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Faculty of Economics and Management

Postgraduate Programme of Enterprise Risk Management

Master's Dissertation



Modern Technology Risks: The real risks of 5G and how people perceive them

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Summary

Introduction - The development of technology positively and negatively affects our daily lives worldwide. Every new discovery or development of technology is accompanied by risks that affect people, some positively and some negatively. An important pillar in the development of technology and science is the evolution of wireless networks since after fourth generation (4G) now comes the place of the fifth generation (5G).

Purpose - This research focus on how people individually perceive the risks that new technologies bring to their daily lives, by studying and examining two different groups of people. The 1st group is concerned to how people who are involved and have knowledge about technology perceive these risks and if they really consider these as risks, to what extent it affects them and the 2nd to how people who are not familiar with the subject perceive these risks, to what level and to what extent they are willing to perceive and really understand them.

Methodology – A theoretical analysis of the subject is used, based on the existing literature on new technologies. The necessary data are collected by using a questionnaire and taking a random sample from a mixture of people who are familiar with the new technologies or not (Cypriots and foreigners) who live in Cyprus, asking them to respond to the importance they attach to each risk, by using a relevant scale. For the analysis of the questionnaires, is used the SPSS package No.22 where the student proceeds with the statistical description of each of the questionnaires as also answering the research questions by using the methods of cross tabulations so as to clarify, whether the specific tabulations are really existing or not.

Results – The 70% of the participants said that one of the risks they are going to face from the arrival of the new technology is the fear of the unknown, the 40% mentioned the Insufficient knowledge for most users of the internet, the 31,7% referred to the Lack of a legislative framework, the 25% said that Personal privacy will be more at stake and the 15% referred to health problems that may pop up. In advance, it was found that the group with knowledge agree more than the group with no knowledge that the arrival of

the new technological era of 5G, is a positive thin as the first group has a mean of 3,4 and the second group has a mean of 2,6. We have a statistical significance.

Conclusion - The scientific community tends to continue to study, observe and be vigilant on these issues. However, a complete ban on the 5G network would be excessive and would be a barrier to technological innovation. There has also been no significant increase in brain cancer in the last 20 years, although cell phone use has increased significantly. Therefore, scientists conclude that public, state and European institutions should invest in further investigating the effects of these waves.

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CHAPTER 1

Introduction

1.1. Background Analysis

The development of technology affects positively and negatively our everyday lives worldwide. Every new discovery or development of technology comes with risks that affect people, some positively and some negatively. The main concern of this study will be how people perceive these risks and whether they accept this new technology. An empirical study in the context of this dissertation with a structured approach could give us an understanding of people's decisions and attitudes towards new technologies based on their assessment of the various risks. An important pillar in the development of technology and science is the evolution of wireless networks since after fourth generation (4G) now comes the place of the fifth generation (5G). This latest networking technology paves the way for new industrial applications and is critical to create widely connected "smart cities".

The 5G is the next step in providing better networking in our ever-evolving world. 5G networks are now available worldwide and promise faster data speeds and lower latency to consumers. Smartphones are some of the first devices to support 5G, but soon the rest of the devices will follow this path until we get to the point where everything is connected and supports 5G networks so that there is an interaction between them so a human can control everything from miles away. (Karaboytcheva, 2020, Fifth Generation Mobile Networks: Challenges and Future Research, 2020).

The 5G mobile network is not only the successor to the previous mobile networks (4G, 3G, 2G), but also the beginning of a new era in mobile communication. 5G performance targets include higher speed, more capacity, reduced latency, lower cost, higher resolution and greater bandwidth. 5G technology is officially launched in the world by the end of 2020. 5G technology is expected to be widely used for applications such as Smart logistics, Internet of Things (IoT), Driverless cars and other such smart applications, which require high internet speed. It includes many advanced features that will make 5G technology dominant in the future (Dr. Moskowitz, 2018).

The 5G network, being something new, naturally brings negative reactions from people who do not know and can not understand what it is, how it works and what exactly it does, so it is considered by many to be harmful to health, so they do not accept it and protest (Chiaraviglio, 2019). However, recognizing the justified concern of many people in relation to the possible effects of 5G networks on human health, we will investigate and critically discuss some arguments made by various people in relation to the harmful effects of these networks and EM radiation generally in human health (Jeffrey, 2014)

Mobile telephony is perhaps the most important part of modern telecommunications. It is worldwide estimated that, mobile phone users reach 9 billion excluding users of Wi-Fi networks. The use of mobile telephony has been proven to be directly and indirectly associated with many benefits to our society, economy, health and quality of life in general. Although the first 4 generations were mainly concerned with communication between people, the fifth generation is coming to bring a technological revolution by extending this possibility to communication and the Internet of Things (Internet of Things).

In this context, every smart device acquires connectivity through which it can communicate the data it collects from its environment on its network or on the Internet, the processing of which can lead to smart decisions and actions for the benefit of humans. Classic examples are communication between vehicles to avoid road collisions, telemedicine applications for continuous monitoring of the health of vulnerable groups and much more (Dr. Moskowitz, 2018).

It is estimated that the introduction of the 5th generation launches the number of mobile telephony connections worldwide to 50 billion. Such a number of connections cannot be supported by existing 4th generation systems. That is why the technological goals of the 5th generation are mainly related to the increase of data volume by 1000 times, the increase of the number of connections by 100 times, the increase of the connection speed and the reduction of the response time. In order to achieve such goals, it is necessary to install more base stations (antennas in higher geographical density).

This is where most of the world's concerns are based. However, what needs to be clarified, is that these base stations will have less geographical coverage, which means that they will emit much less power than their predecessors, as their purpose is to serve connections in their short range. Based on this, the exposure to electromagnetic radiation from 5G systems may have lower values and a more uniform distribution compared to existing systems.

In the argument that the integration of 5th generation systems will simply be added to the rate from all existing contributing sources (eg TV, 2G, 3G, 4G, etc.), this is partly true, but is expected to be significantly reduced soon as the business plan for telecommunications services includes the withdrawal of older technologies (e.g. 2G and 3G) which have been proven based on measurements to contribute more to the overall exposure to electromagnetic radiation since they emit more power. (Luca Chiaraviglio, 2019) (Fifth Generation Mobile Networks: Challenges and Future Research, 2020) (Karaboytcheva, 2020)

Based on the above, it should be said that the main concern of this study is to analyze the risks if they exist, and who are they based on the literature and to finally investigate particularly in Cyprus, how people perceive these risks, how they react and whether they accept this new technology. An empirical study in the context of this dissertation with a structured approach could give us an understanding of people's decisions and attitudes towards new technologies based on their assessment of the various risks (Dr. Moskowitz, 2018).

1.2. Purpose of the Dissertation

This research focuses on how people individually perceive the risks that new technologies bring to their daily and particularly of the 5G technology, by studying and examining two different groups of people. The study of the 1st group is concerned to how people who are involved and have knowledge about technology perceive these risks and if they really consider these as risks, to what extent it affects them and the study of the 2nd to how people who are not familiar with the subject perceive these risks, to what level and to what extent they are willing to perceive and really understand them. The

comparative study of the two groups will show the extent to which lack of knowledge on 5G networks affects risk perception about them.

1.3. Research Questions

The research questions are concerned to the following

- ✓ How does each person perceive these risks based on their knowledge?
- ✓ Is there a difference between the two groups as to whether they agree/disagree with the fact that the arrival of the new technological era of 5G, is a positive thing?
- ✓ Is there a difference between the two groups as to whether they agree/disagree that they double check the theories they hear/read before accepting it?

1.4. Necessity and Importance of Research

As to the research about how the people of Cyprus perceive and accept or not the 5G network, by using a structured questionnaire will be given in Cyprus' people to respond whether they know what 5G is, how does it work and whether in the end of the day people accept it or not. Also, from the answers we will get from the questionnaires, we will examine their views on whether 5G is harmful to health, what are the risks they have to face and to what extent, or Whether denial comes only from something they read in a post on Facebook without investigating whether it is scientifically proven or not.

This research tries to explore and provide a deeper understanding of how perceived risks of new technologies affect people's attitude toward new technologies. In addition, it contributes so as to identify the most critical factors that influence behaviour and how people perceive the risks of new technologies. About the necessity of the study, there is an increasing opposition and concerns over this major technology and that opposition to technologies has to be studied in this era where new technologies appear with a rapid pace. Moreover, the impact of knowledge has to be studied to explore strategies for communication of these risks, etc.

1.5. Research Methodology

A theoretical analysis of the subject is used, based on the existing literature on new technologies. The necessary data are collected by using a questionnaire and taking a random sample from a mixture of people who are familiar with the new technologies or not (Cypriots and foreigners) who live in Cyprus, asking them to respond to the importance they attach to each risk, by using a relevant scale. In advance, a questionnaire has been given to two (2) separate groups of people, those who deal with technology and its development at a professional level and those who have nothing to do with technology other than their entertainment. From the separation of these two groups and from the answers they will provide, we will further understand whether knowledge plays a decisive role in humans to accept or not something new in technology, which in our case is 5G.

CHAPTER 2

Literature Review

2.1. Definition and Characteristics of the 5G Network

The 5G network means the fifth-generation network and is the successor to 4G LTE networks that have been operating for the last decade. Its features are higher data speeds, low latency connections and many new uses, from VR tasks to smart cities. In order to achieve this, 5G manufacturing requires new high-frequency radio technologies, device modems, and technologies such as beam formatting (Seungmo, 2020).

The 5G standard is the combined effort of companies around the world that work together to create a unified technology that will be used around the world. Official 5G specifications are published by the 3rd Generation Partnership Project (3GPP) and the International Telecommunication Union (ITU). The ITU IMT-2020 preparations and the 3GPP Release 15 specification lay the foundations for early 5G technology and development (Ciaula, 2018). There are several new features for 5G, below are some of the key concepts for better understanding:

- ✓ mmWave - very high frequency range between 17 and 100GHz and high bandwidth for fast data. Most providers target usage in the 18-24GHz band. This is a small-scale technology that will be used in densely populated areas.
- ✓ Sub-6GHz - operating range at WiFi-like frequencies between 3 and 6GHz. It can be deployed in small cell nodes for indoor use or more powerful outdoor base stations to cover medium range such as the existing 4G LTE. The larger 5G band falls into the above frequencies.
- ✓ Low band - very low frequencies below 800MHz. It covers very long distances and is omnidirectional to provide frame coverage.
- ✓ Beamforming - used on mmWave and sub-6GHz base stations to direct waveforms to consumer devices, such as bouncing waves from buildings. A key technology for overcoming the limitations of amplitude and direction of high frequency waveforms

- ✓ Massive MIMO - multiple antennas at base stations serve multiple end-user devices simultaneously. Designed to make high frequency networks much more efficient and can be combined with beam configuration (Andrews, 2014).

There are only two basic principles to understand what 5G intends to do and how it does it. The first is the use of much more wireless spectrum, more spectrum means more capacity and faster speeds for everyone. To achieve this, 5G is turning to new high-frequency networking technology, such as the wave we often talk about in millimeters (mmWave). These are known as 5G New Radio (NR) technologies (Communications Engineering Perspective, 2020). In short, 5G works by taking advantage of a wide range of wireless spectrum, both old and new. This provides consumers with faster and more reliable coverage not only in densely populated cities, but also in rural areas and network extremes (Karaboytcheva, 2020).

2.2. Various Types of Services Offered by the 5G Technology

Accordingly, the International Telecommunication Union (ITU) has classified 5G mobile services into three categories according to the above technical objectives and has described the various types of services it can offer (Russell, 2018).

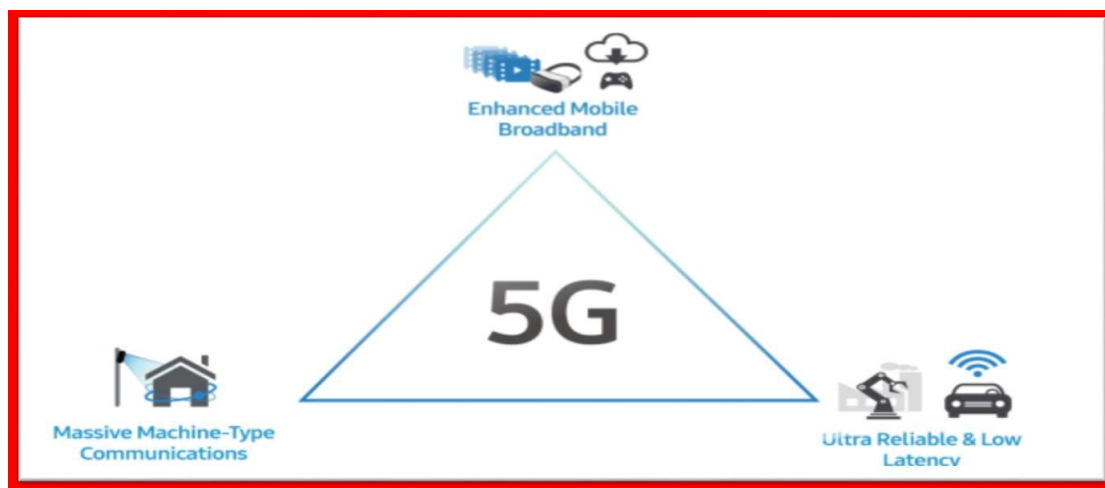


Figure No.1 - The Vision of the 5G Technology

- Enhanced Mobile Broadband (eMBB) services. These services will use a large bandwidth and will require very high transmission rates, to provide excellent coverage

and uniform connectivity everywhere. Relevant services provided are HD video, virtual reality services, or augmented reality services.

b) Ultra Reliable Low-Latency Communications (uRLLC) Extremely Reliable Communication Services. These services require high capacity and data transmission speed for real-time monitoring and control of critical processes. Examples: control of industrial processes, sensor networks, automation of energy distribution, remote control of critical machinery (surgeries / health services, autonomous driving and handling of heavy vehicles or machinery in general, etc.).

c) Massive Machine Type Communications (mMTC). Services to provide wide coverage and deep penetration indoors and outdoors for hundreds of thousands of devices per km². Also, to provide connectivity everywhere with low hardware and software complexity (hw & sw) (and therefore low cost) and low power consumption. Examples: monitoring and automation of buildings, intelligent agriculture, intelligent supply chain (logistics), monitoring and fleet management, implementations of smart cities - smart cities etc.

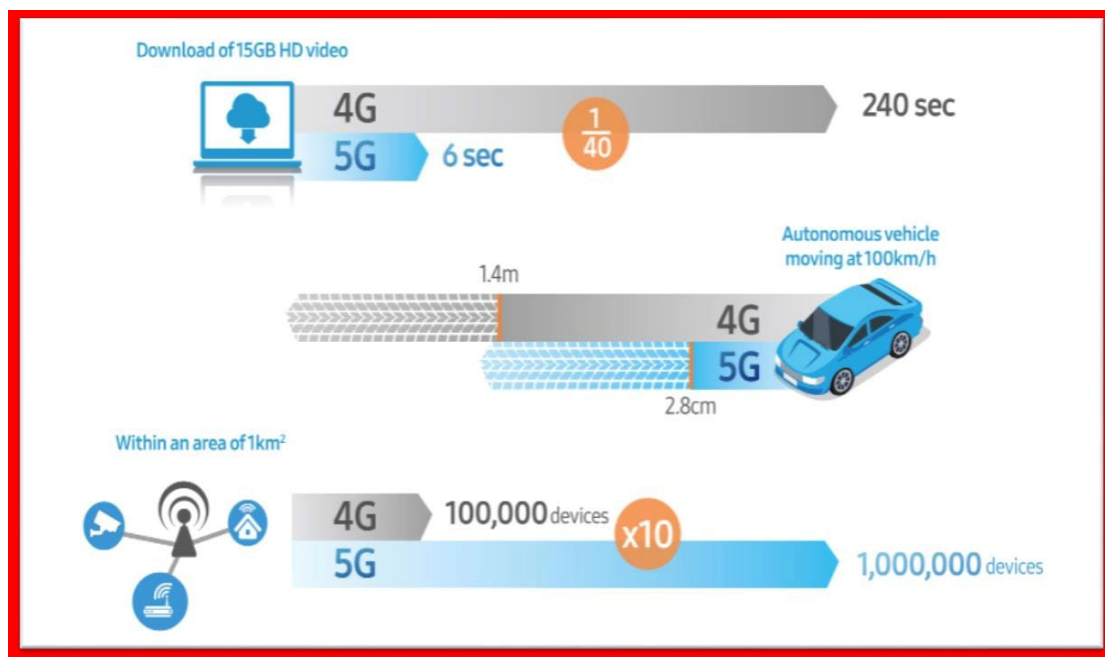


Figure No.2: Example of performance comparison between 4G and 5G

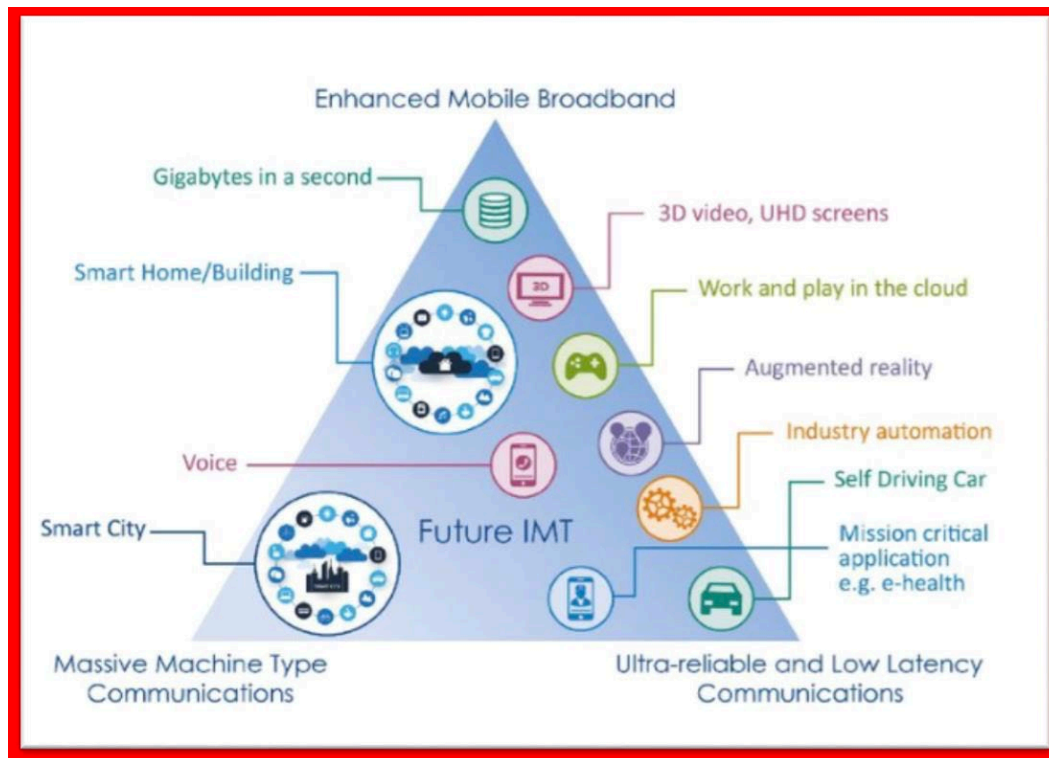


Figure No.3: Types of services 5G according to the main technical objectives

The guidelines set by the ITU are summarized in the table below as well as a comparison between 4G and 5G technologies (Olumuyiwa, 2014). When 4G LTE was first introduced, the maximum performance (or top speed) was 75Mbps, which was less than a tenth of the speed that the industry had set as the highest performance value for technology (1Gbps). Only after the introduction of a support device, which was released in 2018, 4G LTE technology was able to achieve this speed (1Gbps). Every mobile technology takes several years from its inception to achieve the desired speed value. Similarly, 5G will start its services with a maximum output of just a few Gbps, which will gradually increase to the target 20Gbps (peak data rate: 20 Gbps) (Russell, 2018).

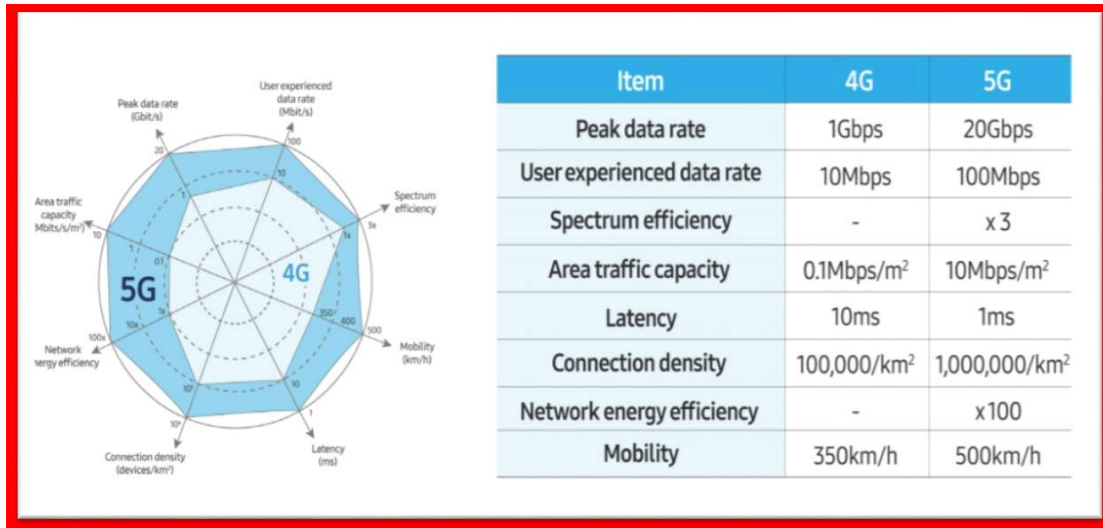


Table No.1 – Comparison Between 4G and 5G

2.3.To What Extend the 5G Technology Has Changed People’s Life in Different Sectors

In this sub-chapter there is a look at the most basic technologies that will meet the requirements of the 5G Network. Wireless systems, backhaul network, softnetization of core networks and radio access networks are the building blocks in the early development of 5G networks, in particular with regard to enhanced broadband technology (Ghoul, Jia, 2015).

The wireless access network (RadioAccessNetwork- RAN) has been used since the beginning of cellular technology and has evolved through the generations of mobile communications (1G to 5G). More specifically in the fifth generation of networks we have NewRadioRAN. NewRadioRAN is a new wireless network interface (newradiointerface) being developed for 5G mobile communications. With the high demands on the new 5G mobile communications standard, a whole new radio frequency and wireless access interface has been developed. The cornerstones in NR used for 5G are (Karaboytcheva, 2020):

New spectrum of radio frequencies

The 5G standards require a wide bandwidth to provide high speed data transmission. Therefore, according to the standards, the band both below and above 6GHz will be used (extremely high frequency bands such as 28GHz and 39GHz).

Use of improved types of orthogonal OFDM configuration

The Cyclic Prefix OFDM (CP-OFDM) and Discrete Fourier Transform spread OFDM (DFT-s-OFDM) will provide even better spectral performance while providing selective attenuation resistance. They also allow multiple access.

Millimeter Frequencies (mmWave) and Beamforming Beam Configuration

It may be relatively easy to secure high frequency bands, but they do have some disadvantages such as low coverage and low penetration. Beamforming technology has been introduced as a measure of overcoming these weaknesses. It is a wireless transmission system that it also allows millimeter frequencies to travel far with less interference than other signals. The more data of the antenna, the larger the coverage radius, it identifies the most efficient supply route, data to a specific user and reduces interference for users who are located in the surrounding area.

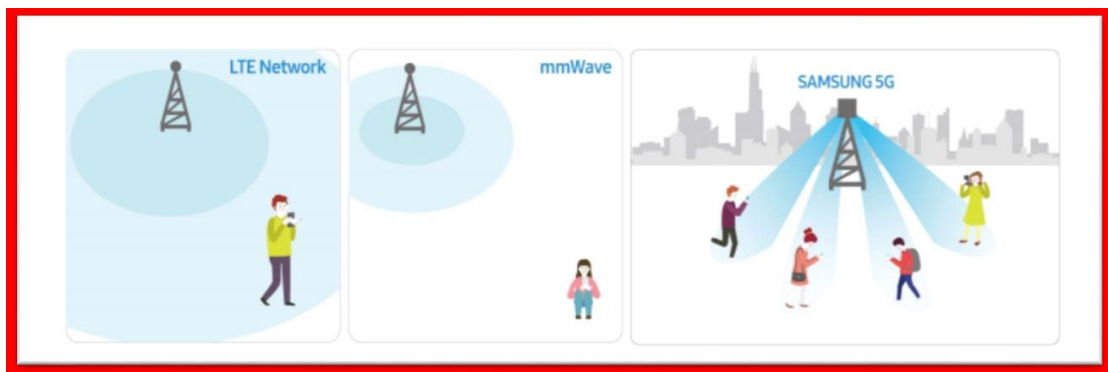


Figure No.3: How beamforming technology works

The directionality of millimeter wave communications (mmWave) poses a significant challenge to servicing fast-moving mobile terminals as they must be monitored more accurately and continuously by the signal beam.

Improvement of spectral performance- Massive MIMO

The Massive MIMO technology (Massive Multi-Input Multi-Output) controls the antenna array of multiple antenna components to generate multiple beams simultaneously and each beam carries a different signal to the user. Spectrum efficiency is improved as it allows multiple users to use the same wireless resource at the same time. A similar MIMO technology is currently used with 4G. However, the beams are not directional enough to locate every user, making MIMO much less effective than it would be in the 5G era. MIMO technology in 4G uses a one-dimensional array of antenna arrays that restricts antenna freedom, which means that it can only distinguish users in a horizontal direction. In contrast, MIMO on 5G supports more users at the same time, incorporating a two-dimensional antenna to cover both the horizontal and vertical directions.



Figure No.4: How MIMO-4Gvs 5G technology works

Heterogeneous networks

The architectural approach that is the basis of today's networks but is also expected to be a cornerstone for 5G, is that of the development of heterogeneous networks. A heterogeneous network is one that incorporates a number of different voice and data radio access technologies (2G, 3G and 4G), as well as multiple types of access

nodes (macro, micro, pico and femto), which together contribute to seamless support for high coverage, capacity and data transmission speed, ensuring excellent levels of service provided to end subscribers.

The coexistence of different radio technologies is mainly due to technological reasons, as the simultaneous provision of high levels of voice and data services can be supported in combination by the individual technologies. However, it is also due to economic and technical reasons based on the long-term investments of communication providers in the network infrastructure.

The level (1 layer) or network tier is a topology of radio access nodes, the so-called base stations, which cover corresponding cells with homogeneous characteristics, in terms of size (cell size), the dimensions of the structure and the maximum emission power. Traditionally, radio networks were designed and distributed based on a single layer, known as macro-cellular or simply "macro". The macro cells serve a wide geographical area of a radius of a few hundred meters (approximately 500 m in typical urban environments) (approximately 10 km in typical rural environments), depending on the profile of the desired coverage area (dense urban, urban, rural, etc.). These base stations are placed after careful planning (network planning) and usually in special constructions (radio towers) that are located outdoors, while their power is suitable to provide coverage even indoors, and support multiple spectral bands, ie 800, 900, 1800, 2100, and 2600 MHz. The current 2G, 3G, 4G voice and data networks have been designed and developed mainly based on the specific macro-cell topology.

The integration of small cells where there is a need for optimal coverage of users, which is shorter in scope than macro cells, is a well-established practice of topological evolution of modern radio networks. Small-cell cells have a range of a few meters (femto-cells) to a few tens (pico) or even hundreds of meters (micro). They have an emission power from 100 mW (femto) up to 10 W (micro), while they are installed either outdoors (micro / pico) or indoors (pico / femto). Higher carrier frequencies are usually used for their operation, e.g. 1800, 2100 and 2600 MHz (and future 3500 MHz or more).

Micro-cells are typically located outdoors, at low altitudes, and cover mainly areas of public interest with increased telecommunications traffic needs (eg stadiums, stadiums, parks, public transport stops, lighting poles, and even manhole covers on the streets. in densely populated urban areas, etc.). The same stations can also offer indoor coverage.

Pico-cells have a radius of a few tens of meters and usually cover demanding interiors or indoor and outdoor areas of public interest, such as multi-storey installations, train stations, public transport stops, lighting poles, and even manhole covers on congested roads. areas etc. The femto-cells are placed in domestic spaces and operate on the basis of a limited access model. Thus, the different hierarchical levels of cells coexist, acting in combination and cooperatively as each level focuses on different profiles of coverage and telecommunication traffic, while utilizing the continuous investments in alternative radio-access infrastructures.

Therefore, the term "heterogeneous networks" is used to describe both current and future mobile networks, which use multiple radio access technologies as well as multiple hierarchical cell levels, in order to optimize each time the levels of coverage and capacity provided. and quality of service of subscribers moving in heterogeneous environments. Without the use of this architecture, it becomes impossible to provide mobile communications services with the required features and network performance requirements, now and in the future.

The 5G technology is not just an evolution of telecommunications technology. It is the fundamental platform for the fourth industrial revolution and will become an integral part of societies and political infrastructures, just like roads, energy and transport. It is the gateway to the virtual world, which will begin to adapt organically to the diverse needs of users with real-time and on-demand applications. For network administrators, the 5G will become the ultimate platform for real business innovation and new revenue streams. Its most radical capability is the transfer of huge volumes of data in real time (Russell, 2018).

The 5G technology, the new generation of mobile communications, was released in 2019 and since May 2020 125 countries around the world have started investing in

this technology. The 5G technology, the next generation network, will radically change not only telecommunications service providers, but the business environment as a whole. In an optimistic assessment of the impact of the modern network, McKinsey in a recent report (February 2020) speaks of an increase in global GDP of 1.2 trillion. USD up to 2 trillion. USD by 2030 (Karaboytcheva, 2020).

KPMG greatly increases the size of the financial benefits from the growth of 5G in key sectors of the economy, reaching 4.3 trillion. USD in the long run. About two billion new users will be ready to connect worldwide, creating new value many times what we knew. The end-to-end networks can be expanded and upgraded to cover about 80% of the world's population with advanced connectivity, at a cost of about \$400 billion to \$500 billion.

However, only a quarter of the world's population is likely to have high-speed 5G coverage by 2030. At the same time, the differences between the countries that will enter the 5G world will be significant. In this context, McKinsey analysts divide the world into Pioneer countries (United States, Japan and South Korea) and China, into Leader Markets such as France, Canada, the *Followers* and specifically Brazil and Poland and in countries far behind - Trailing Countries such as Pakistan and Bolivia. India, which is a special case, has technologically modernized, acquired strong mobile networks, but connectivity is limited to its major urban centers.

Today, 40% of the global adult population still uses low-capacity networks. Worst of all, it remains completely offline due to insufficient coverage, cut off from most digital content. By 2030 this share could be halved. This will be due to a combination of trends, including not only wider network coverage, but also the growing number of affordable devices, in the development of broader demographically and socially adapted online content (Olumuyiwa, 2014).

Countries in North America, Europe and East Asia are at the forefront of 5G. Investments in technology are made in almost all countries of South and Southeast Asia, as well as South America. South Korea is the country that developed the first 5G network and the country is expected to remain a leader. By 2025, almost 60% of mobile subscriptions in South Korea are expected to be for 5G networks.

Especially in Europe 5G can offer benefits of 210 billion. euros, according to the Analysys Mason study. Smart factories, agriculture and suburban and rural areas have a greater impact on GDP. More than € 50 billion in additional 5G benefits can be disbursed for less than € 20 billion in public funding. Germany is projected to see the highest total net profit of 38.5 billion euros, with an investment of 6 billion euros giving a cost-benefit ratio (CBR) of 7.5. Switzerland is also poised to see the highest cost-benefit ratio with a net profit of around € 10 billion on a € 700 million investment (Ghoul, Jia, 2015).

Statista, the international measurement company, expects an explosion of 5G subscribers worldwide from 80 million in 2020 to 2.7 billion in 2025, with the most 5G subscriptions in Northeast Asia, North America and Western Europe. It took 12 years for 3G, introduced in the early 2000s, to reach one billion users worldwide. By comparison, 4G spread three times faster, reaching the signal of one billion users four years after its introduction in 2010 (Karaboytcheva, 2020).

As it is emphasized, in the coming years, the interconnection of the machines will be achieved with higher data speeds, extremely low latency and increased availability, and with multiple benefits for the users. By 2023 the connected cars are going to form the largest established 5G IoT endpoint base worldwide with more than 19 million installed endpoints. External surveillance cameras and telematics devices are also large parts of the installed 5G IoT base. According to McKinsey, by 2030, machine interconnection could account for more than 70% of all connected devices, but only 12% of data traffic (Ghoul, Jia, 2015).

As telecommunications providers point out, while the benefits of introducing new networks will be immediately felt by the rapidly improving internet experience on mobile phones and laptops, the real transformation of users' lives will come from the digitization of everyday services. offered and mainly, through the new technologies that it will highlight. Its ability to support artificial intelligence, robotics, the Internet of Things, remote control and virtual reality will enable the creation of innovations that will offer untold value to our daily lives, affecting a wide range of industrial and economic sectors. Compared to previous technologies, 5G flexibility allows it to adapt to the different needs

of each industry, which increases the opportunities for combined innovation between industries (Olumuyiwa, 2014).

As to the impact of 5G technology in the transportation field, it should be said that overall, McKinsey estimates that 5G use in transportation could have a positive impact of \$ 170 billion to \$ 280 billion in global GDP by 2030. V2N (Vehicle-to-network communication), V2V (Vehicle- to-vehicle communication), V2I (Vehicle-to-infrastructure communication), V2P (Vehicle-to-pedestrian communication) are the acronyms of a different interconnected transport world. "Autonomous driving" is seen as a separate case of use with the potential to create significant value for businesses, consumers and society, gradually leading to a future of full autonomy.

As to the health impact of 5G technology, the overall benefits of digitizing healthcare (in addition to the benefits associated with connectivity) are enormous. According to McKinsey, advanced patient monitoring systems running on advanced networks could generate about \$ 70 billion to \$ 120 billion in annual value worldwide, combined with lower morbidity and greater patient satisfaction, convenience and independence. 5G connectivity can give these systems more sophisticated capabilities. Accurate and continuous data transmission can detect warning signs of illness earlier and resolve them faster with minimal intervention (Russell, 2018).

New health applications over 5G could activate around 1.5 trillion. \$ up to \$3.0 trillion dollars per year until 2030, with a benefit of 11% to 20% of almost 15 trillion. USD in global healthcare projects. In addition to these immediate economic benefits, a further digitized healthcare system could also have significant indirect effects on the economy resulting from better health outcomes and healthier populations.

More efficient remote patient monitoring can also be achieved through sensors and the resulting data can be transmitted immediately to an advanced mobile connection for evaluation. These systems can assist patients as well as real-time care providers if precautionary measures are required. This can lead to the avoidance or shortening of hospital stays as well as lower rates of hospitalization. Remote monitoring can help patients maintain chronic diseases such as diabetes, chronic obstructive pulmonary disease, heart failure and hypotension under control, relieving them of ongoing medical

appointments. As a result, a huge share of healthcare costs is being reduced (Ghoul, Jia, 2015).

As to the impact of 5G on trade, the use of 5G in retail includes some key technologies: sensors, trackers, artificial intelligence, advanced analytics, smart interfaces, automated RFID scanners. The business value resulting from these use cases could generate \$ 420 billion to \$700 billion in global GDP by 2030. The retail sector sees 5G technology as an opportunity to increase sales and retain customers primarily in from the development of e-commerce. The retail sector is already facing a major upheaval from online retailers. Traditional retailers are forced to move fast, trying to acquire new digital capabilities and rejuvenate their store experience. There is definitely a gap between big retail players with the financial ability to get in quickly in the digital world and the relatively smaller players who show weakness due to financial difficulties but also mentality to join the online commercial market (Karaboytcheva, 2020).

As to the impact of 5G on constructions, nowadays, in large construction projects, engineers sit in cockpits and operate machines from a distance. According to the executives of the mining area, the 5G technology gives a speed per second that can not reach 4G and without delay problems, so that you can operate drones, autonomous vehicles, cranes. The drones can be programmed to fly in such a way as to be in GPS coordinates, to monitor the conditions of a project safely both during the day and at night, reducing labor costs. 4G can handle 10,000 to 100,000 devices per square mile, but 5G can handle up to a million devices. Especially in construction, 5G applications can be a labor-saving solution and an important security tool.

As to the impact of 5G on Primary Sector, the primary sector could bring additional benefits to the international economy if it approached the average levels in terms of standardization and business operation, investing in the "knowledge triangle", education-research-innovation, which expresses the three basic coordinates of the development strategy in modern season, increasing productivity. The Food and Agriculture Organization of the United Nations (UN Food and Agriculture Organization) predicts that in order to meet the needs of the rapidly growing population of the planet, the production of food from the earth must be increased.

To meet these requirements, farmers will need new technologies to produce more from smaller plots of land and with less labor, the agency said. 5G is ideal for transmitting information from remote sensors and ground drone observatories, which farmers use to measure humidity, soil temperature and light intensity. In the Netherlands, 5G drones are used to improve potato cultivation. The agricultural sector will collect data remotely, and we know that farms cover large areas that are difficult to monitor. Irrigation systems can be activated at the right time of day. The accuracy and efficiency of crop spraying can be increased. Cattle can graze in areas that provide food with high nutritional value. It can also help automate cultivation methods (Ghoul, Jia, 2015).

Finally, as to the impact of 5G on industry, a wave of technological advances known as "Industry 4.0" is driven by the explosion of available data, developments in analysis and machine learning, new forms of human-machine interaction (such as touch interfaces and augmented reality systems) and the ability to transmit digital in the physical world that 5G brings. These complementary technologies can operate smart, cost-effective, efficient and automated factories. Where connectivity has been a barrier, a variety of new standards will now be able to accelerate the transition to the digital environment.

The business value of using cases with improved connectivity could increase global GDP from \$ 400 billion to \$ 650 billion by 2030. IoT devices will take off in a few years, with strong penetration of construction and processing but also of the automotive industry, which is already mutating in the context of electrification and the Fourth Industrial Revolution. For example, Daimler has partnered with Telefónica and Ericsson to implement a 5G private car network. Audi and Ericsson partnered to implement 5G technology at the Audi Production Lab in Gaimersheim, while Volkswagen partnered with AWS to build an industrial cloud for IoT devices (Karaboytcheva, 2020).

2.4. Various Researches About the Impact of 5G Network Concern on People's Health

For a better understanding of the wireless network let's leave aside for a while the conspiracy theories and myths, which are based on a complete lack of understanding

of physics and focus on how wireless frequencies work. The 5G radio towers are governed by the same security regulations and power limits as existing 4G, WiFi and other wireless technologies. The Sub-6GHz 5G remains in the same area as existing networks anyway, but even the higher frequency mmWave (which operates at much lower frequencies than the cancer ionizing radiation) also adheres to the existing strict exposure limits (Andrews, 2014).

Based on the literature, many high-quality long-term studies show no link between cell phones and cancer, some of them from the Danish Strategic Research Council, the National Science Council in Taiwan and the Japanese Ministry of Interior and Communications. The wider scientific and journalistic communities are constantly welcoming and reviewing with new and comprehensive research whether 5G is harmful to human health (Communications Engineering Perspective, 2020).

Some of the leading studies on the apparent dangers of 5G reassure about the security / secure of mobile technology by dispelling some of these persistent rumors. When we hear about radiation we think directly of the dangers of waste and nuclear bombs. While this is true, there are many very safe forms of radiation. In fact, we are constantly exposed to background radiation, such as cosmic rays from the sun (Tae Hwan Koh, 2020). There is a significant difference between safe radiation and bad radiation associated with parts such as Chernobyl or X-ray machines. This is the difference between ionizing and non-ionizing radiation. Ionizing radiation occurs at wavelengths above ultraviolet light, also known as X-rays and gamma rays. These can damage your DNA by knocking out electrons from key molecules, leading to tumors and cancer (Kostoff, 2019).

Lower frequency radio waves, such as those used for LTE mobile networks, do not ionize - that is, they cannot cause the same type of damage as before. Some non-ionizing wavelengths can be bad for you, as they generate heat at extremely high-power levels. The microwave, for example, can heat food, but it requires more than a thousand watts to make it (Russell, 2018). A UV tanning chamber that is constantly used by humans is much more dangerous than the signals emitted by LTE and WiFi.

The frequencies set for 5G are similar to those of existing systems such as 4G. Specifically, frequencies close to 1000 (MHz), frequencies close to 3.5 (GHz) and frequencies close to 26 (GHz) have been proposed. 2nd generation systems operate at 900 and 1800 MHz, 3G systems at 2.1 GHz, WiFi at 2.4 and 5.2GHz and 4G provide various options in the 1-4GHz range. Even for the 26GHz option offered on 5G it is worth noting that this is a better option compared to human exposure as the higher the frequency the greater the signal attenuation and the lower the absorption by the human body. That is why the European Commission is adopting higher exposure limits at higher frequencies. Europe tends to use 3.5GHz frequencies for 5G networks (Ciaula, 2018).

However, a more general basis should be introduced and 5G should not be targeted since as far as the type of Electromagnetic radiation is not different from the existing systems and as far as the transmitting power of the antennas is concerned it at lower levels. The potential effect of electromagnetic radiation on humans in general could be debatable, however, so far there are no valid and documented studies that prove beyond any doubt that it actually causes harmful effects in humans. The potential effect of Electromagnetic Radiation on the human body has been studied by many researchers, but mainly by the World Health Organization (WHO) through the International Agency for Research on Cancer (IARC) in the last 30 years and tens of thousands of scientific papers that have been published demonstrate nothing reprehensible (Russell, 2018).

The IARC coordinates and investigates possible causes of cancer through global epidemiological studies and the study of possible mechanisms of carcinogenesis and develops strategies for cancer control. It therefore classifies the various risks into 5 categories:

- ✓ Carcinogenic,
- ✓ Most likely Carcinogenic,
- ✓ Possibly Carcinogenic,
- ✓ Unclassifiable on carcinogenesis
- ✓ Probably non-carcinogenic.

Based on this classification Ionizing radiation (eg radioactivity) is classified in category 1 along with smoking and asbestos, while electromagnetic waves are classified

in category 2B along with gasoline, coffee. The main proven effect of radio waves on the human body is an increase in body temperature due to its absorption by it. Based on this absorption, the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which is officially recognized by the WHO and whose role is to focus on studying and evaluating scientific results from the literature, suggests limitations in relation to exposure to non-ionizing radiation. The most recent ICNIRP Directive was adopted in 1998 and adopted by the European Committee for Standardization (CENELEC) and the European Council through Recommendation 1999/519 / EC. (Mattsson, 2019).

In Cyprus, as in most European countries, the reference levels set out in EU Recommendation 1999/519 / EC are adopted as national exposure limits, but the Ministry of Health is also given the right to revise these limits. The competent authority for the control of the operation of the radio communication stations, including the control of the compliance with the national exposure limits is the Department of Electronic Communications (THE) of the Ministry of Transport, Communications and Works. All stations that broadcast THE licensed frequencies are checked before installation and then twice a year to confirm that their contribution to the Total Exposure Rate does not exceed the acceptable limits.

The half-yearly measurements at each station are performed according to the European Recommendation CEPT / ECC / REC / (02) 04 only by ISO17025 accredited laboratories and their results are checked and approved by THE. No station in Cyprus is installed, unless an assessment study of the contribution of this station to the total exposure in the installation area has been previously carried out. (cyta, n.d.). There are currently around 40 5G commercial networks in Europe, and it is estimated that by 2025 it will cover 65% worldwide. The commercial use of 5G has started in Cyprus through the company Cyta on January 31, 2021.

The FCC safe limit for mobile phones is a specific absorption rate (SAR) of 1.6 watts per kg (1.6 W / kg) of mass, which is not enough to keep our bodies warm. Smartphones on the market in the US must prove compliance with this limit before they can be sold. The ICNIRP guidelines used in Europe and most other countries set this limit at around 2.0 W / kg. These are the absolute legal limits of exposure. Most of the

time, the actual prices are significantly lower, especially when we put our phones down. (Russell, 2018)

Except from the above, many studies have looked at whether radio frequency electromagnetic radiation (RF EMR) can affect healthy people. A review of the literature and the 2010 Interphone study greatly summarized the lack of findings on this topic. In 2011, the World Health Organization (WHO) declared cell phones to be carcinogenic class 2B, meaning technology could be linked to cancer. This does not immediately mean that the level of exposure to commercial products is dangerous. Other carcinogens of category 2B include pickles, aloe leaf extract (Balta, 2002).

There have been no convincing results showing that mobile technologies are extremely dangerous to humans, many rely on how difficult it is to compare scientific results to make wild claims that have not been tested for a long time. In particular, they often cite a specific study as "evidence" of their misinformation (Seungmo, 2020). None of this, however, means that research into the possible effects of radio frequency radiation is not important or should be completely ignored. We can always learn more, such as how cell phone radiation affects fertility or whether there are increased risks to children. If there are unknown risks, we definitely want to know about them. (Dr Moskowitz, 2018). However, based on current data from reliable research, there is no evidence to suggest that their smartphones or related radio signals are not safe for public use.

In 2016, in a different research study, the US National Toxicology Program (NTP) published a draft of study findings examining the effects of non-ionizing radiation on rats and mice. They created a control group of rats with males exposed to CDMA or GSM cell phone radiation, and with females exposed to GSM cell phone radiation. The technology used was that of 2G and not modern 4G. The researchers used the following exposure protocol to test the animals:

- ✓ Rats and mice were exposed to GSM or CDMA signals with full body exposure from zero to 15 W / kg (rats were given a lower dose). (Dr Moskowitz, 2018)
- ✓ All openings were applied 7 days a week, for about 9 hours a day.

Two years later, the study found that several rats and mice developed tumors. However, these results mainly concerned exposure to the whole body and not exposure to certain parts of the body as in the case in humans. Also, there were insufficient controls for exposure uniformity, making it difficult to see the exact exposure in each rat. (Dr. Moskowitz, 2018, Ciaula, 2018).

However, it is important to remember that some rats with tumors have been exposed to two to four times the allowable limit (1.6W / kg) RF EMR, which is not proof of anything for mobile phones. Humans will never be exposed to the amount of RF EMR used in this study. With mice, they used ridiculously high-power levels - up to 10W / kg for 2-year studies and 15W / kg for short-term studies. All test groups actually had higher survival rates than the control groups, showing how the correlation was not causal (Karaboytcheva, 2020).

Many institutions such as the American Cancer Society report this study without taking a strong stand, but the FDA, the National Cancer Institute and the FCC note that the overwhelming data show the safety of cell phones and technologies such as Bluetooth and WiFi - even after reviewing the results of the study (Communications Engineering Perspective, 2020).

Another major study is that of the Ramazzini Institute on the effects of distant field radiation on rats. This very large study used radiation levels up to 60 times lower than the NTP study, in the range of what a person can experience. There have been several notable reviews of this research. While the total number of rats in the study was large, the number in each experimental group was small (Chiaraviglio, 2019).

The only statistically significant finding of the report was the increased incidence of benign tumors in the heart observed in male rats treated with the highest dose (50 V / m) of radiation. The team rated it in SAR for comparison with the NTP study and FCC regulations equivalent to about 0.1 W / kg, within legal limits (Andrews, 2014). The survey highlighted the incidence of men as statistically significant, at 1.4 percent, but not for women. This is because the male control group had zero spontaneous ejaculation rate, compared with one percent in the female group. In other words, these data suggest that male rats may not develop scabies from other sources, while females

may. The bottom line is that only male data looks suspicious, especially compared to female data (Karaboytcheva, 2020)

Other lower controlled power levels $25\text{V} / \text{m}$ ($0.03\text{W} / \text{kg}$) and $5\text{V} / \text{m}$ ($0.001\text{W} / \text{kg}$) did not show such connections. There are also further anomalies in the data. There was a higher rate of schwannoma in female rats at the lowest exposure level. If the data from the Ramazzini study were completely accurate, it would also indicate that the NTP study should have much higher tumor detection rates. At best, further research is needed to rule out errors and explain these discrepancies (Communications Engineering Perspective, 2020).

Stephen Chanock, director of the Department of Cancer Epidemiology and Genetics at the National Cancer Institute, is sceptical of the results. The institute monitors brain tumors in the general population and has found nothing to report since the work began in 2004. In addition, it sees no evidence from the Ramazzini study suggesting that current safety limits for cell phone radiation are insufficient (Russell, 2018, Karaboytcheva, 2020).

In addition to poorly conducted studies, poor scientific theory is often used to reinforce fear in wireless technologies. In a letter to Broward County public schools in 2000, Dr. Curry used a notorious chart showing “Microwave absorption in the brain tissue (Gray Matter)”. The graph shows that the level of radiation received by the human brain increases exponentially as the frequency of the wireless signal increases. This made the situation more difficult as it already looked bad given the network frequency at that time and it would be even more worrying with the adoption of 5G mmWave signals. To make matters worse, he used the acute vulnerability of the brain in children (Chiaraviglio, 2019).

In late 2011, Dr. Carpenter used the same chart in a lawsuit against Portland, Oregon Public School in an attempt to force them to abandon their wireless computer networks. Dr. Carpenter continued to support this argument against various other network technologies, including 5G (Chiaraviglio, 2019, SeguõÂ, 2000). The problem there is that this specific graph used, is incorrect as many experts argue the opposite view regarding the biological effects of electromagnetic radiation. Higher frequency radio

waves are safer, not more dangerous, but to the point where they reach extremely high frequencies such as X-rays.

The answer is that human skin offers a protective limit that reflects high frequencies, protecting internal organs. Higher frequency radio waves are less likely to reach the brain than lower frequency waves (Chiaraviglio, 2019). With 5G, the very high frequencies used by mmWave are reflected to such an extent that if we place our hands over the antenna of our phone the signal is blocked (Communications Engineering Perspective, 2020).

Based on historical statistics on cancer incidence, mobile network coverage and the number of bands dedicated to its use have expanded rapidly over the last decade, enabling us to have more wireless networks than ever before. If radiation is dangerous, cancer rates should definitely increase (Ciaula, 2018). The US population data on SEER cancers contradicts this view. Cell phone subscriptions in the US along with this data reveal that cancer rates actually increased long before even a small percentage of people had cell phone packages. The trend has since reversed - cancer rates do not actually increase / affected as smartphone use has increased. Brain cancer rates have remained virtually unchanged for the past four decades (Communications Engineering Perspective, 2020).

The cancer rate is just 1.14 percent since the first U.S. consumer cell phone network was launched in 1983. The rates actually dropped 9.56 percent in comparison to since the GSM and CDMA networks started, causing the explosion of cell phone use in the late 1990s. Obviously, it would not be right to suggest that cellular networks reduce cancer rates (Tae Hwan Koh, 2020).

In a different study, there is no convincing evidence linking cellular cancer, but what about the upcoming 5G technologies. Most of these frequencies occupy existing low frequency bands and Wi-Fi, so there are no really new hazards. Higher frequency mmWave technologies still do not approach ionization wavelengths and the technology actually extends beyond the maximum human RF absorption frequency of about 70MHz (Tae Hwan Koh, 2020). The MmWave mostly grows in the 24 to 29GHz range, which suffers from very high reflection rates. Therefore, energy absorption is limited to the

surface layers of the skin and not to deeper tissues that are touched at lower frequencies. Penetration into the bones or skull is indisputable, so the arguments for brain tumor are rejected (Ciaula, 2018)

The 5G mmWave devices are bound by the same security specifications as existing 4G LTE, Bluetooth and WiFi. FCC FR security regulations apply up to 100GHz, so mmWave 5G devices are bound by the same security standards and power limits as existing 4G LTE, Bluetooth and Wi-Fi products. According to research, a 60GHz mmWave emitting an imposing power of 50W / m² (which will not approach FCC regulations) only raises the skin temperature by 0.8 degrees Celsius, which is below the IEEE 1 temperature limit. Celsius for mmWave based on radiation instructions (Andrews, 2014). Technology seems to be safe and current FCC and global regulations already cover these frequencies. Nevertheless, 180 scientists from around the world signed a report in September 2017, calling for a delay in the development of the 5G network in the European Union until the health effects are studied in more detail. More experiments seeking specifically at 5G would be welcome (Russell, 2018)

Once it has been covered the issue of whether cellular networks cause cancer, we will see what happens to other health problems. Infertility is probably the second biggest risk attributed to cell phones, based on some studies (Dr. Moskowitz, 2018). The main cause of infertility from mobile phones is the heat generated by them. In several studies, there was a lower sperm count based on heavy cell phone use, but the only part that was connected was the heat generated by the phone. It is very difficult to examine the effect of radiation from real units, because the presence of increased heat is a confusing factor, especially when it is directly related to lower sperm counts. (Balta, 2002).

In conclusion to the above research, even after reviewing the above literature, we conclude that horror stories create popular titles, but the reality of potential evidences is often thrown out quickly. The most popular research papers on the subject has major errors. Many high-quality long-term studies still find no link between cell phones and cancer, including the Danish Strategic Research Council, the National Science Council in Taiwan and the Japanese Ministry of Interior and Communications. RF radiation levels

even from today's LTE networks fall well below regulatory and scientifically tested safety limits.

All smartphones must prove that they will not exceed these limits, even in the worst case, before they even go on sale. In addition, the upcoming 5G and mmWave wavelengths are already subject to the same levels of protection. Based on the scientifically proven data we have so far, it does not prove anywhere that 5G networks are related or affect our health to such an extent and dangerous as some people want to terrorize the world. It would definitely be good to do continuous research and studies so that we are always informed and prepared for any eventuality.

2.5.Synopsis of the Literature Review About the Disadvantages and Risks of the 5G Technology

The 5G network technology in addition to its advantages is called to face the disadvantages and risks. One of the main disadvantages is the security and the lack of technological progress in most geographical areas, at the same time we have to deal with its lack of support from old smart devices and the range of costs for people to replace them. This requires a lot of money. In several countries, a response study is already being carried out due to the non-increase of high speeds which will interfere with the radio waves.

It requires huge investment in infrastructure and development, the 5G network has security and privacy issues. This requires specialized engineers to install and maintain infrastructure. The coverage is 2 meters indoors and 300 meters outdoors. With the first tests, the 5G network presupposes frequencies for data transmission at around 6GHz. Unfortunately the areas of these radio frequencies are already occupied by other signals which means that with 3G network towers they cover huge areas with minimal cell commitment in the cells because it does not require a large bandwidth.

Then 4G came into our lives. Network which, although it produces more bandwidth, but the reduction of coverage was observed. As technology evolves and for more proper use more towers are needed to cover this large bandwidth and more cells will have to be developed.

Even before the advent of 5G networks, the development of fifth generation technology in mobile telephony was accompanied by rumors and conspiracy theories, which according to experts lack any scientific basis. The most recent example was the theory that was reproduced mainly on social media with the advent of COVID-19, according to which the coronavirus epidemic is linked to wireless technologies, such as 5G. Although completely absurd for elementary common sense, the theory was so popular that social networking platforms were forced to take action to curb its spread, following incidents of attacks on mobile phone towers mainly in the United Kingdom.

To some extent, it is reasonable in the beginning for anything new and innovative, a portion of the public to "stand" with some caution as to the possible long-term effects on human health. This is where the catalytic role of science enters to give the necessary answers to any questions. After years of research and review of all available relevant literature worldwide, the competent independent body of scientists from around the world, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) has reaffirmed and March 2020 that 5G is safe and that there is no scientific data to prove that it is a threat to humans. Many of these myths stem from a lack of understanding of the radiation from cell phone towers and have remained the same since we had 2G.

Why do they insist even though they have been answered? Because the word "radiation" in itself causes fear, since over time people have associated it with nuclear weapons but also with accidents that shook the world, such as that of Chernobyl and more recently, that of Fukushima. What most people do not know is that there are two types of radiation, ionizing and non-ionizing. The aforementioned nuclear explosions are related to ionizing radiation.

In contrast, 5g technology is associated with non-ionizing radiation, electromagnetic radiation or electromagnetic fields, and it includes many technologies that we all use every day, e.g. power lines, FM radio and WiFi. These frequencies have already been extensively studied in terms of their potential health effects. So far and after several reliable studies that have been conducted, no disease has been causally linked to exposure to electromagnetic radiation.

Competent bodies with international prestige and time experience, such as the aforementioned ICNIRP, the World Health Organization (WHO) and the Scientific Committee for New Risks of the European Union (SCENIHR), but also scientists internationally and in our country, have overthrown the the operation of 5th generation networks and confirm through the conclusions of long-term and in-depth studies, that the use of 5G technology is safe and does not pose a risk to human health or harm to the environment.

Specifically, according to the President of ICNIRP and following the security limits recommended by the organization internationally, Dr. Eric van Rongen: "The most important thing to remember is that 5G technologies can not cause any harm when the limits set out in the guidelines are met." In addition, the World Health Organization (WHO) has adopted and recommended the safety limits of ICNIRP as sufficient to protect the health of all social groups, while regarding the concerns expressed by the WHO emphasizes "There is no convincing scientific evidence that weak radio frequency signals from mobile antennas are harmful to health."

In addition, according to a WHO announcement, "a large number of studies have been conducted in the last two decades to assess whether mobile phones pose a potential health risk. To date, there has been no documented adverse health impact from use of mobile phones a link between exposure to radiation and the development of cancer".

The "valves" that consolidate the feeling of security For the most skeptical public, there are additional safety "valves" in order to strengthen their confidence, as through the operation of the competent national bodies, such as the Hellenic Atomic Energy Commission (GAEC), the safe observance of safety limits for health and environment. In addition, our country has adopted even stricter limits than those recommended by ICNIRP near places frequented by socially vulnerable groups, such as children or the elderly, although such a need is not scientifically substantiated.

For example, in schools, nurseries, nursing homes and hospitals, it is recommended by the competent bodies and a minimum distance is ensured for the installation of mobile telephony antennas, while even stricter (by 40%) radio emission limits are set than those recommended by the European Union and ICNIRP.

The mobile infrastructure does not burden the environment. The scientific community is deconstructing those "voices" who say that the installation of new 5G mobile antennas is detrimental to the natural environment, as in practice, the operation of the new networks will be based on upgrading and improving the existing infrastructure utilized by digital networks, without impact on the natural environment, especially in Natura 2000 protected areas. 5G has a catalytic role in the digital maturation of the country and is changing the world safely.

The presence of 5G extends beyond the simple use of mobile devices, with speeds 100 times faster than 4G, with excellent response and increased capacity, in the whole range of social and business activity, since all entrepreneurs will have the opportunity to utilize low-cost services in the long run, on numerous devices (Internet of Things - Internet of Things), collecting data and detecting trends that will help them adapt to the circumstances. Europe and the rest of the world are already living in the pace of the 4th Industrial Revolution, as 5G is expected to further highlight new possibilities for simplification and automation of processes, from telemedicine and robotic medicine to building "smart cities" with autonomous vehicles moving to smart roads, better management of the environment and infrastructure, rational water management and virtual reality applications that will change the data to date.

CHAPTER 3

Research Methodology

3.1.Purpose of the Dissertation

This research focus on how people individually perceive the risks that new technologies and particularly 5G in Cyprus bring to their daily lives, by studying and examining two different groups of people. The study of the 1st group is concerned to how people who are involved and have knowledge about technology perceive these risks and if they really consider these as risks, to what extent it affects them and the study of the 2nd group as to how people who are not familiar with the subject perceive these risks, to what level and to what extent they are willing to perceive and really understand them.

Research Questions

The research questions are concerned to the following

- ✓ How does each person perceive these risks based on their knowledge?
- ✓ Is there a difference between the two groups as to whether they agree/disagree with the fact that the arrival of the new technological era of 5G, is a positive thing?
- ✓ Is there a difference between the two groups as to whether they agree/disagree that they double check the theories they hear/read before accepting it?

3.2.Research Methodology

A theoretical analysis of the subject is used, based on the existing literature on new technologies. The necessary data are collected by using a questionnaire and taking a random sample from a mixture of people who are familiar with the new technologies or not (Cypriots and foreigners) who live in Cyprus, asking them to respond to the importance they attach to each risk, by using a relevant scale. In advance, a questionnaire has been given to two (2) separate groups of people, those who deal with technology and its development at a professional level and those who have nothing to do with technology

other than their entertainment. From the separation of these two groups and from the answers they will provide, we will further understand whether knowledge plays a decisive role in humans to accept or not something new in technology, which in our case is 5G.

Based on the above, it should be said that for the analysis of the questionnaires, is used the SPSS package No.22 where the student proceeds with the statistical description of each of the questionnaires as also answering the research questions by using the methods of cross tabulations so as to clarify, whether the specific tabulations are really exist or not. The specific methods have been chosen, as the questionnaire is self made and these are the most relevant methods to use for the analysis.

3.3.Sample of the Research

The number of the sample of the specific research, is about 60 persons divided into two (2) groups, as mentioned above. The 56,7% of our participants were female and the rest 43,3% were male. The 53,3% of the participants were from 18-29 years old, the 36,7% were from 30-39 years old and the rest 10% were from 40-49 years old. The 43,3% of the participants were University/College Students, the 30% had a bachelor's degree, the 20% had completed the compulsory education and the rest 6,7% has a master's degree. The 45% of the participants were single, the 41,7% were married and the rest 13,3% were in a relationship. All the participants had a smart device. The 41,7% of the participants said that they spend 3-5 hours in the internet daily, the 28,3% 1-3 hours, the 21,7% more than 5 hours and the rest 8,3% less than 1 hour.

Moreover, it should be mentioned that the questionnaires were offered to the respondents on hard copy, where 30 of them were belong to the 1st group and 30 to the 2nd group of the whole respondents. The specific no. is concerned to a representative percentage of 0,001% of the whole population.

CHAPTER 4

Results Analysis

4.1. Demographic Questions

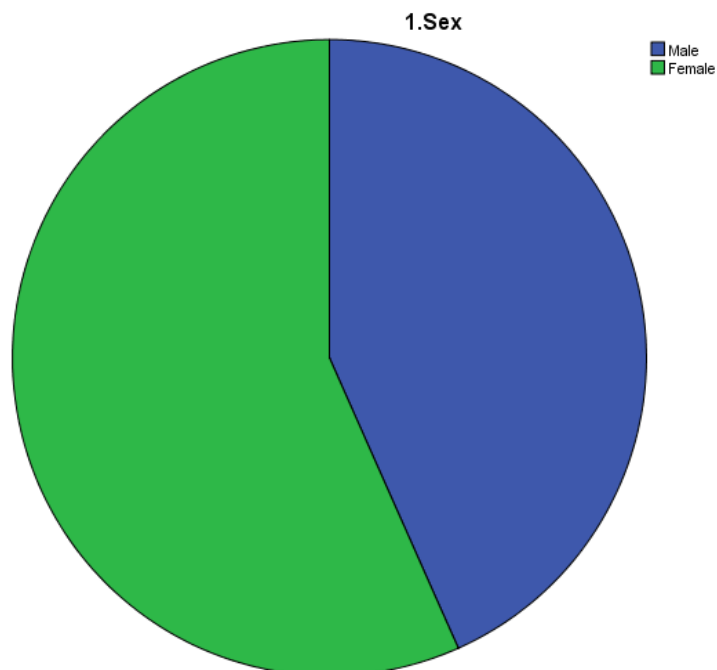
Question 1

The 56,7% of our participants were female and the rest 43,3% were male.

Table 1.Sex

	Frequency	Valid Percent	Cumulative Percent
Male	26	43,3	43,3
Female	34	56,7	100,0
Total	60	100,0	

Chart 1



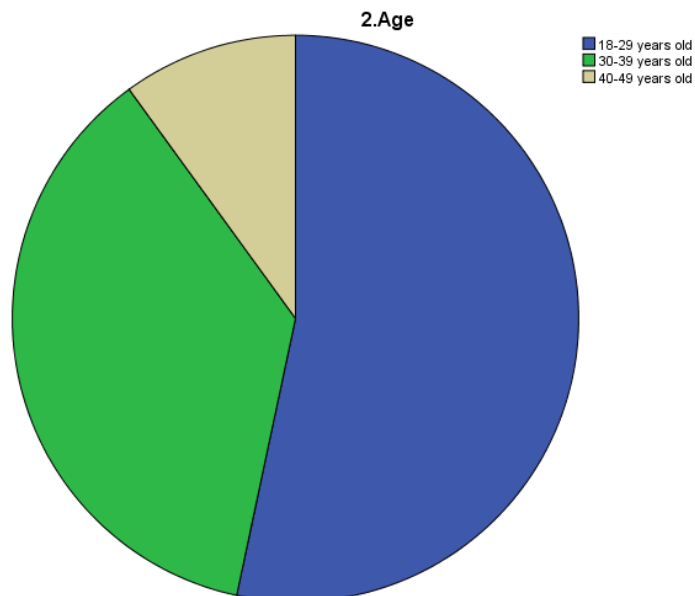
Question 2

The 53,3% of the participants were from 18-29 years old, the 36,7% were from 30-39 years old and the rest 10% were from 40-49 years old.

Table 2.Age

	Frequency	Valid Percent	Cumulative Percent
18-29 years old	32	53,3	53,3
30-39 years old	22	36,7	90,0
40-49 years old	6	10,0	100,0
Total	60	100,0	

Chart 2



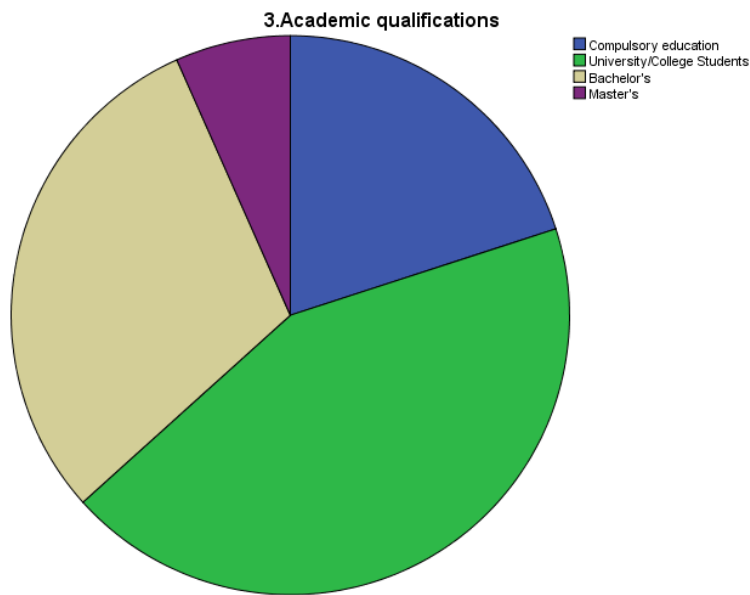
Question 3

The 43,3% of the participants were University/College Students, the 30% had a bachelor's degree, the 20% had completed the compulsory education and the rest 6,7% has a Master's Degree.

3.Academic qualifications

	Frequency	Valid Percent	Cumulative Percent
Compulsory education	12	20,0	20,0
University/College Students	26	43,3	63,3
Bachelor's	18	30,0	93,3
Master's	4	6,7	100,0
Total	60	100,0	

Chart 3.



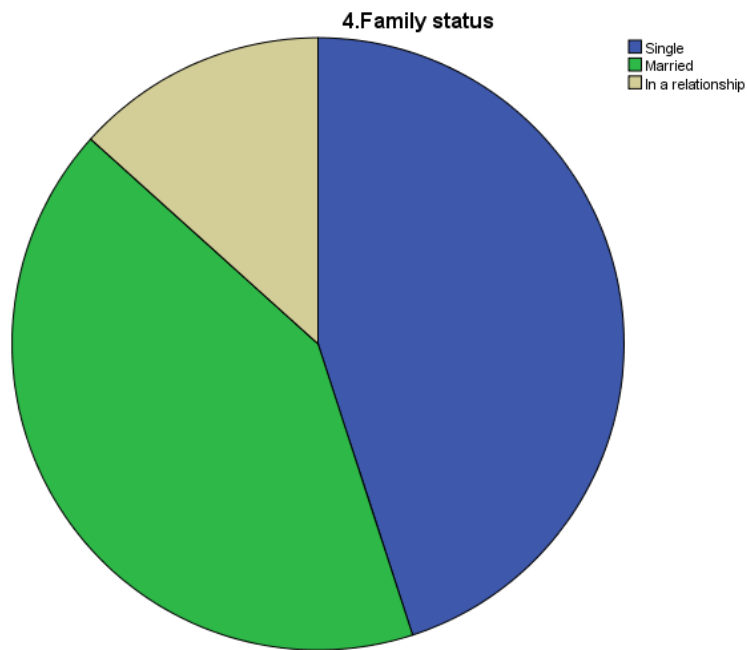
Question 4

The 45% of the participants were single, the 41,7% were married and the rest 13,3% were in a relationship.

Table 4.Family status

	Frequency	Valid Percent	Cumulative Percent
Single	27	45,0	45,0
Married	25	41,7	86,7
In a relationship	8	13,3	100,0
Total	60	100,0	

Chart 4



Question 5

All the participants had a smart device.

Table 5.Do you own smart device/s?

	Frequency	Valid Percent	Cumulative Percent
Yes	60	100	100

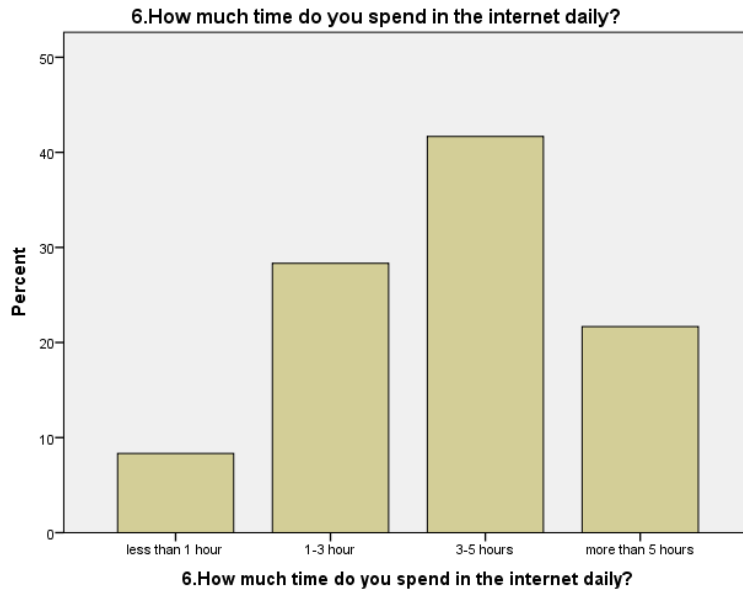
Question 6

The 41,7% of the participants said that they spend 3-5 hours in the internet daily, the 28,3% 1-3 hours, the 21,7% more than 5 hours and the rest 8,3% less than 1 hour.

Table 6.How much time do you spend in the internet daily?

	Frequency	Valid Percent	Cumulative Percent
less than 1 hour	5	8,3	8,3
1-3 hour	17	28,3	36,7
3-5 hours	25	41,7	78,3
more than 5 hours	13	21,7	100,0
Total	60	100,0	

Chart 5



4.2.Main Questionnaire

Question 7

All the participants know what 5G is, but half of them have no further knowledge about it, whereas the other half are more aware of the 5G technology.

Table 7.Do you know what 5G is?

	Frequency	Valid Percent	Cumulative Percent
Yes	60	100,0	100,0

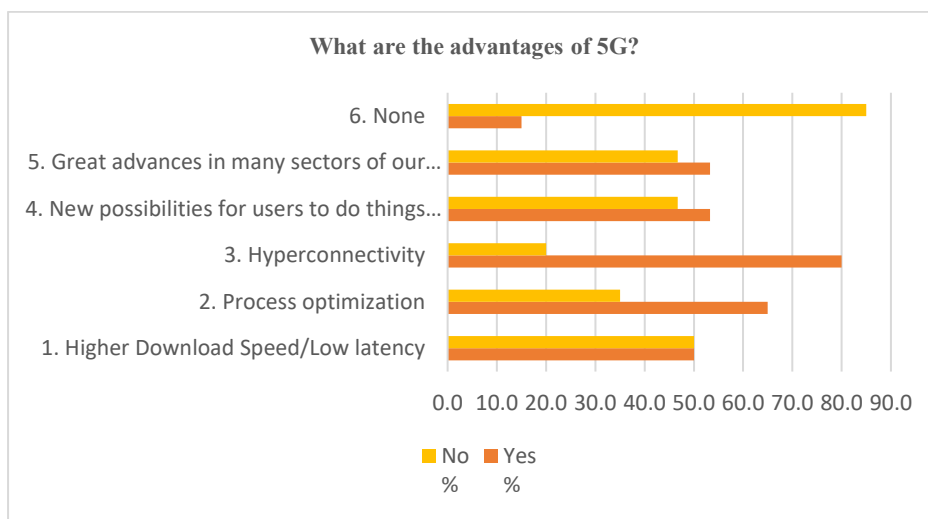
Question 8

The 80% of the participants said that Hyperconectivity is one of the advantages of 5G, the 65% said that another advantage is the process optimization, the 53,3% mentioned the New possibilities for users to do things from afar, another same percent referred to the Great advances in many sectors of their lives, the 50% the Higher Download Speed/Low latency and the 15% said that there is no advantage of the 5G.

Table 8.What are the advantages of 5G?

	Yes %	No %
1. Higher Download Speed/Low latency	50,0	50,0
2. Process optimization	65,0	35,0
3. Hyperconnectivity	80,0	20,0
4. New possibilities for users to do things from afar	53,3	46,7
5. Great advances in many sectors of our lives	53,3	46,7
6. None	15,0	85,0

Chart 6



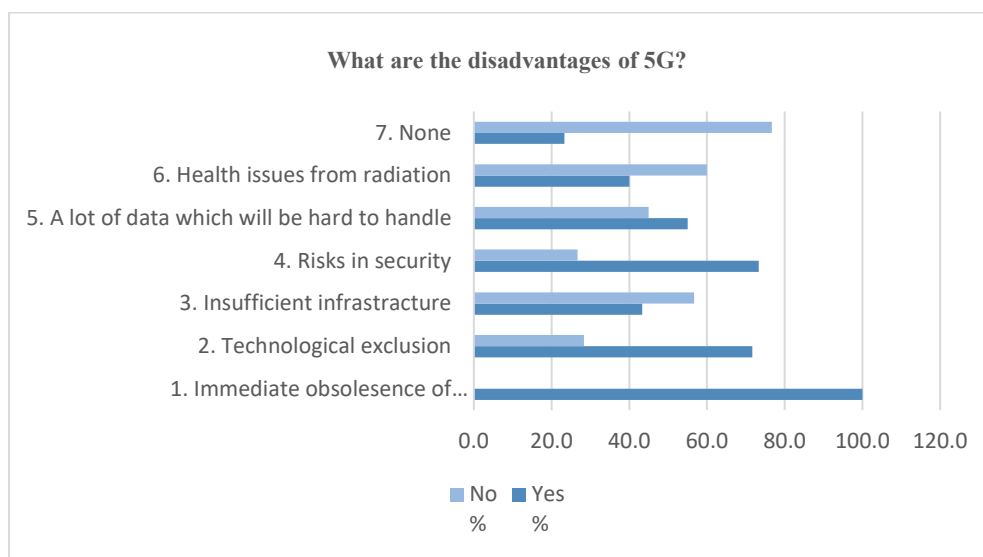
Question 9

All the participants said that one of the disadvantages of 5G is the Immediate obsolescence of equipment/devices. The 73,3% referred to Risks in security that might come up, the 71,7% mentioned the technological exclusions of part of the users of the internet, the 55% mentioned the large amount of data which will be hard to handle, a 43,3% mentioned the insufficient infrastructure in Cyprus and a 40% of the participants referred to Health issues from radiation. There was a 23,3% of the participants believe that, according to their personal opinion, the 5G technology has no disadvantages.

Table 9. What are the disadvantages of 5G?

	Yes %	No %
1. Immediate obsolescence of equipment/devices	100,0	
2. Technological exclusion	71,7	28,3
3. Insufficient infrastructure	43,3	56,7
4. Risks in security	73,3	26,7
5. A lot of data which will be hard to handle	55,0	45,0
6. Health issues from radiation	40,0	60,0
7. None	23,3	76,7

Chart 7



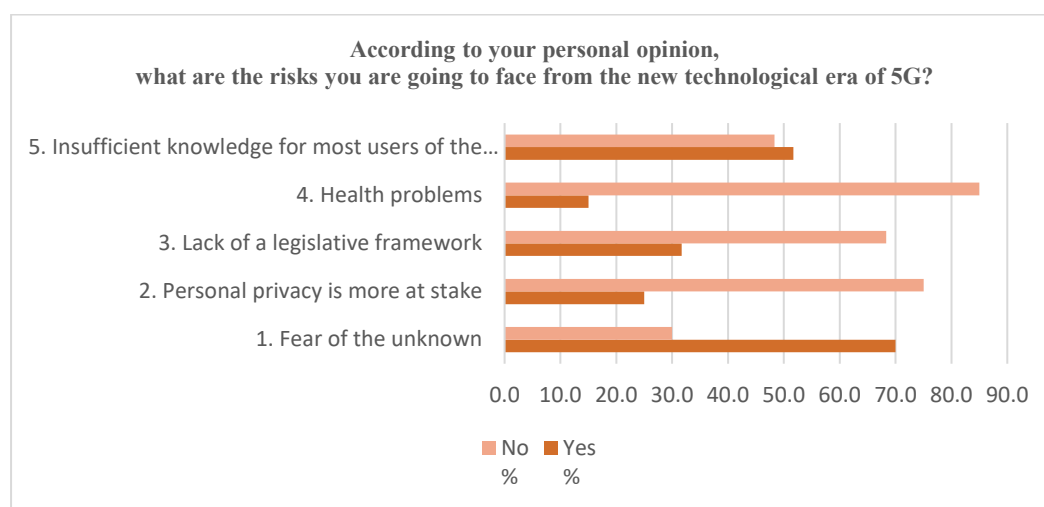
Question 10

The 70% of the participants said that one of the risks they are going to face from the arrival of the new technology is the fear of the unknown, the 40% mentioned the Insufficient knowledge for most users of the internet, the 31,7% referred to the Lack of a legislative framework, the 25% said that Personal privacy will be more at stake and the 15% referred to health problems that may pop up.

Table 10. According to your personal opinion, what are the risks you are going to face from the new technological era of 5G?

	Yes %	No %
1. Fear of the unknown	70,0	30,0
2. Personal privacy is more at stake	25,0	75,0
3. Lack of a legislative framework	31,7	68,3
4. Health problems	15,0	85,0
5. Insufficient knowledge for most users of the internet	51,7	48,3

Chart 8



Question 11

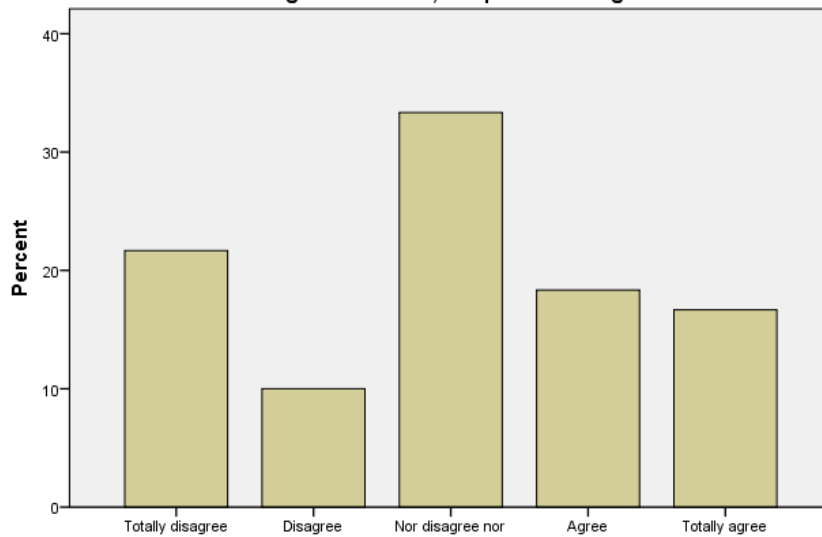
The 33,3% of the participants said that they neither agree nor disagree with the fact that the arrival of the new technological era of 5G, is a positive thing, the 35% (cumulatively) said that they agree or completely agree with the above opinion and the 31,7% (cumulatively) disagree or completely disagree.

Table 11. To what extent do you agree/disagree with the fact that the arrival of the new technological era of 5G, is a positive thing?

	Frequency	Valid Percent	Cumulative Percent
Totally disagree	13	21,7	21,7
Disagree	6	10,0	31,7
Nor disagree nor agree	20	33,3	65,0
Agree	11	18,3	83,3
Totally agree	10	16,7	100,0
Total	60	100,0	

Chart 9

5. To what extent do you agree/disagree with the fact that the arrival of the new technological era of 5G, is a positive thing?



5. To what extent do you agree/disagree with the fact that the arrival of the new technological era of 5G, is a positive thing?

Question 12

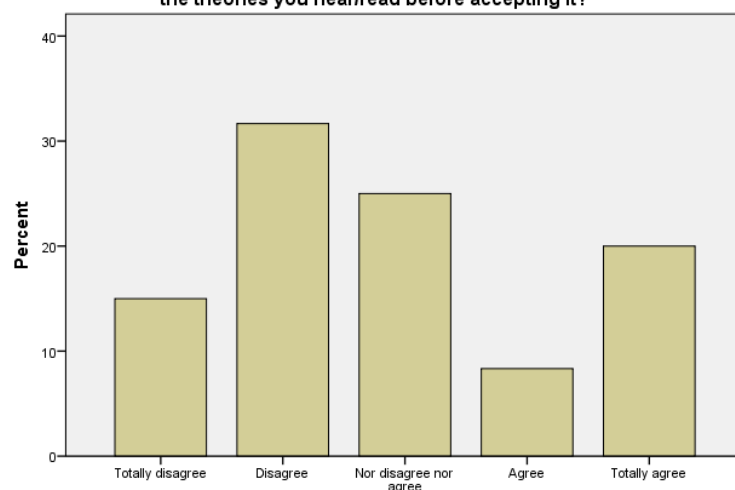
The 46,7% of the participants said that they disagree or completely disagree with the opinion that they double check the theories they hear/read before accepting them, the 25% neither agree nor disagree with the above opinion and the rest 28,3% (cumulatively) agree or completely agree.

Table 12. To what extent do you agree/disagree with the opinion that you double check the theories you hear/read before accepting it?

	Frequency	Valid Percent	Cumulative Percent
Totally disagree	9	15,0	15,0
Disagree	19	31,7	46,7
Nor disagree nor agree	15	25,0	71,7
Agree	5	8,3	80,0
Totally agree	12	20,0	100,0
Total	60	100,0	

Chart 10

6. To what extent do you agree/disagree with the opinion that you double check the theories you hear/read before accepting it?



6. To what extent do you agree/disagree with the opinion that you double check the theories you hear/read before accepting it?

Question 13

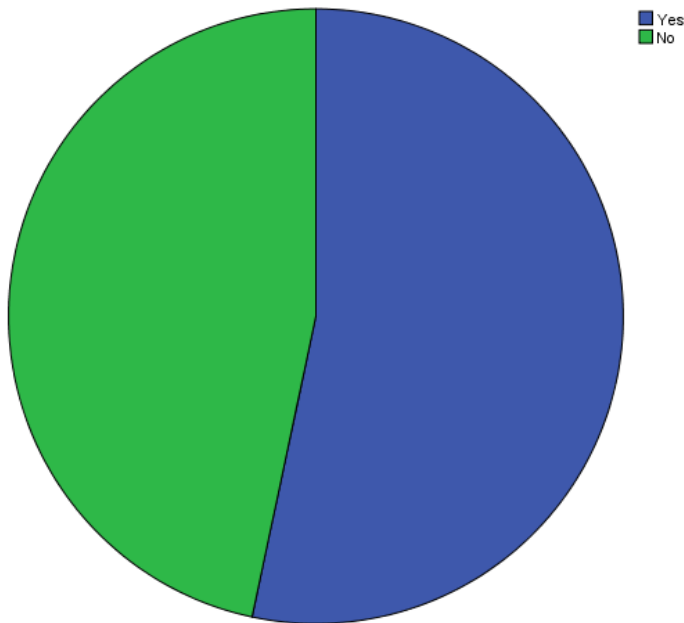
The 53,3% of the participants said that they had concerns about possible risks in past technological achievements and the rest 46,7% they didn't have any concerns.

Table 13. Did you have concerns about possible risks in past technological achievements?

	Frequency	Valid Percent	Cumulative Percent
Yes	32	53,3	53,3
No	28	46,7	100,0
Total	60	100,0	

Chart 11

7. Did you have concerns about possible risks in past technological achievements?



Question 14

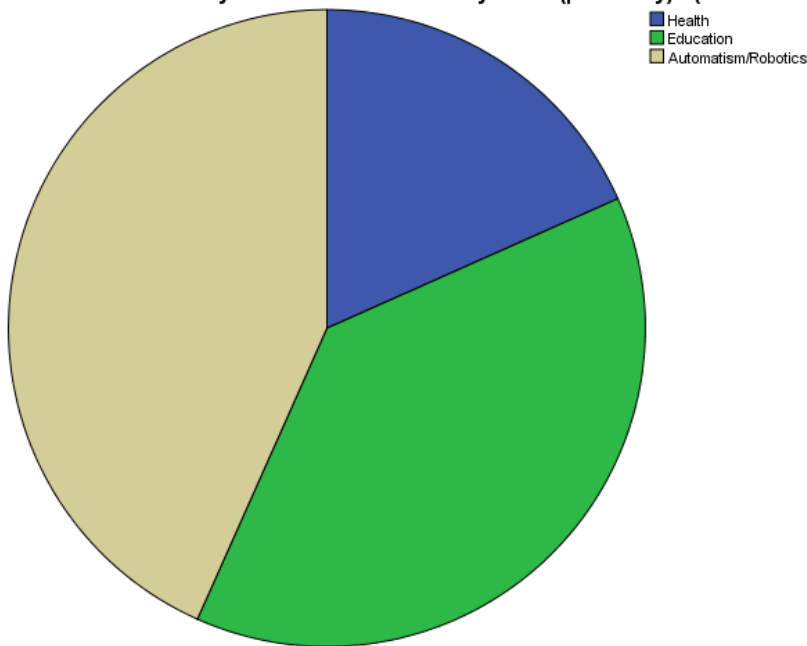
The 43,3% of the participants believe that Automatism/Robotics is the sector that will be mostly affected from the arrival of the 5G technology, the 38,3% said that Education is the second sector that will be affected and the rest 18,3% believe the Health is the third sector that will be affected.

Table 14. Which sectors do you believe 5G will mostly affect (positively)? (Hierarchically)

	Frequency	Valid Percent	Cumulative Percent
Health	11	18,3	18,3
Education	23	38,3	56,7
Automatism/Robotics	26	43,3	100,0
Total	60	100,0	

Chart 12

8. Which sectors do you believe 5G will mostly affect (positively)? (Hierarchically)



4.3. Research Questions

How does each person perceive these risks based on their knowledge?

We made a chi-square test among the groups and all the risks they are going to face from the new technological era of 5G and we are going to state those risks that had a statistical significance.

15. Table of crosstabulation among the two groups and question “According to your personal opinion, what are the risks you are going to face from the new technological era of 5G? Personal privacy is more at stake”

	Yes	No	Total	x2
1st Group (Knowledge)	14	16	30	
2nd Group (No knowledge)	1	29	30	0,000
Total	15	45	60	

From the table 15, we see that the group of people with knowledge believe that the risk they are going to face from the new technological era of 5G is that their personal privacy will be more at stake, whereas almost all the people from the group of people that have no knowledge don't think that their personal privacy will be more at stake. The $\chi^2=0,000$ which means that it is smaller than the Pearson 0,05 and that is why we have a statistical significance.

16. Table of crosstabulation among the two groups and question "According to your personal opinion, what are the risks you are going to face from the new technological era of 5G? Lack of a legislative framework"

	Yes	No	Total	χ^2
1st Group (knowledge)	16	14	30	
2nd Group (no knowledge)	3	27	30	0,000
Total	19	41	60	

From the table 16, we see that the group of people with knowledge believe that the risk they are going to face from the new technological era of 5G is that there is Lack of a legislative framework, whereas almost all the people from the group of people that have no knowledge don't think that this risk will be a problem for them. The $\chi^2=0,000$ which means that it is smaller than the Pearson 0,05 and that is why we have a statistical significance.

17. Table of crosstabulation among the two groups and question "According to your personal opinion, what are the risks you are going to face from the new technological era of 5G? Insufficient knowledge for most users of the internet"

	Yes	No	Total	χ^2
1st Group (knowledge)	11	19	30	
2nd Group (no knowledge)	20	10	30	0,020
Total	31	29	60	

From the table 17, we see that the group of people with no knowledge believe that the risk they are going to face from the new technological era of 5G is that there will be Insufficient knowledge for most users of the internet, whereas most of the people from the group of people that have knowledge don't think that this risk will be a problem for

them. The $\chi^2 = 0,000$ which means that it is smaller than the Pearson 0,020 and that is why we have a statistical significance.

What are the risks of new technologies and how these risks will affect them?

The 70% of the participants said that one of the risks they are going to face from the arrival of the new technology is the fear of the unknown, the 40% mentioned the Insufficient knowledge for most users of the internet, the 31,7% referred to the Lack of a legislative framework, the 25% said that Personal privacy will be more at stake and the 15% referred to health problems that may pop up.

Is there a difference between the two groups as to whether they agree/disagree with the fact that the arrival of the new technological era of 5G, is a positive thing?

In order to answer the above research question, we performed independence sample t-test.

18. Table of Independent sample t-test

		N	Mean	Std. Deviation	t	df	sig.
5. To what extent do you agree/disagree with the fact that the arrival of the new technological era of 5G, is a positive thing?	1st group (Knowledge)	30	3,40	1,33	2,476	58	0,016
	2nd group (No knowledge)	30	2,57	1,28			

From table 18, we see that the group with knowledge agree more than the group with no knowledge that the arrival of the new technological era of 5G, is a positive thing as the first group has a mean of 3,4 and the second group has a mean of 2,6. We have a statistical significance as sig.=0,016.

Is there a difference between the two groups as to whether they agree/disagree that they double check the theories they hear/read before accepting it?

In order to answer the above research question, we performed independence sample t-test.

Table.Group Statistics

		N	Mean	Std. Deviation	t	df	sig.
6.To what extent do you agree/disagree with the opinion that you double check the theories you hear/read before accepting it?	1st group (Knowledge)	30	3,23	1,45	2,175	54,806	0,034
	2nd group (No knowledge)	30	2,50	1,14			

From table 19, we see that the group with knowledge agree more than the group with no knowledge that they double check the theories they hear/read before accepting it them as the first group has a mean of 3,2 and the second group has a mean of 2,5. We have a statistical significance as sig.=0,034

CHAPTER 5

Discussion - Conclusion

According to what mentioned above, in this dissertation, the technologies and topologies of mobile telephony networks in combination to the specific risks arising from the particular technology have been studied. The constant evolution of networks has resulted in the possibility of using the fifth generation, this gives all users worldwide the use of applications that generate large volumes of data traffic. To meet this need, as the number of mobile network users increases year by year, it becomes necessary to build smart devices that support and serve the requirements of users for the fifth-generation network.

As the largest volume of data for users on the go is generated by streaming video and social networking applications, existing networks will not be able to handle their smooth operation. The fifth-generation mobile network came to meet the expectations of users because we will have shorter latencies, high transmission rates, large bandwidth as the existing range for the fourth-generation network is limited.

The 5G network construction processes started in 2012, after an important study of the structure and architecture of the standards, as well as the development of existing technologies (LTE) was completed this year. This presupposes the constant evolution of even new technologies for flexibility capabilities according to user requirements. Appropriate architectures and technologies have been selected to meet the goals of fifth generation mobile networks. The severe shortage of spectrum has prompted research into the fifth-generation network in the architecture of intense cell densification where in combination with technologies such as mmWave and Massive MIMO they bring great benefits to users and telecommunications providers.

This architecture model reduces the coverage area corresponding to each cell, increases the total number of network cells and increases the capacity as greater frequency reuse occurs and the size of the base stations decreases. So, less installation costs and reduced energy consumption. Some other important fifth generation network

architectures are central resource management and virtualization using NFV and SDN technologies. This architecture eliminates interference and each user receives the maximum possible data rate. NFV and SDN working in combination bring huge benefits to fifth-generation networks, where NFV offers ease of function conversion and upgrading, SDN through centralized controllers that process network traffic data and, as needed, direct traffic volume.

The combination of all these architectures and technologies would be ideal, but there are many obstacles and challenges as developed in the context of the dissertation. Research projects are currently underway to address obstacles to making fifth-generation mobile networks the ultimate user experience. All these general comments up to this point about 5G are not required here in discussion. Therefore and based on the above, it could be said that according to the research in the specific dissertation, it could be said that all the participants knew what 5G is, but half of them had no further knowledge about it, whereas the other half are more aware of the 5G technology.

The 80% of the participants said that Hyperconnectivity is one of the advantages of 5G, the 65% said that another advantage is the process optimization, the 53,3% mentioned the New possibilities for users to do things from afar, another same percent referred to the Great advances in many sectors of their lives, the 50% the Higher Download Speed/Low latency and the 15% said that there is no advantage of the 5G.

In advance, all the participants said that one of the disadvantages of 5G is the Immediate obsolescence of equipment/devices. The 73,3% referred to Risks in security that might come up, the 71,7% mentioned the technological exclusions of part of the users of the internet, the 55% mentioned the large amount of data which will be hard to handle, a 43,3% mentioned the insufficient infrastructure in Cyprus and a 40% of the participants referred to Health issues from radiation. There was a 23,3% of the participants believe that, according to their personal opinion, the 5G technology has no disadvantages.

Except from the above, there are also the research questions mentioning that the group of people with knowledge believe that the risk they are going to face from the new technological era of 5G is that their personal privacy will be more at stake, whereas

almost all the people from the group of people that have no knowledge don't think that their personal privacy will be more at stake. In advance, it was mentioned that the group of people with knowledge believe that the risk they are going to face from the new technological era of 5G is that there is Lack of a legislative framework, whereas almost all the people from the group of people that have no knowledge don't think that this risk will be a problem for them.

Moreover, it was found that the group of people with no knowledge believe that the risk they are going to face from the new technological era of 5G is that there will be Insufficient knowledge for most users of the internet, whereas most of the people from the group of people that have knowledge don't think that this risk will be a problem for them.

The 70% of the participants said that one of the risks they are going to face from the arrival of the new technology is the fear of the unknown, the 40% mentioned the Insufficient knowledge for most users of the internet, the 31,7% referred to the Lack of a legislative framework, the 25% said that Personal privacy will be more at stake and the 15% referred to health problems that may pop up. In advance, it was found that the group with knowledge agree more than the group with no knowledge that the arrival of the new technological era of 5G, is a positive thing as the first group has a mean of 3,4 and the second group has a mean of 2,6. We have a statistical significance.

Finally, it was found that the group with knowledge agree more than the group with no knowledge that they double check the theories they hear/read before accepting it them as the first group has a mean of 3,2 and the second group has a mean of 2,5. We have a statistical significance. Therefore, and concluding on the above, it should be said that serious concerns are expressed that the electromagnetic radiation used by all mobile technologies and especially 5G will eventually lead some people to increased health risks, including the development of certain types of cancer.

The radiation is divided into two major categories depending on whether or not it causes ionization in the individual or molecule of a biological organism. Non-ionizing, or also known as electromagnetic, radiation that carries relatively little energy,

which does not cause ionization, but is capable of causing electrical, chemical and thermal effects on the body.

These radiations include, among others, radio waves and microwaves emitted by communication antennas, radio and television antennas, microwave ovens. Harmful health effects due to non-ionizing radiation are those that occur during or immediately after exposure if some exposure thresholds are exceeded after large safety factors have been adopted. The main limitations in most of them are not directly measurable quantities in the broadcast environment, but induced quantities inside the body of people that are difficult to measure. For this reason and taking into account the most unfavorable conditions for the coupling of radiation with humans, "reference levels" are obtained which are easily measurable parameters of electromagnetic radiation and their observance ensures the observance of the basic limitation and consequently the absence of harmful effects for health.

Summary

According to what mentioned above about the topic examined, it should be said that at the root of all concerns about mobile networks and especially the 5G, is radio frequency (RFR) radiation. The RFR is anything emitted in the electromagnetic spectrum, from microwaves to X-rays to radio waves to light from your screen or light from the sun. Clearly, RFR is not inherently dangerous, so the problem is finding out under what conditions it may be.

The scientists say that the most important criterion for whether a particular RFR is dangerous is whether it falls into the category of ionizing or non-ionizing radiation. Simply put, any non-ionizing radiation is too weak to break the chemical bonds. This includes ultraviolet, visible light, infrared radiation and all with lower frequency, such as radio waves. Everyday technologies such as power cables, FM radio and Wi-Fi also fall into this range. (Microwaves are the only exception: they do not ionize but can damage tissue, they are precisely and deliberately tuned to resonate with water molecules.) Frequencies above ultraviolet radiation, such as X-rays and gamma rays, are ionized.

Some scientists although, they understand that people are generally concerned about radiation. The use of the term radiation is misleading because people think of nuclear weapons - they think of ionizing radiation that can do absolutely harm. It can kill cells. It can cause DNA mutations. But because non-ionizing radiation does not cause DNA damage or tissue damage, Novella says most of the concern about the RFR cell phone is wrong. There is no known mechanism for most forms of non-ionizing radiation to have a biological effect.

Of course, just because there is no known mechanism for non-ionizing radiation to have a biological effect does not mean that it is safe or that there is no effect. Indeed, researchers continue to conduct studies. A recent study was released by the National Toxicology Program (NTP), an office run by the Ministry of Health and Human Services. In this widely reported study on cell phone radio frequency radiation, scientists found that high exposure to 3G RFR led to some cases of cancerous tumors, brain tumors and adrenal tumors in male rats.

Study is a good subject lesson on how difficult it is to do science like this. As RealClearScience points out, the number of tumors detected was so small that they could statistically have happened by chance (which may be more likely since they were detected in men only). the real human who would never have been exposed, and in fact, the irradiated test rats lived longer than the control rats that had not been exposed.

A common complaint about 5G is that due to the lower power of 5G transmitters, there will be more of them. The Environmental Health Trust claims that *"5G will require the development of literally hundreds of thousands of new wireless antennas in neighborhoods, cities and towns. A small cellular cell or other transmitter will be placed every two to ten houses according to estimates"*.

It is easy to find claims on the internet that the higher frequency of 5G alone is a risk. RadiationHealthRisks.com notes that 1G, 2G, 3G and 4G use between 1 and 5 gigahertz frequencies. 5G uses a frequency between 24 and 90 gigahertz and

then claims that Inside the RF radiation section of the electromagnetic spectrum, the higher the frequency, the more dangerous it is for living organisms. But to claim that higher frequency is more dangerous is just that - a claim, and there is little real science to support it. 5G remains non-ionizing in nature.

The FCC, however, is responsible for licensing the spectrum for public use - also weighs. However, for the 5G equipment, signals from commercial wireless transmitters are usually well below radio frequency exposure in any location accessible to the public. The FCC is resisting the FDA for real health risk assessments, which is taking an immediate but low-risk approach. The weight of scientific evidence has not linked cell phones to health problems.

In 2011, the World Health Organization stopped classifying RF radiation as an agent of Group 2B, which is defined as potentially carcinogenic to humans. This also has nuances. Part of the problem with the WHO statement is that it focuses on risk, not risk - a subtle distinction often lost to non-scientists, as opposed to the strict distinction between "accuracy" and "precision". When WHO classifies coffee or nickel or pickles as a potential carcinogen, supports risk without taking into account the actual risk.

Scientists will continue to test new networks as technology evolves to make sure the technology, people use every day remains safe. Just in February, U.S. Senator Richard Blumenthal criticized the FCC and the FDA for insufficient research into the potential risks of 5G. As the NTP study shows, research into radiation hazards is difficult and often vague, which means it can take a long time to make real progress. But for now, everything we know about 5G networks tells us that there is no reason to worry. After all, there are many technologies that we use every day with a significantly higher measurable risk. With 5G the risk is low - but not zero and the real risk seems to be zero. We have not received any signal in the real world.

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