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The viability of Telesurgery Service in the Autonomous Region of the Azores, supported by the 5G Network

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Abstract

5G network technology is considered one of the driving forces behind various societal changes. Among multiple uses, it offers Telesurgery. In situations where the patient needs specialized surgery, but there are no conditions to be transported to where the surgical intervention can be performed, Telesurgery allows access to the procedure with all the security that 5G network technology offers.

The Autonomous Region of the Azores (ARA), despite the thousands of kilometres that separate it from the European continent, is considered an outermost region which is an integral part of the EU. Therefore, the EU law applies to these regions with all rights and duties associated.

The Support Service to the Displaced Patient (SADD) accompanies annually and under normal conditions an average of more than 1500 patients from the Azores. They travel to the mainland for health reasons. This scenario is also applied between islands, where an average of 550 patients have moved from the islands without a hospital to the islands with a hospital annually. As a result, health costs raise in this Region.

In this paper it will be used the survey methodology, since it is the most appropriate method when you want to obtain answers/data that express opinions, customs or characteristics of a certain target audience. Therefore, a mixed mode will be used, namely interviews and questionnaires, having as scientific target areas medicine and engineering, in the specialties of gastroenterology and telecommunications, to support the research questions.

This paper aims to present research on the viability of Telesurgery in the Autonomous Region of the Azores, supported by the 5G network, as an alternative for travelling patients.

Keywords: Technology 5G Networks, Autonomous Region of the Azores, Telesurgery.

1. Introduction:

In the modern society in which we live today, the right to health is a complex theme, as it involves the total physical and mental well-being of everyone. Human beings must see their right to food, shelter, protection, safety, and treatment where justified.

Given that the right to care and treatment directly integrates health policies, which some states of law are obliged to provide, the user has the right to choose health care services and providers, to the extent of the existing resources and the rules of organization of health services. In this sense, there is a constant need to provide and innovate new ways of guaranteeing this right to all citizens [25].

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The present work aims to know the "state of the art" and perspectives of the implementation of Telesurgery in the Autonomous Region of the Azores (ARA), aiming at its structured operationalization and thus promoting a true cohesion policy in the health area.

To know the realities of the institutions involved and comply with the main objective, specific objectives will be defined to identify the difficulties and needs and their receptivity to Telesurgery.

Achieving less than 1m latency in peer-to-peer communication required for certain 5G services, as this study intends to demonstrate, is a situation that is imposing serious technical challenges in the implementation of the next-generation networks. Current 4G cellular networks have a round-trip latency of about 80ms. Despite this high latency, scientific articles demonstrate the existence of some experiences performed in Telesurgery [20].

Telesurgery, also called remote surgery, is performed by a surgeon at a remote site far from the patient. Surgical tasks are directly performed by a robotic system controlled by the surgeon at the remote site. The word "telesurgery" derives from the Greek word *tele*, meaning "far off," and *cheirourgia*, meaning "working by hand." Telesurgery is surgery, actual cutting and suturing, performed by a surgeon at a remote console far from the patient. Advanced communication technology allows the surgeon to manipulate endoscopic cameras and surgical robots to perform the surgery while being distant from the operating room. The remote surgeon and the surgical team with the patient have the same view of the surgical site [28].

Telecommunications are increasingly a way of reaching users who need medical assistance that, for several reasons, cannot be done in person. Given this reality, teleconsultation and telemonitoring have been a solution for some time, using 4G networks - 4th Generation Mobile [26]. Even with these networks' limitations, they have had acceptable results. However, for more delicate situations, this solution is not ideal for some treatments since there is a need for waiting times to be much lower than 1 millisecond (ms), and it is also necessary that there are simultaneously several connections without congestion, often using high-definition streaming tools [27].

It is imperative to change the nature of the telecommunications network system, namely increased speed, better technology, change in frequency range and increased data capacity, all with the lowest possible latency. Each generation of telecommunications has some standards with different capabilities, new techniques and new characteristics that differentiate them from the previous one [21]. This will benefit, in many factors, regions where geographical characteristics require their residents to live in small and scattered agglomerates.

According to the official website of the European Commission, outermost regions face several specific constraints, such as geographical remoteness, insularity, small size, difficult topography and climate and economic dependence on a small number of products. The combination of these factors over time seriously undermines the socio-economic development of the regions. The recognition of its special status in Article 349 of the Treaty on the Functioning of the European Union is based on the principles of equality and proportionality, which allow certain regions to benefit from different treatment in such a way that their specific circumstances are considered [1].

Nine regions of the European Union are classified as 'outermost' [1], where the Autonomous Region of the Azores (ARA) is included.

The technology that allows telepresence facilitates the performance of complex surgical procedures in regions lacking specialized surgeons, such as in small hospitals, developing countries and military personnel in combat. At the same time, robotics provides invaluable assistance by allowing procedures to be performed less invasively, thereby reducing complications and delivery times. One aspect that will advance Telesurgery further is getting an Internet connection fast enough to allow real-time telepresence [12].

5G technology -5th Generation Mobile - will enable remote assistance with real-time surgical procedures. Incorporating this technology will allow us to overcome barriers and reduce the current latency period from 0.80 seconds to 0.01 seconds, a crucial reduction of time in any surgical procedure. The 5G network will also provide increased image quality and definition, a key factor for medical teams to make decisions with as much information as possible [13]. Therefore, the 5G communication service, which will be made available by the existing communications operators, may be of great importance to break a barrier that has been solved by making patients travel abroad, to the Portuguese mainland or even just inter-islands. These trips alone are expensive and often cumbersome for patients, increasing healthcare costs.

The categories of immersive, intelligent, ubiquitous, autonomous, public 5G technology services and detailed service scenarios alone demonstrate their potential in healthcare and the case of Telesurgery. Depending on the use case, 4G's technical limitations, which can be 5G's technical challenges, offer innovative technologies and new network architecture. The proposed requirements for wireless and core networks can be used as a guideline in the standardization, implementation and deployment of 5G networks [2].

In remote regions with low population density, such as the ARA, air transport networks play a crucial role in the mobility of people and goods. However, they can hardly be viable without the support of public subsidies. Consequently, this role has much more relevance in the Health Area, and these costs are high and impact the Region's economy [19].

The importance of Telesurgery services is evident due to three factors related to economic issues and the provision of services. The first factor is the economic one since health services are generally synonymous with a

high financial burden; the second is the availability of specialized services only at the international level, which lead patients to travel outside the country, with all that this represents for the user. The third factor is the lack of specialized services to remote areas of a given country, which implies the internal movement of users with consequences in internal health policies. It is important to recognize how we can meet these accessibility demands by introducing a basic or sketch structure to identify and provide possible solutions [4]. With recent advances in 5G network technology, many researchers are testing newer and older system capabilities based on this technology. Overall, initial results demonstrated the potential of this technology which can be an effective strategy to reduce transmission latency [5].

1.1 From Telemedicine to Telesurgery

A rigorous process evaluation plays an essential role in the progress of any medical field, as well as in Telemedicine. Conducting evaluations and disseminating results can be especially important in Telemedicine because of the lack of empirical evidence for its use. These evaluations can help generate reliable data to develop national telemedicine policies and strategies to optimize the implementation of Telemedicine and inform about the potential for improvement and transfer of Telemedicine projects [15].

Thus, with constant updates in society, Telemedicine becomes important because advances in medicine are already a certainty for the coming years with the benefits of technology. "Telemedicine has the potential to improve the quality of care by allowing physicians in a "control centre" to monitor, attend and perform some procedures on patients who are in different places" [16]. For situations where only medical consultation procedures or patient monitoring are performed, the current 4G networks, being in a good coverage area, can respond well. The scenario is more demanding if it is necessary to perform a Telesurgery.

Telesurgery, also called *teleoperation* by some researchers, is a procedure that, due to its nature and complexity, involves human-machine interaction in multiple tasks performed and which field of application has increased in recent decades. The popularity of these systems is based on minimizing operators' risk exposure. These systems have been successful because they have fulfilled their tasks in inhospitable environments such as space, nuclear power plants and battlefields [17]. Therefore, Telesurgery is a direct application of *teleoperation* in medicine, providing unimaginable possibilities.

Telesurgery is a procedure in which a specialized doctor performs a surgery on a patient with the help of robotic equipment, with the particularity that both, the surgeon and the patient, are in different locations.

Telesurgery systems are given by two main elements, shown in Figure 1: (a) Robotic surgery equipment, which in technical terms acts as a slave, installed in a highly specialized operating room, where the patient is located, accompanied by a local team of health professionals who intervene as requested by the specialist, and (b) a control console master operated by a specialized surgeon and some supporting elements that may be located hundreds or thousands of kilometres away from the operating centre. In the operating room (a) all operations are monitored by specialists at a distance, by high-definition video, not only regarding the surgical procedure but also the entire surrounding environment [18] [13].

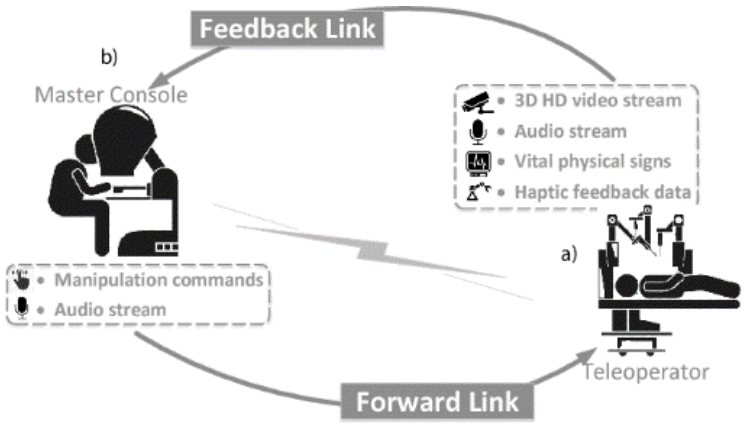

Figure 1 - Scheme of the constituent elements of Telesurgery [30]

In Figure 1, in the centre, we see a beam symbolizing a "High-Speed Network". Communication between the main elements should be fast and stable due to the nature of the procedures, in which there is no place for errors or disturbances that may put a patient's life at risk. This is one of the biggest obstacles to Telesurgery. It is crucial to

reduce the adverse effects related to latency delay, stability, and bandwidth of the network interconnection, to ensure the safety and reliability of long-distance surgical procedures [18].

As already mentioned in this article, the 4G networks do not allow us to have this stability, but the promising 5G network already meets all the requirements for its implementation.

Robots are on a high-growth trajectory within the industrial and consumer sectors. The 5G will provide networking functions necessary to allow various industries to leverage the next phase of robot evolution. Moreover, the information flow between assemblies and control systems with robots is another example of the 5G services. The 5G will pave the way for a new generation of robots. Some robots that can freely move are controlled via wireless rather than wired communication links and exploit the cloud's vast computing and data storage resources [2].

This document is structured in four sections: introduction, state of the art, methodology and conclusions. In the second section that follows the introduction, the theoretical framework describes 4G vs 5G technologies, namely their origin, historical evolution, concepts and definitions, identification of its benefits, barriers and critical success factors associated with their implementation in the ARA. The third section refers to the research questions and the methodology used to achieve the defined objectives. Furthermore, it describes the materials and methods used to comply with this intent. The fourth and final section presents the conclusions and final considerations.

2. Why can 5G provide the technology for Telesurgery and 4G cannot?

The 4G networks already provide many alternatives in the health field but are still far from the ideal wanted for Telesurgery. Over the past few years, mobile networks have developed almost exponentially.

Successive generations of communications networks have been deployed to provide "mobile broadband". At its core, the 4G network, according to the advanced specifications of international mobile telecommunications, requires data transmission at a peak rate of at least 100 megabits per second for high mobility and 1-gigabit communications per second for low mobility communications. However, even if the 4G is named the successor to previous generations, the future is not limited to existing systems. The 4G should not be seen exclusively as a linear extension of its predecessor. Access to the 4G network requires a substantial increase in the number of transmitters and receivers on the device. The applications of the 4G are many and diverse, including multimode software and video encoding. Internet streaming relies heavily on file transfer to provide end-to-end video. However, the decoding delays associated with these codes can be very "expensive" regarding video quality. In addition, source-based solutions can overload a network along the packet route when only borders require increased reliability [11] [12].

To improve the 4G network service, the 4G Advance was created, also called LTE (Long Term Evolution) Advance, which provides the speeds needed to accommodate the quality of service (QoS) and the tariff requirements established by the development of existing applications such as mobile broadband access, the Multimedia Messaging Service (MMS), video chat, mobile television, and also new services as high-definition television (HDTV).

The 4G technology features adaptive links with bug-correcting codes for fewer bugs. The 4G offers a globally enhanced mobile experience [11].

In this context, the goal of the 4th generation systems is to provide users with continuous services over time. Thus, mobile users can access and share information regardless of their position or time and use equipment with different capacities. The 4G provides high data rates on the go and offers users mobility, establishing interoperability between different networks.

Its goal is the transition between transparent networks and to avoid interruption of services during delivery. Therefore, the feature of this technology is to stop using circuit switching mode (establishing a circuit to transmit a "voice" call), which means that phone calls may use Voice Over Internet Protocol (VoIP) [11][12].

However, the latency presented in the streaming service is not yet expected for this work. The 4G achieves latencies in the order of 80ms. According to studies already conducted for Telesurgery, the latency value must be as low as possible [13]. Thus, the recent 5G will provide the long-awaited low latency that will allow, among other advantages, the performance of Telesurgery.

The main differences between the 4G and the 5G are data transfer speed, which will be much higher, and latency much lower. This means that data transfers can be made almost immediately. The 5G technology promises to have a latency between 1 and 2 milliseconds, maximum of 4 milliseconds. Currently, with the 4G technology, the maximum download speed is about 150 Mbps, and the 5G network is 10000 Mbps [11].

The 5G networks are known to be ultra-reliable low latency communications. (URLLC). Moreover, it can be considered a new service category supported by New Radio (NR). It is aimed at emerging applications where data messages are time-sensitive and must be delivered in end-to-end security, subject to high reliability and rigorous latency. The strict latency requirement means data transmission cannot be decoded on the receiver before the deadline. If this is not the case, it is of no use and can be abandoned by the system, resulting in a loss of reliability. This means that URLLC's quality of service (QoS) is broken if more than one of the 10^5 packets is not delivered in a millisecond over the wireless network system, i.e. 99.999% reliability is required. In contrast to the QoS of mobile broadband applications, this technology optimizes data production and average delay.

Cases of URLLC use will focus on autonomous vehicles performing cooperation and safety functions, monitoring and control in smart grids, tactile feedback on remote medical procedures, control and coordination of crewless aviation vehicles, robotics and industrial automation [14]. These reasons make the **5G network technology ideal for Telesurgery**. In this sense, table 1 is presented, which contains the main differences in general traits between the two generations of communications.

Table 1- Main differences between 4G and 5G [11][12][14]

Feature	4G	5G
Speed (data transfer)	150 Mbps	10000 Mbps
Latency	80 milliseconds	1 - 4 milliseconds
Connected Devices	10,000 devices per km	More than 1,000,000 devices per km
Long Band	Reduced	Wide
Energy Consumption	Higher energy consumption	Saves energy by almost 90%

2.1 5G Network Technology supports the viability of Telesurgery.

Virtual Reality and Augmented Reality are the actual contents of future communications.[2] Operator Nos & Johnson MedTech have implemented a remote support solution for healthcare professionals at *Dr Nélio Mendonça* Hospital in *Funchal, Madeira* island, that is already fully covered with the 5G network. The remote assistance solution establishes a 4K high-definition video connection between two healthcare professionals connected remotely using smart glasses. The system was put into practice with a remote specialist in Lisbon, who followed and supported physicians in the hemodynamic laboratory of the hospital during the ablation of supraventricular tachycardia [31].

The 5G enhances great technological advances, allowing a better future for all Portuguese. The combination of these technologies potentiates the continued training of health professionals and the differentiated treatment of patients [32]. Thus, VR and 3D holograms can be used to make this a reality.

Future 5G services will have to handle 4-K or 8-K resolutions to solve the image quality problem. The current VR technology provides a 110-degree viewing angle and needs to be extended to 200 degrees to meet the minimum level of user satisfaction. The user's equipment or HMD is limited in resources, such as memory, storage capacity, heat management and battery. This is a major obstacle in providing highdefinition video and 3D graphics in mobile environments. Cloud processing is one solution to this problem, and the 5G networks offer high supporting bandwidth with low latency. Real-time AR/VR services cannot be achieved without a higher transmission rate and low latency. In terms of a core network, network slicing can be one of the key technologies to achieve low latency, high throughput VR/AR services with other wireless technologies [33].

On the Portuguese mainland, there has already been performed successful test. According to *Champalimaud* Foundation, *Altice Portugal* and the operator *Movistar* were the participants of this event that placed 5G technology at health service. The distance of 900 km between Lisbon and Zaragoza was shortened by the valences of *Altice Portugal's* 5th mobile generation. **Higher speed, lower latency, intelligence and reliability** were key factors for the reputed surgeon Dr Pedro Gouveia of the Breast Unit of the *Champalimaud* Clinical Center, be in direct contact, through permanent and real-time audio-visual, with the Spanish surgeon Dr Rogelio Andrés-Lun, of the same unit, in *Zaragoza*. The surgery was followed by the Congress of the Spanish Association of Breast Surgeons (AECIMA) stage. Dr Pedro Gouveia (2022, P.2) says, "We have carried out the first experience in real time of what is called 'remote proctoring' during breast cancer surgery." [24].

The ARA has geographic conditions that justify the choice of Telesurgery as an instrument to promote interaction between users and providers, isolated by geography and conditioned by climatic conditions. In table 2, we have a distribution of the population by island. Only 3 islands have hospitals (*São Miguel, Terceira* and *Faial). A*lthough it is a small population if we consider the annual displacements, we have around 550 people that circulate inter-island, exceeding the population of the farthest island (*Corvo*). Nevertheless, we still have patients who travel to the Portuguese mainland, near 1500 a year [35].

Table 2- Distribution of the ARA population by the island [35].

Island	Population	Percentage
Santa Maria	5 614	2,30%
São Miguel	137 220	56,60%
Terceira	54 998	22,70%
Graciosa	4 193	1,70%
São Jorge	8 252	3,40%
Pico	13 643	5,60%

Faial	14 482	6,00%
Flores	3 628	1,50%
Corvo	467	0,20%
Total	**242 497**	**100%**

According to the Portuguese Communications Entity (ANACOM), the coverage of 5G networks is a goal to be achieved even for regions of low population density, with the coverage obligation of 75% (by the end of 2023) and 90% (by the end of 2025) of the population of each of the parishes considered low density and each of the parishes of the Autonomous Regions of Madeira and the Azores.

On the other hand, it is 70% (by the end of 2024) and 90% (by the end of 2025) the obligation to cover the population of each of the parishes that are not considered low density, but which integrate municipalities with low-density parishes [7].

This coverage creates the fundamental condition in terms of communications so that Telesurgery is a reality in the ARA.

Telesurgery has not been tested, and little information exists on its intention either by government entities or telecommunications operators in the ARA.

3. Methodology

The research project will have as its purpose the study of the viability of the Telesurgery service in the ARA supported by the 5G networks and seeks to answer the following research questions:

- *Which factors contribute to the success of Telesurgery using the services and solutions of the 5G networks?*
- *What are the effective characteristics of ARA that justify Telesurgery using the 5G networks?*

In this article, health specialists and telecommunications engineers, who are implementing the 5G network in the ARA, will be approached on the key feature and state of the art that this cutting-edge technology offers to identify the challenges inherent to health care appropriately Telesurgery. An inquiry will be carried out on the latest developments applied to health care, oriented toward the use of 5th generation communications, focusing on Telesurgery. For this, we will use the qualitative and quantitative methods with the objective of the survey research being exploratory.

Two interviews will be conducted, one with a surgeon of the gastroenterology speciality, since it is an area where they are very familiar with robotics, and the other with an expert engineer responsible for implementing the 5G network in ARA. These interviews will be of a direct method, with open questions and aim to provide qualitative and quantitative answers regarding the viability of Telesurgery supported by the 5G networks.

Afterwards, telecommunications engineers and technicians, health professionals and surgery assistants will answer a closed questions questionnaire which aim is to obtain quantitative results on the knowledge of the study in question and to show the willingness to use this solution, in order to justify and demonstrate its viability in the ARA, and consequently presenting an alternative to the displacement of patients and doctors from this Region marked by the characteristics of insularity.

The global survey method, which will be carried out to obtain, describe or explain people's knowledge, is intended to understand a particular aspect of a population [22]. The survey can be described as obtaining data or information about a particular group of characteristics, actions or opinions of people, indicated as a representative of a target population, through a research instrument, usually a questionnaire [23].

The following figure, figure 2, represents the 6 phases that will be performed as a survey instrument for the construction of the study. From the planning phase to the conclusion/report phase there are several steps which must be followed, namely the constitution of the sample, collecting data, data organisation and data analysis.

The planning phase is a critical one. Without it, this study could run the risk of creating an over-inflated and rudderless survey, resulting in poor levels of engagement and findings from which no useful conclusions could be drawn.

The sample size is also very important since in most cases it is not possible to survey the entire target population of interest due to the sheer volume of people in it. At this stage, a list of twenty technical and scientific questions will be presented to the two interviewees, always focusing on the research questions. Then, based on the results of the interview, a closed-response questionnaire will be elaborated for the remaining group, already mentioned in this study.

The data collection surveys collect information from a specific group of people regarding their opinions, behavior or knowledge. In this sense, all data collection will be done according to the results obtained in the interview and the questionnaire.

Regarding the phase of organizing the data and performing the analysis, attention should be paid to how the whole procedure was conducted, in the present study, since the mixed method of interview and questionnaire is being used. In this way, and for a better analysis, the software "NVivo" will be used as a tool to organize and analyse the data.

Finally, when presenting the report, it should be taken into consideration that the result, only in numbers, may seem imperceptible, abstract and difficult to grasp for some people. Therefore, the data will be presented through visual means, such as graphs and pictures to describe the results.

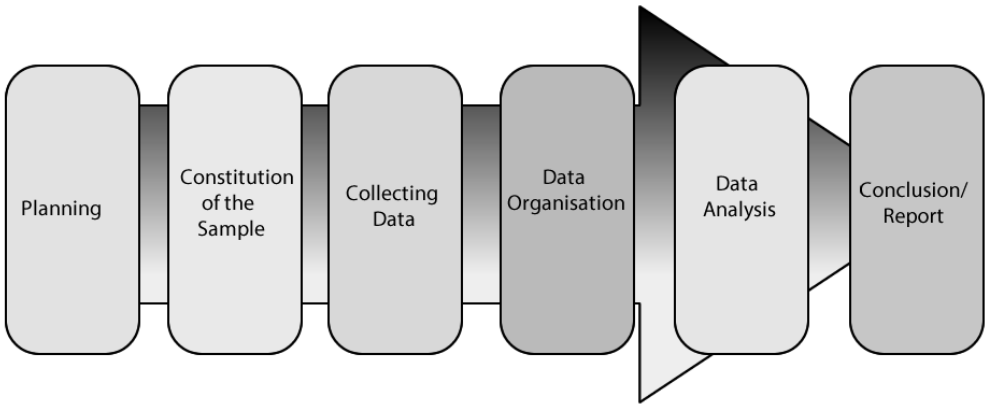

Figure 2 - Schematics of a study by survey [29].

To sum up, the first step in conducting a survey is identifying a research question. Only after that should the researcher be concerned with preparing the questionnaire. The better the research question, the less difficult the instrument construction will be. In addition, the researcher should make clear the purpose of the survey research: exploratory, descriptive or explanatory [29][34].

After that, the next step is to create the questionnaire. The preparation of the instrument is complex work and requires specific training. Even experienced researchers face problems in their construction. Given the breadth of the theme, it is impossible to present all the peculiarities that involve elaborating a questionnaire. However, it is possible to present some more general recommendations [34].

The instrument must be pre-tested. The pre-test aims to improve the instrument and ensure that it measures what it proposes. In the analysis, one should observe if all questions were answered correctly and if the answers do not indicate difficulty understanding the question and how to fill out the questionnaire.[29][16]

Moreover, the clarity and accuracy of the terms, the number of questions, the question form, the order of questions and the introduction should be considered in the pre-test [16].

After collecting the data, the next step is to organize it. At this point, the data is divided according to its category for further analysis. This phase is of great importance because this statistic will reveal the relevance of this study. Finally will be presented the report that aims to answer the research questions [29].

4. Conclusions and final considerations

Currently, several issues related to health costs are discussed in the plenary of the Azores Regional Assembly of the Autonomous Region, usually associated with the displacement of patients in the most diverse circumstances, including certain surgeries [3]. The various political forces that compose the Regional Assembly do not associate technology with the answers. They present many problems and solutions considered archaic without any sense of existence. In certain debates, they refer to the discussion only to defend certain lobbies, which often have much higher costs than if they made a correct study of the various technological hypotheses at their disposal.

The 5G networks are already being implemented by operators providing telecommunications services in ARA. In the medium and long term, this solution can justify an investment in health, specifically in Telesurgery, avoiding the costs associated with patient travel.

With the results obtained, through the methodology applied in this work and its statistical analysis, it will be possible to demonstrate the feasibility of the implementation of Telesurgery in the ARA supported by the 5G networks. The investment in this field will be rewarded in terms of costs and the quality of the treatments given to patients.

In the ARA, there are only four hospitals for nine islands. Three are public and one private, two of which are on the same island [6] [9]. It is necessary to invest in the six islands without a hospital so that their health centres are

equipped with Telesurgery equipment. Low-risk surgeries, such as appendix extractions or something similar, may be performed early.

In addition to the benefits for the patient, Telesurgery ensures the surgeon's safety and technical accuracy. Specialists and caregivers from different locations can also work together in the communication network to succeed in surgical procedures. They need to examine the patient data stored on the centralized cloud server for a correct diagnosis and surgical procedure to perform [8].

The factors assumed to have the greatest impact on the successful implementation of Telesurgery will be the change in mentalities and the availability of resources. The second aims to bridge the identified main barrier by implementing 5G network technology [10].

The interest is notorious, and expectations are growing. Until now, some academic documents in which studies on Telemedicine applied to the Regional Health Service of the Azores are demonstrated, with nothing specifically about Telesurgery.

In this context, it is considered relevant to study the use and applicability of Telesurgery in ARA, supported by the 5G Network.

There is a lack of specialities in islands with a hospital, which only exist on the Portuguese mainland. The technological evolution in medicine, such as Telemedicine and Telesurgery, will provide the population, especially the most isolated, with greater access to specialized health care since it is cross-border and overcomes geographical barriers. The dispersed state of the Azorean islands is more than enough to promote Telesurgery using the technology offered by 5G networks. The feasibility of this resource is notorious, not only in the islands without a hospital but also in the remaining islands where specialities are lacking.

This paper aims to demonstrate that the population is receptive to Telesurgery, and the specialists support the viability of its implementation in this Region. Even if the implementation of Telesurgery in the ARA may initially represent a high cost, its advantages will probably compensate for it.

In future research, one can analyse patient displacement costs and provide all the technological infrastructures to establish Telesurgery in ARA. The consequences of losing connection during a Telesurgery procedure must be considered. For this reason, a backup plan must exist.

References

[1] European Commission https://ec.europa.eu/regional_policy/pt/policy/what/glossary/o/outermost-regions Access at: **27/03/2022**.

[2] Heejung Yu, Howon Lee & Hongbeom Jeon, (**2017**). What is 5G? Emerging 5G mobile services and network requirements. Sustainability (Switzerland), 9(10), 1–22. https://doi.org/10.3390/su9101848

[3] Decreto Legislativo Regional 28/99/A, **de 31 de Julho 1999** https://dre.tretas.org/dre/104604/decreto-legislativo-regional-28-99-A-de-31-de-julho Access at: 27/03/2022

[4] Sadia Anwar & Ramjee Prasad, (**2018**). Framework for Future Telemedicine Planning and Infrastructure using 5G Technology. Wireless Personal Communications, 100(1), 193–208. https://doi.org/10.1007/s11277-018-5622-8

[5] Wei Tian, Mingxing Fan, Cheng Zeng, Yajun Liu, Da He & Qi Zhang, (**2020).** "Telerobotic spinal surgery based on 5G network: The first 12 cases," Neurospine, doi: 10.14245/ns.1938454.227.

[6] Jorge Simões, *Retrato Político da Saúde. Dependência do Percurso e Inovação em Saúde. Da Ideologia ao Desempenho***, Coimbra, Edições Almedina, 2009, 2.ª Reimpressão da Edição de Setembro/2004**, ISBN: 9789724023427, 346p.

[7] ANACOM: https://anacom.pt/render.jsp?contentId=1567662 Access at 27/03/2022

[8] Rajesh Gupta; Sudeep Tanwar; Sudhanshu Tyagi; Neeraj Kumar; Mohammad S. Obaidat & Balqies Sadoun, (**2019**). HaBiTs : Blockchain-based Telesurgery Framework. 2019 International Conference on Computer, Information and Telecommunication Systems (CITS), 1–5. doi: 10.1109/CITS.2019.8862127

[9] Cátia Sá Guerreiro, Zulmira Hartz, Luís Sambo, Cláudia Conceição, Gilles Dussault, Giuliano Russo, Miguel Viveiros, Henrique Silveira, Pedro Pita Barros & Paulo Ferrinho, (**2017**). Política de investigação científica para a saúde em Portugal: II-factos e sugestões. Acta Medica Portuguesa, 30(3), 233–242. https://doi.org/10.20344/amp.8012

[10] Vanessa Saliba, Helena Legido-Quigley, Riina Hallik, Ain Aaviksoo, Josip Car & Martin McKee,(**2012)**. Telemedicine across borders: A Systematic review of factors that hinder or support implementation. International Journal of Medical Informatics; 81:793-809. https://doi.org/10.1016/j.ijmedinf.2012.08.003

[11] Emna Hajlaoui; Aida Zaier; Abdelhakim Khlifi; Jihed Ghodhbane; Mouna Ben Hamed; Lassâad SbitaEmna Hajlaoui; Aida Zaier; Abdelhakim Khlifi; Jihed Ghodhbane; Mouna Ben Hamed & Lassâad Sbita, (**2020**). 4G and 5G technologies: A Comparative Study. 2020 International Conference on Advanced Technologies for Signal and Image Processing, ATSIP 2020, 1–6. https://doi.org/10.1109/ATSIP49331.2020.9231605

[12] Banhijit Bhattacharyya & Somdutta Bhattacharya, (**2013**). Emerging Fields in 4G Technology, its Applications & Beyond-An Overview. 3(4), 251–260. https://www.ripublication.com/irph/ijict_spl/05_ijictv3n4spl.pdf

[13] Alperen Acemoglu, Jan Krieglstein, Darwin G. Caldwell, Francesco Mora, Luca Guastini, Matteo Trimarchi, Alessandro Vinciguerra, Andrea Luigi Camillo Carobbio, Juljana Hysenbelli, Marco Delsanto, Ottavia Barboni, Sabrina Baggioni, Giorgio Peretti & Leonardo S. Mattos, (**2020**). "5G Robotic Telesurgery: Remote Transoral Laser Microsurgeries on a Cadaver." IEEE Transactions on Medical Robotics and Bionics. doi: 10.1109/TMRB.2020.3033007

[14] Chih-Ping Li, Jing Jiang, Wanshi Chen, Tingfang Ji & John Smee, (**2017**). 5G Ultra-Reliable and Low-Latency Systems Design. 14–18. doi: 10.1109/EuCNC.2017.7980747

[15] Milton Steinman, Renata Albaladejo Morbeck, Philippe Vieira Pires, Carlos Alberto Cordeiro Abreu Filho, Ana Helena Vicente Andrade, Jose Claudio Cyrineu Terra, José Carlos Teixeira Junior & Alberto Hideki Kanamura, (**2015**). Impacto da telemedicina na cultura hospitalar e suas consequências na qualidade e segurança do cuidado. Scielo,. https://doi.org/10.1590/S1679-45082015GS2893

[16] António Carlos Gil, *Como Elaborar Projetos de Pesquisa*, **4ºed. São Paulo, Atlas, 2002, 7º tiragem**, ISBN 85-224-3169-8, 175p.
[17] Jianhong Cui, Sabri Tosunoglu, Rodney Roberts, Carl Moore & Daniel W. Repperger, (**2003**). "A review of teleoperation system control". Florida Conference on Recent Advances in Robotics, FCRAR, Boca Raton, Florida, **May 8-9, 2003**. Corpus ID: 9006501
[18] Emmanuel Mendoza Navarro, Adrielly Nahomee Ramos Álvarez & Francisca IreneSoler Anguiano, (**2022**). A new telesurgery generation supported by 5G technology: benefits and future trends. Procedia Computer Science, 200, 31–38. https://doi.org/10.1016/j.procs.2022.01.202
[19] António P. Antunes, Miguel G. Santos, João P. Pita & António G. Menezes, (**2018**). Study on the evolution of the air transport network of the Azores. Transportation Research Part A: Policy and Practice, 118(January), 837–851. https://doi.org/10.1016/j.tra.2018.10.021
[20] Taimoor Hassan; Asad Hameed; Sajid Nisar; Nabeel Kamal & Osman Hasan, (**Published September. de 2016)** "Al-zahrawi: A telesurgical robotic system for minimal invasive surgery", **IEEE Systems Journal, vol. 10, pp. 1035–1045**, **doi:** 10.1109/jsyst.2014.2331146
[21] Lopa Jilpesh Vora, (**Published 31 October 2015**). Evolution of mobile generation technology: 1G to 5G and review of upcoming wireless technology 5G. **International Journal of Modern Trends in Engineering and Research**, 2(10), 281–290. Corpus ID: 31229954
[22] Claes Wohlin, Per Runeson, Martin Höst, Magnus C. Ohlsson, Björn Regnell & Anders Wesslén, (**2012**). *Experimentation in software engineering*. Springer Science & Business Media. ISBN: 978-3-642-29044-2
[23] Alain Pinsonneault & Kenneth Kraemer, (**1993**). Survey research in agement information systems: an assessement. **Journal of Management Information System**. https://doi.org/10.1080/07421222.1993.11518001 Pages 75-105, Published online: **15 Dec 2015**
[24] Pedro Gouveia, Rogelio Andrés-Lun. Altice Labs, (**2022**). *Altice Portugal e Fundação Champalimaud protagonizam cirurgia inédita com recurso ao 5G*. https://conteudos.telecom.pt/Documents/PT/media/comunicados/2022/maio/altice-portugal-e-fundacao-champalimaud-protagonizam-cirurgia-inedita-com-recurso-ao-5G.pdf Access at 15/05/2022
[25] Valéria Burity, Thaís Franceschini, Flavio Valente, Elisabetta Recine, Marília Leão & Maria de Fátima Carvalho, (**2010**). Direito Humano à Alimentação Adequada no Contexto da Segurança Alimentar e Nutricional, https://www.redsan-cplp.org/uploads/5/6/8/7/5687387/dhaa_no_contexto_da_san.pdf Acess at 23/07/2022
[26] Ye, Junna MDa; Zuo, Yanhai MDa; Xie, Ting MD, PhDb; Wu, Minjie MDb; Ni, Pengwen MDb; Kang, Yutian MDa; Yu, Xiaoping MDa; Sun, Xiaofang MDb; Huang, Yao MDa; Lu, Shuliang MD, PhDa, (**Published August 2016**). A telemedicine wound care model using 4G with smart phones or smart glasses, Medicine: - Volume 95 - Issue 31 - p e4198 doi: 10.1097/MD.0000000000004198
[27] Lalita Mishra, Vikash & Shirshu Varma, (**2021**). Seamless Health Monitoring Using 5G NR for Internet of Medical Things . Wireless Pers Commun 120, 2259–2289. https://doi.org/10.1007/s11277-021-08730-7
[28] Kumar, (**2008**). Introduction to Telesurgery. In: Kumar, S., Marescaux, J. (eds) Telesurgery. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-72999-0_1
[29] Clara Pereira Coutinho. *Metodologia de Investigação em Ciências Sociais e Humanas: Teoria e Prática*. **Coimbra: Almedina** , **2018**, ISBN: 9789724051376, 412p
[30] Qi Zhang, Jianhui Liu, Guodong Zhao, (**2018**). Towards 5G Enabled Tactile Robotic Telesurgery. ArXiv, abs/1803.03586. https://doi.org/10.48550/arXiv.1803.03586
[31] Carolina Rodrigues, Jornal de Noticias,(**Published 20 Junho 2022),** "Hospital Dr. NélioMendonça coberto com o 5G da Nos para cirurgias remotas", https://www.dnoticias.pt/2022/6/20/316341-hospital-dr-nelio-mendonca-coberto-com-o-5g-da-nos-para-cirurgias-remotas/ Access at 26/07/2022
[32] Manuel Ramalho Eane, Ana Ayres, Nos & Johnson & Johnson MedTech "Cirurgias remotas em 5G chegam ao Hospital do Funchal" **20 Junho 2022** https://eco.sapo.pt/2022/06/20/cirurgias-remotas-em-5g-chegam-ao-hospital-do-funchal/ Access at 26/07/2022
[33] Haijun Zhang; Na Liu; Xiaoli Chu; Keping Long; Abdol-Hamid Aghvami;Victor C. M. Leung,(**2017**), Network Slicing Based 5G and Future Mobile Networks: Mobility, Resource Management, and Challenges doi**:** 10.1109/MCOM.2017.1600940
[34] Ranulfo Paranhos, Dalson Brito Figueiredo Filho, Enivaldo Carvalho da Rocha & José Alexandre Silva Junior, (**2013**) Corra que o survey vem aí. Noções básicas para cientistas sociais, ISSN: 1853-6190
[35] SREA- Estatística dos Açores, (2020) https://srea.azores.gov.pt/default.aspx?lang_id=1, acedido a 11/05/2022