. The companies have introduced to the public several applications and devices that use the new generation network to work in operating rooms in real-time, as well as to quickly send images with analysis results [26].

4.3. Use of virtual and augmented reality (AR-/VR-) technologies in fifth-generation networks

The human body is a unique sociobiological system. Even for a specially trained talented doctor with experience: complex diagnosis, treatment, and surgery are always non-trivial tasks. Augmented reality systems now provide significant assistance in their work.

By analyzing remote patient data and UHD images, a digital model can be created for physicians to work with online through connected AR/VR headsets. This innovative model streamlines the process of diagnosis, predicts potential health issues, investigates their underlying causes, recommends preventative and treatment measures, and facilitates remote implementation. The incorporation of AR technology in surgical procedures is particularly advantageous, as it enhances the visualization of affected tissues, offers operational guidance, and enables real-time evaluation of actions. This not only minimizes the likelihood of medical mistakes but also expedites the surgeon's work, particularly during high-pressure interventions where quick decision-making and distinguishing between various tissues and body parts can be challenging [10].

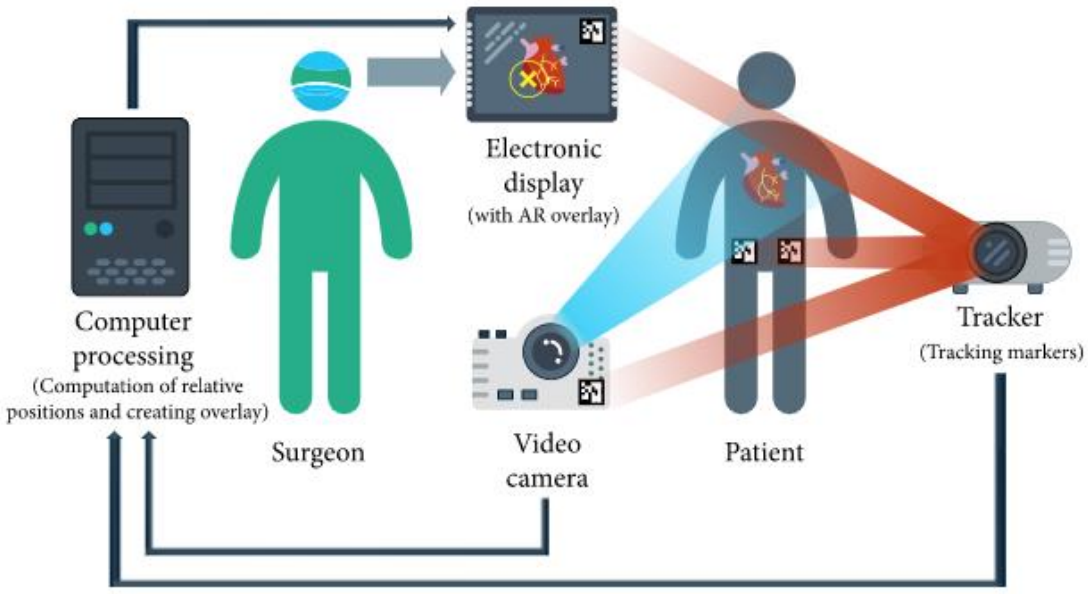

Figure 4: Carrying out the operation using AR-/VR- technologies

Standardized and flexible solutions for AR-/VR- operation with low signal delays and higher UHD video streams are now only possible in 5G, which also provides tight synchronization of data display in AR-/VR- headsets.

The single 5G cloud infrastructure is indispensable for the rapid creation and reproduction of digital models according to patient data. From this, we get a reduction of the time of operations and the risk of infection; minimization of risks of medical error; reduction of postoperative mortality and complications; reduction of costs for medical equipment due to cloud service.

In addition, using VR technology, students can gain knowledge and understanding of the human body through interaction in a virtual environment.

It is very interesting that we see in virtual reality that people can use this technology to improve students' surgical skills. As we all know, the training of surgeons usually includes corpses and gradually helps more experienced doctors before "beginners" can take on tasks and perform more surgeries. Virtual reality can provide another practical method without any risk to real patients: perform procedures "manually", but interact with virtual patients in a safe and controlled environment to learn skills that can be applied in real life [27].

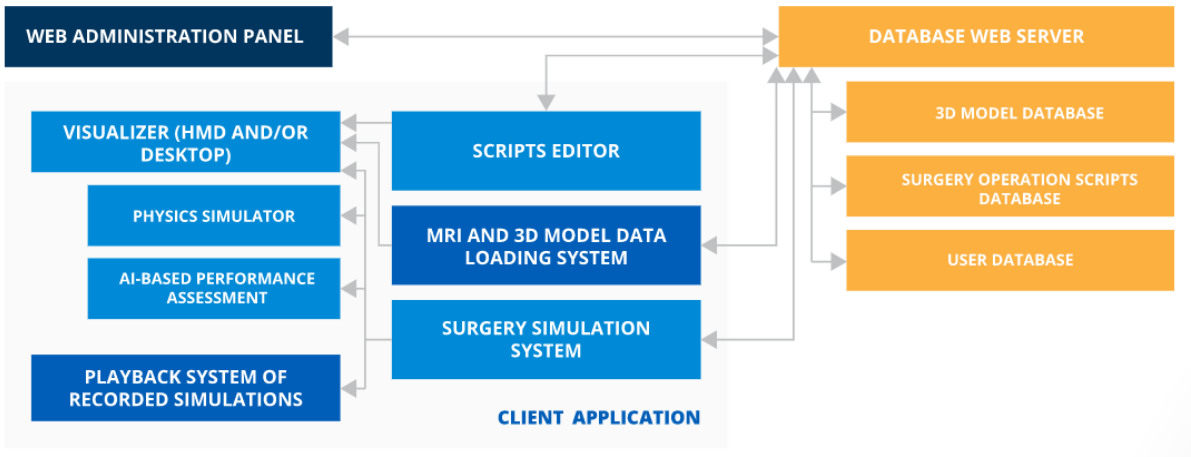

Figure 5: The utilization of virtual reality technology in surgical training.

Medivis (USA), founded by surgeons, radiologists, and engineers, is developing an AR platform for the preparation and conduct of surgical operations based on traditional diagnostic systems and artificial intelligence. To receive the 5G service, Verizon is moving the platform to its cloud infrastructure. Based on the same principles, SentiAR (USA) creates a platform for projecting high-quality 3D images of internal organs on AR glasses during operations: they are projected on monitors above the operating table in real-time, providing detailed visualization during the operation. The project is being developed jointly with Microsoft. The software AR-solution of the medical firm Proprio (USA) also serves the best preparation of operations: work with AR in it is broadcast at once to several qualified doctors for online consultations at their carrying out [10].

5. Impact of 5G networks and electromagnetic fields on human health

We live in a continuous field of radio waves. This causes people the opposite concern: how harmful it is to health and how dangerous each new generation of radio communication is.

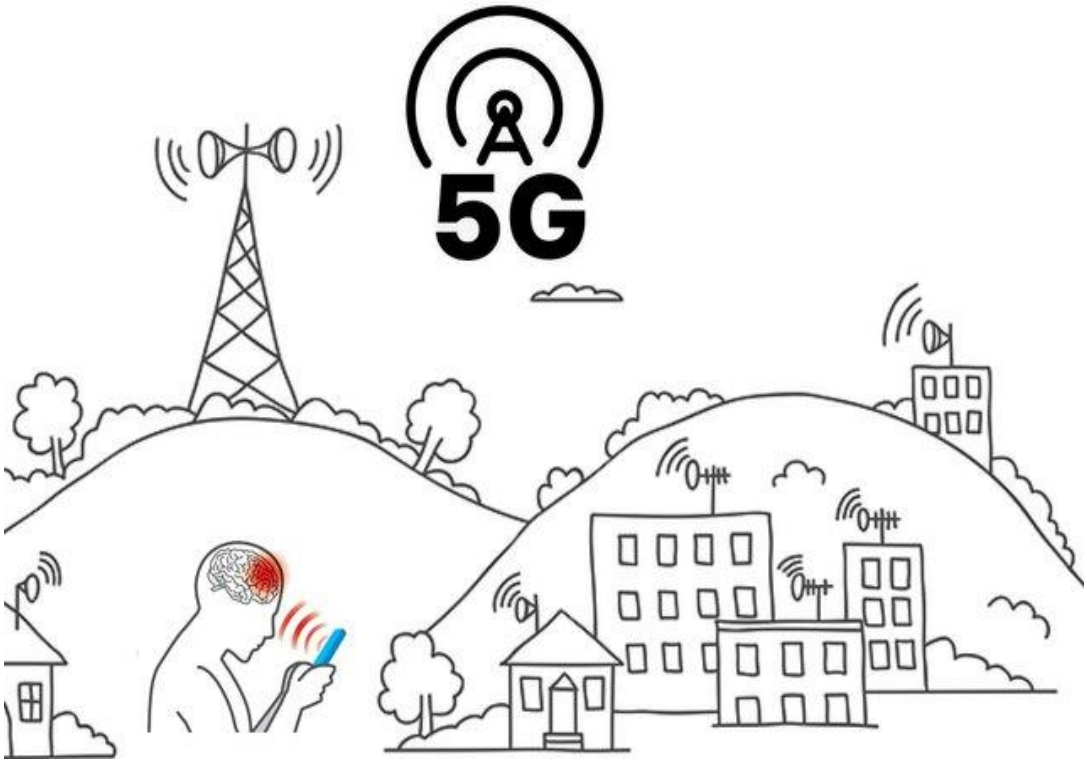

Figure 6: Effects of radio frequencies on human health

There is growing concern among certain individuals that the fifth generation of wireless networks, known as 5G, poses a risk to public health. This is due to a belief that the level of electromagnetic fields (EMF) is higher than that of current networks. However, it should be noted that some of these concerns may be based on misinformation.

Determining the impact of radio radiation on human health and reducing its effects is in the interests of many international organizations [29]. Other competent international and national scientific organizations, equipment manufacturers, national regulators, and telecom operators are also involved in the research.

Along with the results, you should be informed about the implementation of the EPC standards. To change the organization of the organization to implement the EMP standards: "Based on all the options chosen, there is no short or predetermined inheritance of a negative gene for the health of the RF signal bases." [30].

After conducting numerous studies [31], no harmful effects on health have been linked to wireless technology. Though studies have been conducted across the radio spectrum, only a few have explored the effects of frequencies used in 5G. As the frequency increases, the energy absorption becomes more limited to the body surface, such as the skin and eyes, with less penetration into body tissues. As long as the overall exposure remains below international recommendations, there are no expected effects on public health. The World Health Organization [32, 33] continues to review the scientific evidence for potential health risks from 5G as new technology is introduced and more public health data becomes available.

The upcoming 5G networks are designed with smaller antennas, which will emit lower levels of radiation compared to previous networks. This will result in improved quality of service and higher connection speeds, with many of these antennas resembling Wi-Fi access points. The updated ICNIRP manual has taken into account all the new features of 5G technology. The Commission (EU) [31] has adopted the Commission Implementing Regulation (EU) 2020/1070 to define the characteristics of small-area wireless access points in accordance with Article 57 (2) of Directive (EU) № 2018/1972 of the European Parliament and of the Council on the implementation of the European Electronic Communications Code. It is important to note that this regulation does not impose any new EU restrictions on electromagnetic fields, and existing national or regional regulations [34, 35] must be followed for wireless access points. Scientific data confirms that 5G networks do not cause an increase in electromagnetic fields that surpass the EU's allowed limit [36]. Therefore, following all existing recommendations, the deployment of 5G networks will not negatively impact human health.

6. Conclusion

Wireless networks constantly strive to improve their capabilities and keep up with the latest technological advancements. Prior to the emergence of the fifth-generation network, various generations of wireless cellular networks had already been developed. The 5G mobile standard is a necessary investment towards advancing technology and expanding internet access through radio access. The margin of 5G provides new opportunities for the development of digital technologies, and, obviously, it will become the basis for the development of medical galusa. It's important to note that the upcoming fifth-generation technology will play a crucial role in advancing various digital information and communication services, as well as addressing issues regarding infrastructure and budget for 5G. With the advent of 5G, mobile communication is no longer a technological advantage, but a basic need, a key resource of most industries. With the widespread digitalization, and the introduction of ICT in the main business systems, the latest generation of cellular networks affects all production processes, industries, and the economy as a whole, changing them rapidly and dramatically. 5G technologies and services are becoming the foundation of digital transformation, infrastructural and technological basis of new business models, and industry development scenarios.

7. Acknowledgment

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