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The Impact of Telemedicine on Healthcare Access for Patients with Cognitive Disorders and Dementias

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INDEX/SUMMARY

ABSTRACT

The central topic of this thesis concerns telemedicine, generally understood as the provision of healthcare services remotely. Specifically, it is a study aimed at examining its impact on access to healthcare for patients with dementia and cognitive disorders. The choice of this topic is motivated by the relative novelty of this technique (especially in the Italian context), in constant evolution parallel to modern technological innovations, and its potential in optimizing the healthcare system, especially in situations of health crises such as that of COVID-19. After a proper introduction of the topic, the actual econometric study begins with a descriptive statistical analysis of hospital data kindly provided by ASL4 concerning a sample of patients with dementia and cognitive disorders from 2019 to 2022. Subsequently, a Poisson regression and a Zero-Inflated Poisson regression are applied and compared to model the number of emergency room visits and hospitalizations, including telemedicine usage as an independent variable. The latter, along with the variable representing the Charlson comorbidity index, will be statistically significant and have a positive effect on the dependent variables under consideration.

1 INTRODUCTION AND CONTEXT

1.1 INTRODUCTION

For the first time, at the Hanover Technology Fair in 2011, the term *Industry 4.0* was used to signify the beginning of the Fourth Industrial Revolution (Drath et al., 2014). In the last few decades, countless research, investments, and projects have given rise to new digital technologies around the world that are changing industrial systems, such as: advanced robotics, additive technologies, integrated automation of production processes, Internet of Things, virtual reality, networking of production and design activities, use of big data, cloud, artificial intelligence and much more other (Glauner et al., 2021). In other words, the term *Industry 4.0* describes the ongoing digitalization process of companies, not only in terms of production but also for the organisation and work, for example the digitalisation of management processes, data collection and analysis, connectivity between systems and much more (Matt et al., 2020). Today nearly every industry is affected by this transformation with the emergence of new business models, leading the stakeholders to completely rethink their way of working. This development also involves the health sector (Glauner et al. 2021).

The exponential increasing digitalization is already changing the healthcare system, providing new techniques and opportunities, in relation to the large amount of data used, the need for consistent accuracy in complex procedures, and increasing demand in service for healthcare (Pacis et al., 2018). In particular, it's now possible for data to be seamlessly shared across the boundaries of institutions and medical monitoring of patients is possible from anywhere. This is the case of telemedicine.

Telemedicine is a telematic service which allows to transfer medical information through interactive digital communication, to carry out medical consultations, tests, different procedures, and professional collaborations remotely (Burrai et.al, 2021). It's the answer for the necessity to adapt traditional sanitary models with technological innovations, bringing them up to date (Glauner et al., 2021). Of course, the complete replacement of traditional systems is not currently feasible, and it is not even the intended goal. The objective of telemedicine is to support these models and implementing them by facilitating the exchange of information and data, thereby optimizing their effectiveness (Burrai et al., 2021).

This technique gives rise to a more digital and unconventional healthcare, which must therefore guarantee the continuity of assistance and the quality of the treatment in synergy with the services physically carried out in presence (Haleem et al., 2021). As will be further explained in this first chapter, the urgency of this digitalization process in the healthcare system has also been highlighted by the recent onset of the COVID-19 pandemic. In this regard, telemedicine may represent a valuable tool for the treatment of the population, especially in times of epidemics and health crises, helping reduce infections in hospital facilities (Portnoy et al., 2020).

1.2 DEFINITION OF TELEMEDICINE

The term "telemedicine" is a neologism that combines the Greek prefix "tele," meaning "at a distance," with “medicine”. This concept integrates two fields: medicine and telematics, the latter of which further branches into telecommunications and informatics (Zundel, 1996).

Telemedicine is a service which exploits telecommunications and electronic information technologies, specifically in the healthcare sector and it refers to the whole collection of deliverables designed to enable patients and their physicians or healthcare providers (Haleem et al., 2021). It can be used for different purposes, such as: remote control, online patient consultations, remote nursing and telematic physical and psychiatry rehabilitation. This allows patients to receive medical attention at the convenience of both doctor and him by using, for instance, a video application software (Mullick et al., 2020). In 1990, experts from the European Community provided a fairly comprehensive definition of telemedicine as:

” the integration, monitoring, and management of patients, as well as the education of patients and staff, using systems that allow ready access to expert advice and patient information, regardless of where the patient or the information resides.”

In this sense, we are very close to what is defined as 'Telehealth' in the United States, a broad concept that goes beyond simple assistance to patients far from places of treatment and instead involves the entire healthcare system in an overall reorganization and rationalization of the sector (Selvaggi et al., 2010).

The definitions proposed thus far, in a certain way, are rather generic. In fact, techniques and methods have changed along with the arrival of more and more innovations in telecommunications and electronic information technologies over time, up until the last few years. Telemedicine is an open and constantly evolving science as it incorporates new advancements in technology and responds and adapts to the changing health needs and contexts of societies (World Health Organization, 2010). For instance, a 2009 scientific study from *Journal of Diabetes Science and Technology* (Volume 3, Issue 4), identified five elements that could not be missing in a proper telemedicine system:

1) A process for accurate data collection in digital format.
2) An electronic medical record for data incorporation and remote transmission.
3) A set of protocols for distant data analysis.
4) A variety of communication tools to permit effective dialogue between patients and health care providers.
5) A system for automatically flagging and providing feedback for outlier data (Klonoff et al., 2009).

However, technological advances have made telemedicine more advanced and accessible over the years. In the last decades, in particular, it became clear the crucial role of artificial intelligence (AI) for its evolution (Gallese). This aspect will be examined in greater detail in the next chapter.

1.3 HISTORICAL BACKGROUND

Although the idea of telemedicine is currently a matter of great interest, thanks to its advancement facilitated by the latest technologies, the original concept of the use of telecommunication in healthcare may have been originated centuries ago: hypothetically, in XIV century, information about bubonic plague may have been transmitted across

Europe by bonfires or heliograph as was information about war and famine (Zundel, 1996). Several centuries later, the invention of telegraph was intensively exploited during the American Civil War to order medical supplies and transmit lists of casualties and injured. Moreover, during the 1900s, the telephone was invented and quickly adopted by physicians, becoming a mainstay of medical communications. In 1906 Willem Einthoven, one of the fathers of electrocardiography, was the first to study an electrocardiogram, transmitted via telephone line. About the time of World War I, radio communication was established, and, by 1930, it was used in remote areas such as Alaska and Australia to transfer medical information. By the time of the Korean and Vietnam conflicts, radio communication was used regularly to dispatch medical teams and helicopters (Zundel, 1996). One of the major influences on the development of telemedicine was the introduction of television. In 1955, at the Nebraska Psychiatric Institute, a closed-circuit television was tested for educational purposes and to carry out remote consultations between specialists: an experiment that contributed to the birth of telepsychiatry (Selvaggi et al., 2010).

During the 1970s, developments in the manned space-flight program and satellite transmission were of crucial importance: NASA began telemetry research and development, demonstrating that physiological functions for astronauts in space (initially to study the effects of zero gravity) could be monitored successfully by physicians on earth. This experience paved the way for bringing the same experiment back to Earth (Zundel et al., 1996).

It was in this period that the term telemedicine was introduced for the first time by the American Thomas Bird as "the practice of medicine without the usual physical confrontation between doctor and patient, using an interactive multimedia communication system" (Bird, 1975). Various experiments were also carried out in Italy, which proved to be at the forefront in devising innovative solutions for telemedicine. In 1970, the Faculty of Medicine of the La Sapienza University of Rome carried out the transmission of biomedical signals for a prototype of Cardiotelephone and, based on this study, a committee dedicated to remote medical assistance was created (Vadalà et al., 2019). One of the first and most important experiments was carried out in 1976 at the Marconi Foundation in Bologna, in which electrocardiographic examinations were carried out via switched telephone lines at the patient's home, taken over directly by the hospital (Gaggioli et al., 2004).

In certain historical instances, telemedicine has served as a means to bridge not just physical distances but also political, economic, and social divides. An example of this can be found in the aftermath of the devastating earthquake that struck Armenia in 1988, which led to collaboration between the United States and the Soviet Union through telemedicine (Houtchens et al., 1993).

Since the 1980s, with the digitalization of healthcare communication systems, it has become possible to integrate telecommunications with computers. This integration enables the transmission of a larger volume of data, and thanks to the Integrated Services Digital Network (ISDN) protocol, which governs the initiation and termination of calls, simultaneous transmission of video, voice, and data became achievable (Nguyen et al., 1985). In the following decades, the advent of the internet led to the overcoming of the experimental phase: this revolutionary innovation opened the way to global communication, allowing the possibility of recording and transfer a huge amount of data, images, and audio to a practically unlimited number of individuals at the same time. The development of the internet has been the key for telemedicine to become more and more rooted in everyday life to improve the social and healthcare system, as it made sharing possible beyond distance, radically reducing costs compared to the past (Selvaggi et al., 2010).

From the beginning of the twenty-first century to the present day, the internet has enabled a progressively rapid technological development, resulting in the increasing sophistication of telemedicine (Gallese). The introduction of cutting-edge technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) has redefined telemedicine, enhancing the effectiveness of healthcare delivery, data management, and the security of medical information (Pacis et al., 2018). Looking at the future, it's evident that these innovations will continue to reshape telemedicine, opening new possibilities for remote medical services, breaking down geographical barriers, and improving access to healthcare worldwide.

1.4 THE COVID-19 CONTEXT

On March 11, 2020, the World Health Organization (WHO) officially declared a pandemic related to the coronavirus-associated acute respiratory disease called coronavirus disease 19 (SARS-CoV-2, COVID-19), the third documented spillover of an animal coronavirus to humans in the last two decades. The first one, a severe acute respiratory syndrome (SARS), was caused by the SARS-CoV virus, first emerged in 2002-2003 in China; the second one, the Middle East respiratory syndrome (MERS) was caused by the MERS-CoV virus and first emerged in 2012. In both of these instances, the epidemics were effectively contained within localized geographic regions, without triggering significant global apprehensions or alarm (Ciotti et al., 2020).

However, COVID-19 proved to be more infectious than severe acute respiratory syndrome, causing unprecedented stressors on international health systems. Initially, a significant portion of cases (especially in China in the first phases) were due to hospital-related transmissions (Portnoy et al., 2020). A hospital lacking adequate containment measures could only serve as a breeding ground for infections, compromising the ability of physicians to treat seriously ill patients infected with the virus. For this reason, the recent pandemic has highlighted the importance of reducing visits to healthcare centers as a safety measure, and consequently, the need to replace them with telematic consultations (Blount et al., 2022). In other words, The COVID-19 pandemic has unmistakably highlighted the pressing need for healthcare systems worldwide to embark on a transformative journey, essentially 'reinventing' themselves by fostering the growth and integration of telemedicine.

Telemedicine has the potential to provide adequate care by allowing people with mild illnesses to access needed supportive care, all while mitigating their exposure to people with acute conditions (Haleem et al., 2021). This approach not only improves the safety of both patients and healthcare workers but could also facilitate a more efficient allocation of resources within the healthcare system, enabling comprehensive care during times of crisis and beyond (Blount et al., 2022).

An article from the *American Journal of Health-System Pharmacy*, titled "*Use of telemedicine to provide clinical pharmacy services during the SARS-CoV-2 pandemic*", described the response of the Children's Mercy Kansas City (CMKC) at the early stages of pandemic, adopting a remote working strategy. Initially, 7 pharmacists were assigned to non-clinical duties and began working remotely, followed by another 14 pharmacists in a second phase, with the pharmacy department team of pharmacists working on a rotational basis. These redeployments left approximately 14 pharmacists (42% of the typical on-site staff) with direct patient care duties on-site and 19 (58%) working remotely to provide consistent clinical services (Elson et al., 2020). Therefore, the goal of the third phase involves an essential pharmacy distribution model with 8 on-site pharmacists and telemedicine support (At the time of writing the article, the third phase had not yet commenced). To ensure optimal patient care and address healthcare system needs, state pharmacy boards and the U.S. Department of Health and Human Services (DHHS) temporarily adjusted telemedicine requirements. Specifically, DHHS exercised enforcement discretion for covered healthcare providers, allowing them to use videoconferencing applications such as Skype for Business, Microsoft Teams, Updox, or VSee, even if these applications were not fully compliant with HIPAA (*Health Insurance Portability and Accountability Act*) rules. State pharmacy boards either were temporarily permitted remote work for pharmacists or emphasized non-dispensing activities outside of licensed pharmacies and some boards considered or implemented waivers for remote medication processing. Activities carried out through video conferencing (not related to dispensing) included, for example, patient education, review of patient profiles and clinical histories, management of drug therapy and review of drug use.

Unfortunately, Italy faced challenges in managing patients with chronic diseases during lockdown because it lacked widespread access to large-scale telemedicine solutions (Omboni, 2020). Italy's response was somewhat delayed, with the Ministry for Technological Innovation and Digitalization and the Ministry of Health initiating a 3-day open call to telemedicine stakeholders to gather information about existing digital solutions (apps and chatbots) for tracking COVID-19 patients and others, but this action took place two months after the epidemic started (Omboni, 2020). There are four main reasons explaining why Italy has, at the start of quarantine, missed a unique opportunity to establish an infrastructure for delivering healthcare through telemedicine and facilitate the transition to a more modern and efficient healthcare system:

1) *Heterogeneity of solutions*: The diversity of available telemedicine solutions, along with their inability to share patient data, hinders integration with the

national electronic health record system. This results in redundant data and the absence of a unified patient information repository, leading to increased healthcare costs and reduced efficiency, making the current telemedicine model unsustainable.

2) *Poor interconnection*: Telemedicine services at higher healthcare levels (e.g., secondary, or tertiary care facilities) are often poorly connected with those in primary care clinics or community pharmacies. The lack of a multidisciplinary approach focused on the patient prevents maximizing the benefits of these digital solutions.
3) *Lack of evidence for clinical and cost-effectiveness*: Many telemedicine services funded by governmental institutions lack scientific evidence to support their clinical and cost-effectiveness. This lack of data results in inefficient deployment and necessitates adjustments while in operation, rather than immediate and effective functionality. This issue arises due to the absence of appropriate regulations for software and hardware development, clinical validation, and solution certification.
4) *Privacy regulations and practical recommendations*: The implementation of telemedicine solutions is frequently hindered by strict privacy regulations and a lack of practical guidelines (Omboni, 2020).

In conclusion, the COVID-19 pandemic has prompted a growing discussion on the need for a transition to a more modern healthcare model, which could inherently involve the full integration of telemedicine services and solutions into the broader spectrum of healthcare services. The consideration of telemedicine as either a proactive or reactive approach to maintaining care, especially for chronic disease patients during national emergencies, remains a subject of ongoing debate (Omboni, 2020).

2 TELEMEDICINE APPLICATIONS

2.1 DOES THE HEALTHCARE SYSTEM NEED TELEMEDICINE?

The increase in healthcare costs is a widespread concern in many countries in recent years: this increase may result from several factors, including the aging of the population, technological innovation in the provision of medical care, the increase in expectations of patients and the administrative costs associated with healthcare (Arce, 2019).

Regarding Italy, the dual healthcare system, consisting of a cost-free (or at least at low-cost) public sector and a more expensive private sector, has resulted in an overburdened demand for treatment within the public sector (Omboni, 2020). The slowdown in healthcare provision during the pandemic has exacerbated lengthy waiting times, leading to increased income disparities (Haleem et al., 2021). These disparities, in turn, have cascading effects, manifesting as inequalities in health and life expectancy. The growth of the elderly population is driving a significant increase in healthcare costs. These expenses are aimed at improving life expectancy, with a focus on enhancing the quality of life in old age by addressing and treating chronic conditions, rather than accepting them as inevitable consequences of aging. But the progressive aging of the population and the increase in life expectancy led to an increase in people living with illnesses and disabilities, increasing the demand for treatment and assistance and consequently healthcare costs (Lee et al., 2023). Since public health spending cannot fully satisfy this growing demand due to budget constraints and sustainability issues, a significant increase in "out of pocket" health spending is expected, i.e. paid by citizens themselves.

The rising costs, the need for better treatments, and the overall necessity to upgrade healthcare systems for better utilization of healthcare facilities and improved physician-patient communication are the main reasons why more and more hospitals are investigating and evaluating the benefits of telemedicine (Haleem et al., 2021).

Further reasons why it may be the most convenient choice is the promotion of better connectivity, reducing hospital re-admissions and improving patient adherence to care plans. It also enhances doctor-to-doctor communication, allowing them to exchange skills and deliver better healthcare services (Haleem et al., 2021). Telemedicine delivers medical treatment over the internet via video chat, offering benefits to both patients and healthcare providers despite some technical challenges and criticism (Haleem et al., 2021).

The advantages of telemedicine (but also the costs and the limitations) will be further explored in this chapter.

2.2 MAIN APPLICATION AREAS

Telemedicine technology can be applicated to a wide variety of treatment options. Among the main areas of application, there are primary care consultations, where doctors can conduct virtual visits for diagnoses, routine treatments, drug prescriptions and preventative consultations (Vadalà et al., 2019). In certain cases, patients use telemedicine in conjunction with their primary care physician: this combination of services allows patients to receive medical care from a doctor remotely (via telemedicine) in addition to the care provided by their primary care doctor (Haleem et al., 2021). It is also very frequently applied in the field of psychotherapy, improving the privacy, and making it more accessible (Lovo, 2021). Another example is given by the physical therapy area, overcoming geographical limitations, and ensuring continuity of care: in this way patients can receive regular physiotherapy treatments even if they move or travel, which helps maintain consistency in treatment plans (Vadalà et al., 2019).

Telemedicine is a cost-effective and convenient way to help individuals with severe illnesses manage their conditions, stay involved in their treatment, and prevent complications from worsening (Haleem et al., 2021). It has various applications in healthcare, connecting doctors and patients in different locations via telecommunications. This is particularly useful in remote or underserved areas where experts might not be readily available and it also facilitates remote visits, saving time and money (Chellaiyan et al., 2019). In this way, the access to services is simplified for patients having disabilities, the elderly, the culturally isolated, and the incarcerated (Lovo, 2021).

Modern mobile health apps support telemedicine, offering an interactive clinical interface that connects patients and doctors. These apps handle noncritical events like treating minor illnesses, exchanging data and imaging findings. Patients can even purchase medications and receive prescriptions via dedicated apps, ensuring close coordination with payment gateways. These systems are often integrated, allowing easy collaboration between patients and doctors, sharing data and transcripts, which doctors can interpret (Haleem et al., 2021). Telemedicine relies heavily on secure medical records for capturing, storing, and sharing data (Yordanov et al., 2020). The implementation of this technology in healthcare, clinicians, researchers, lab staff and doctors may also use the concept of *telehealth*, which implies a broader area of use and includes a wide range of health services and care (Gajarawala et al., 2021).

Telemedicine can also be helpful for the treatments of school-going children: schools could partner with doctors to perform video tours from the classroom when a child became ill, and the provider may decide what how to act and provide parents with guidance or reassurance. In fact, immediately taking a child to urgent care facilities when it's unnecessary can be inconvenient and result in useless costs (Haleem et al., 2021).

Another common application is related to dental care. Teledentistry allows dentists to obtain teeth, dentures, and any other dentistry parts photographs (or any other related evidence) to evaluate it and share it with another practitioner or specialist for examination and to establish the proper treatment. In this way, problem areas are easier to identify and it’s possible to recommend prevention steps to patients to stop expansive and complex procedures (Jampani et al., 2011).

Similarly, telemedicine can be used in dermatology. Dermatologists can assess conditions like psoriasis, bedsores, eczema, and more by examining high-resolution photos and videos (using smartphones, tablet, computers etc.), making it especially valuable for homebound patients. This approach ensures safe and reliable skincare disorder diagnosis and treatment while preserving patient convenience and integrity. It enhances doctor-patient communication and is supported by electronic patient management systems in many healthcare settings (Lee and English, 2018).

These examples represent only a portion of the extensive range of fields where telemedicine finds utility. In addition to these, it can play an important role in cardiology, radiology, critical care, anesthesia, oncology, and many other medical specialties (Zundel, 1996).

2.3 TECHNIQUES AND PROCESS

Depending on the case and the numerous areas of application of telemedicine (as seen in the previous paragraph), the respective techniques and processes for treating the patient remotely can be various.

However, one of the most common and widely used method is certainly that of teleconsultations, which represent a central aspect of telemedicine, allowing patients to communicate with healthcare providers remotely, often through videoconferences or virtual communications with the use of computers, tablets or even smartphones . They are an effective way to make diagnoses, provide medical consultations and manage care in situations where the patient's physical presence is not necessary or difficult to reach, such as in rural areas or in emergency situations (Haleem et al., 2021).

There are countless video conferencing platforms and apps for this purpose. More generic ones can often be used, such as Skype for Business, Microsoft Teams, WhatsApp, Google Meet and so on. In this regard, it is interesting to observe how the famous Zoom platform has implemented its own version designed specifically to meet the needs of healthcare institutions and health professionals, Zoom for Healthcare (Lunney et al., 2021). In its official website, a clear commitment is articulated regarding its adherence to HIPAA standards in the management of health information. While formal certification by official entities is absent, Zoom emphasizes its dedication to compliance by securing a compliance certificate from a reputable third party. This certification attests to Zoom's implementation of stringent controls to safeguard health information, aligning meticulously with HIPAA's security, breach notification, and privacy regulations. Furthermore, the platform, known for its user-friendly interface, actively facilitates HIPAA-compliant initiatives through strategic agreements with business associates, underscoring its steadfast commitment to ensuring the utmost security of health information (Zoom, n.d.).

Another technique is telemonitoring, enabling the remote observation of patients. In France, for instance, the Covidom app was developed for monitoring Covid-19 patients at home during the pandemic (Yordanov et al., 2020). Additionally, there are techniques utilizing telecommunications and information technologies to transmit pathological images, data, and diagnostic information remotely. Examples include teledentistry (as discussed in the previous paragraph), telepathology, and telediagnosis.

A more intricate and sophisticated procedure is telesurgery, an advanced medical practice that involves the use of telecommunications and robotics technologies to enable a surgeon to perform surgery on a patient located in a different location. This emerging field is often linked to advanced technologies, including surgical robots and high-speed network connections (Choi et al., 2018).

2.4 ARTIFICIAL INTELLIGENCE

Advancements in technology, such as the internet, data processing capabilities, and the rise of innovations like information sharing, analytics, IoT, wearables, cloud tech, and robotics, are shaping the future of global healthcare, particularly in telemedicine (Glauner et al., 2021). As these elements respond to the growing complexity of healthcare data, the demand for precise procedures, and increased service needs, the integration of artificial intelligence (AI) is crucial for optimizing efficiency and automating hospital logistics to streamline healthcare delivery (Gallese, n.d.).

This technology can be applied in various aspects of healthcare, such as providing a system to analyse medical information to determine sources of errors and develop solutions using existing results from procedures and enhancing procedures by adding computerized intelligence to medical devices and tools. The expeditious and precise identification of patterns presents a notable advantage in discerning optimal medical procedures and decision-making. Analysing patterns in the outcomes of medical procedures facilitates optimization and the proactivity in anticipating potential issues. As regards telemedicine, it's possible to identify four main trends in the utilization of artificial intelligence (Pacis et al., 2018).

One of the most common applications regard patient monitoring, which enables efficient remote doctor-to-patient consultations, resembling face-to-face interactions through video conferencing and digital device connections. The goal is to enhance accessibility, ease, efficiency, and cost-effectiveness in comparison to traditional patient monitoring (Jeddi et al., 2020). Additionally, recent advancements in telepresence robots, incorporating artificial intelligence and vision systems, allow autonomous navigation within healthcare facilities. Examples like the Dr Rho Medical Telepresence Robot showcase intuitive features for collaborative communication and adaptable physical setups, demonstrating the potential integration of artificial intelligence to enhance telemedicine functionality (Pacis et al., 2018). The integration of AI extends beyond video communication, as exemplified by an Ankle Rehabilitation System using a wireless gyroscope platform and machine learning: this wireless vital sensor technology facilitates seamless data transmission for continuous monitoring (LeMoyne et al., 2015). Another instance involves a web-based management system with machine learning for real-time data collection from sickle cell disease patients, enhancing predictive capabilities. These advancements support self-diagnosis and extend telemedicine beyond hospitals, emphasizing the importance of standardized data architecture in devices for monitoring patients outside healthcare facilities (Khalaf et al., 2015).

The second trend is associated with healthcare information technology: the increasing volume of healthcare data, coupled with the global scope of telemedicine, underscores the need for a universal record system (Demiris, 2003). Trends like big data analytics and neural networks aim to streamline electronic health records management: the integration of AI to systemize data retrieval and analysis addresses challenges faced in hospital procedures, with innovations like Remedy, which is a system that replaces manual vital sign examination with a chat-based questionnaire, streamlining the process and accelerating communication with the doctor (Pacis et al., 2018). Cloud computing is emerging to resolve electronic infrastructure issues, enhancing the efficiency of data collection and distribution (Apostu et al., 2013). Cloud-based telemedicine services, as seen in studies like "A Cloud Computing Based Telemedicine Service" by Matlani and Londhe (2013), accelerate medical analysis by transmitting signals through the cloud. This extends to consumer electronics like Microsoft Band 2, integrating cloud computation for faster data retrieval and improved processing capacity, contributing to regional standardization of medical records (Garai and Adamko, 2017). Despite wireless connections in telemedicine posing security risks, studies in image processing and AI propose solutions, such as Wavelet Based Watermarking for securing medical images.

The ongoing development of device-to-device communications adds robust security measures, emphasizing authentication for secure data transmission.

A third trend includes intelligent assistance and diagnosis: robotic technology is gaining popularity as it integrates assisting mechanical components and utilizes collected medical information for intelligent diagnosis. These tools, driven by neural networks and machine learning, aim to aid patients physically or through initial evaluations within the hospital system (Pacis et al., 2018). Self-diagnosing applications, like Lemonaid Health (a start-up company), utilize AI models for screening and evaluation through questionnaires, categorizing patients based on complexity (Bollmeier et al., 2020). Another similar example is given by Carbon Health's chatbot interface streamlines triage examinations, monitoring patients and facilitating consultations (Pacis et al., 2018).

Finally, the fourth trend involves information analysis (Pacis et al., 2018). As has already been highlighted in the previous paragraphs, the use of telemedicine in medical research and academic consultations facilitates international collaboration among medical experts. This fosters not only cooperation in diagnostic perspectives but also in sharing medical data. The application of big data analytics and genetic neural networks in pharmaceutical research is transforming how clinical test results are consolidated and patterns are identified (Glauner et al., 2018). The trends in utilizing artificial intelligence for analysing clinical data, determining pharmaceutical product value, and treatment outcomes are significant: an illustrative example is the Predictive Model for Assistive Technology Adoption for People with Dementia, utilizing neural networks to assess technology adoption potential (Zhang et al., 2014). Another key application involves neural networks establishing connections in patient records across multiple healthcare facilities, enabling comprehensive data analysis for insights at individual and regional levels (Pacis et al., 2018).

Telemedicine, facilitated by intelligent systems, improves patient care but raises legal challenges: unresolved issues, including regulation for patient-specific systems and protection of vulnerable individuals, need thorough examination. Despite EU efforts to address AI development, unresolved matters persist. Adequate exploration of these issues is crucial before AI-driven telemedicine becomes commonplace nationally (Gallese Nobile, 2023).

2.5 ADVANTAGES

The purpose of this paragraph will be to summarize the main benefits (many of which have already been mentioned previously) brought about by telemedicine for the healthcare system.

First, telemedicine offers the opportunity for remote care, effectively reducing hospital visits. Patients seeking specialized expertise for specific diseases can access healthcare without long travel, using video visits. In this way, telehealth would drastically reduce the number of appointments and minimize travelling of patients. This translates into a reduction in monetary (workdays missed, transportation costs etc.) and non-monetary costs (for example in terms of time and effort for the travel or the wait at the hospital) for the patient. This also allows the optimal use of specialists' knowledge. The collaborative nature of healthcare, involving GPs and specialists, is strengthened through telemedicine, promoting communication to achieve the best outcomes for patients via a secure remote connection (Haleem et al., 2021).

Through its several functional applications, telemedicine is able to address unavoidable face-to-face meetings efficiently, enhancing hospital operability. Simultaneously, healthcare providers can monitor multiple patients within the hospital, reducing emergency department congestion and caring for critically ill patients through telemedicine appointments and supervision. The exchange of medical information among hospitals is expedited, facilitating quicker care. It aids in treating patients requiring supervision, contributing to an overall reduction in health risks. This is also important to create safe environment by allowing patients with contagious illnesses to consult doctors without spreading germs, which is an aspect that has proven to be crucial especially after the COVID-19 pandemic (Blount et al., 2022).

Obviously, telemedicine proves effective for conditions not requiring physical exams or lab tests, including ongoing treatments like psychotherapy (Link et al., 2023). Particularly during the COVID-19 pandemic, it facilitates improved access to care for patients residing at a distance from primary care centers or those with transportation challenges. Providers can expand their scope of manageable conditions, for instance by using telemedicine to prescribe antibiotics for potential infections (Blount et al., 2022).

The era of social distancing led to a growing reliance on virtual doctor appointments through telemedicine, with the aim of improving medication management, patient quality of life, and lowering healthcare costs (Blount et al., 2022). The increasing focus on telemedicine app development is a priority for healthcare providers aiming to offer online and remote healthcare services (Kautish et al., 2023). The technology should enables the creation of user-friendly telemedicine applications with robust authentication mechanisms, making it dependable and straightforward for both doctors and patients (Tamilkodi and Rama, 2023).

The benefits of artificial intelligence applied to telemedicine have already been discussed in the last paragraph: by utilizing video conferencing and machine learning, these systems refine algorithms for improved diagnoses based on individual patient cases. Telemedicine, involving the connection of physicians and patients through networked devices, offers alternative options like virtual appointments, reviews, and photo transcript applications, ensuring safety during pandemics and expanding digital medical services (Blount et al., 2022).

Moreover, telemedicine technologies enable healthcare providers to monitor their patients' medication adherence, track patients' well-being over long distances using advanced medical equipment, and transmit vital data such as heart rate, blood pressure, and glucose levels between systems. This may be particularly useful for older patients, since they are more prone to forgetting to take their prescriptions (Haleem et al., 2021).

Telemedicine offers numerous benefits to both clinicians and patients: it addresses the paramount need for improved patient services while aiding physicians in refining and enhancing their private practices. It is also useful to bridge the gap caused by the global shortage of skilled healthcare providers, providing a solution to fulfil the need for doctors. Another advantage is a possible improvement in the coordination of patients and health services in general, addressing issues such as treatment shortages, overuse of medical care and unnecessary or overlapping treatments. The convenience of telemedicine services, combined with nominal fees, improves patient-doctor coordination (Haleem et al., 2021).

In essence, telemedicine offers a cost-effective alternative to traditional healthcare administration, eliminating the need for frequent travel for both doctors and patients (Blount et al., 2022). Video consultations are generally more convenient than in-person visits, reducing expenses related to travel and hospital accommodations. Integrating online booking and video conferencing into healthcare solutions further contributes to cost savings, which is particularly beneficial in areas where accessing a hospital poses challenges (Blount et al., 2022).

In particular, one of the aspects of greatest interest regarding remote visits pertains to the potential cost-effectiveness of telemedicine from the perspective of hospitals and the healthcare system in general. This is attributed to improved staff organization, a more targeted use of medical resources (directing attention to patients requiring more urgent or specific interventions), reduced operational costs (linked to physical facilities, equipment use, and related services), minimized utilization of physical resources (thus avoiding costs associated with physical spaces like waiting rooms and hospital beds), and a decrease in unnecessary hospital admissions, leading to reduced costs related to hospital stays (Glauner et al., 2021).

2.6 COSTS AND LIMITATIONS

While offering numerous advantages, telemedicine also comes with certain costs and limitations, which must necessarily be evaluated to avoid losses and inefficiencies.

In terms of costs, healthcare facilities will naturally need to invest in technology to procure the necessary equipment, phone costs, satellite communication, virtual private networks (VPN) and IT infrastructure: this includes a system of hardware, software, networks, and other processing services required to enable communication, data storage, access to resources, and the implementation of suitable platforms (Glauner et al., 2021). These investments will in turn lead to additional costs for installation and basic equipment. The lack of affordability can be a significant drawback, especially for smaller healthcare facilities.

In order to be best used and handled, telemedicine technologies will also require a certain degree of preparation on the part of doctors and healthcare personnel: for this reason, another important cost to be incurred will have to be dedicated to staff training which may include instruction on the proper utilization of a given telemedicine platform, data security protocols, and efficient communication practices within the healthcare framework.

In addition to the aforementioned costs related to technology investments, healthcare facilities must allocate resources to ensure security and compliance. Safeguarding patient data and adhering to privacy regulations necessitate substantial investments in robust cybersecurity measures. This encompasses the implementation of advanced encryption protocols, regular security audits, and the establishment of a comprehensive framework to ensure seamless compliance with evolving data protection standards (Glauner et al., 2021). There also exists the risk of hacking for patient's medical data, especially if they connect to telemedicine platforms from a public network or an unencrypted channel (Haleem et al., 2021).

In terms of limitations, there are several reasons why, in certain circumstances, telemedicine may not be the best solution for both patients and medical staff. One reason is associated with the possibility of limited technological access for some patients, resulting from the lack of reliable devices and Internet means of communication, especially in remote or rural areas (Yassa et al., 2022). This digital divide raises concerns about the equitable provision of healthcare. Additionally, issues such as poor internet connectivity or insufficient digital literacy further exacerbate the challenges in implementing telemedicine solutions for these populations. In general, technical issues or equipment malfunctions can compromise the quality of consultations (Haleem et al., 2021).

Telemedicine cannot represent a substitute for the conventional healthcare system, for multiple reasons. Not all medical conditions can be effectively managed remotely, especially those requiring thorough physical examinations. For instance, not all healthcare facilities can afford the right equipment to allow doctors to perform surgeries remotely (Haleem et al., 2021) and, in most cases, complex medical conditions may require the patient's physical presence for accurate assessment. In certain cases, due for example to a bad quality of the video, can compromise ability of the doctor to see the patient and conduct a proper examination or to diagnose the condition accurately.

Similarly, the patient may also find it difficult to describe the disease through remote communication (Yassa et al., 2022).

Cultural and linguistic differences pose additional challenges in the widespread adoption of telemedicine. Effective communication between healthcare providers and patients is essential for accurate diagnosis and treatment. Language barriers or cultural nuances may lead to misunderstandings, hindering the establishment of trust and compromising the quality of healthcare delivery. Tailoring telemedicine interfaces and services to accommodate diverse cultural and linguistic backgrounds is crucial for ensuring inclusivity and overcoming these obstacles (Yassa et al., 2022).

Finally, the absence of face-to-face interactions in telemedicine can indeed diminish the human touch in healthcare, potentially affecting the doctor-patient relationship. While the convenience and accessibility of telemedicine are undeniable, the importance of personal connections in healthcare should not be underestimated. The nuances of non-verbal communication, empathy, and the comfort derived from physical presence contribute significantly to the overall patient experience. Striking a balance between the efficiency of telemedicine and preserving the human touch in healthcare interactions becomes paramount (Gajarawala and Pelkowsy, 2021). As technology advances, integrating features that enhance the personal connection in virtual consultations can help bridge this gap and make telemedicine a more holistic and patient-centric approach.

2.7 BARRIERS FOR THE ADOPTION OF TELEMEDICINE

After analysing the primary advantages and disadvantages that telemedicine can introduce to the healthcare system and comparing it to traditional methods, along with highlighting the major limitations from the perspectives of both patients and healthcare professionals, this paragraph aims to summarize the most typical and common barriers to consider when attempting to implement telemedicine practices in healthcare and its related sectors. The things must be very free from any kind of privacy loss, confidentiality revealing, fraud and abuse, inaccurate solutions, etc. as any of these issues may become a reason for anyone's discouragement, or the case may become complex as far as health sediments are concerned (Haleem et al., 2021).

Ensuring patient privacy and confidentiality is essential. Telemedicine involves the transmission of sensitive health information, necessitating robust measures to safeguard against unauthorized access and breaches. The fear of privacy loss can be a deterrent for both patients and healthcare providers (Gajarawala and Pelkowsy, 2021).

Another point to consider concerns the data quality. The accuracy of medical data is crucial for sound decision-making as well. Telemedicine relies heavily on data transmission, making it susceptible to errors or inaccuracies. Ensuring the precision and reliability of transmitted data is imperative to prevent misdiagnoses or inappropriate treatments (Haleem et al., 2021).

The evolving landscape of telemedicine introduces challenges related to medical liability. Determining responsibility in case of adverse outcomes or errors becomes complex when healthcare services are delivered remotely. Legal frameworks need to adapt to clearly define liability boundaries and protect both patients and healthcare professionals (Gajarawala and Pelkowsy, 2021).

Telemedicine is not immune to fraudulent activities or abuse. Instances of fake consultations, unauthorized prescriptions, or misuse of telehealth platforms pose risks to the integrity of the healthcare system. Implementing stringent measures to verify the legitimacy of telemedicine interactions is essential (Haleem et al., 2021).

Remote prescribing of controlled substances raises regulatory concerns as well. Striking a balance between ensuring access to necessary medications and preventing substance abuse poses a challenge. Regulatory frameworks must evolve to address these concerns while maintaining patient care standards (Gajarawala and Pelkowsy, 2021).

One of the major cons that has already been discussed concerns the lack of face-to-face interactions: the absence of physical presence during telemedicine consultations may contribute to challenges in accurate diagnosis. Certain medical conditions may require in-person examinations, and the reliance on remote assessments introduces the risk of misdiagnosis (Haleem et al., 2021).

Ultimately, it is necessary to recognize the intricacies associated with incorporating telemedicine into healthcare operations. The multifaceted nature of healthcare services adds complexity to telemedicine adoption. Integrating telehealth into existing workflows, training healthcare professionals, and ensuring interoperability with diverse systems demand comprehensive strategies (Zhou et al., 2023).

Addressing these barriers requires collaborative efforts from policymakers, healthcare providers, technology developers, and regulatory bodies. Proactive measures, innovative solutions, and a commitment to balancing accessibility with security are essential for unlocking the full potential of telemedicine in supporting healthcare systems.

3 ASL4 CASE STUDY: DESCRIPTIVE STATISTIC

3.1 INTRODUCTION TO THE STUDY

In the previous chapters, a comprehensive exploration has been undertaken to present the multifaceted concept of telemedicine, understanding its different modalities and applications. An examination of its historical trajectory spanning various phases has been carried out, along with an analysis of its evolutionary path marked by technological advancements. Furthermore, an investigation into its advantages, disadvantages, economic implications, and benefits to society has been conducted, offering a basic knowledge of its implications in the field of healthcare.

Once this fundamental understanding has been established, the focus of this thesis will now shift towards a more specific study of the impact of telemedicine in in the regional context of Liguria. Facilitated by the kind provision of hospital data by the ASL4, this study aims to examine the effectiveness of telemedicine interventions in a targeted sample of patients suffering from cognitive disorders and dementia. This effort represents not only a theoretical exploration but a practical investigation into the tangible results generated by telemedicine in a real healthcare context.

As subsequent chapters will clarify in greater detail, the primary objective of this study is to discern the effects of remote consultations on healthcare accessibility and service utilization. Specifically, the investigation will delve into whether the adoption of telemedicine practices for these conditions generates perceivable improvements or exacerbations in health outcomes. A key metric of interest will be the incidence of hospital admissions and emergency room visits within a defined time window, which will serve as a proxy for evaluating the effectiveness and impact of telemedicine interventions.

This study will be examined in depth in the next chapter, where the selection and application of the most relevant statistical models for the dataset in question will be carried out, providing an interpretation of the results and further conclusions.

This chapter instead represents a preliminary phase to statistical modelling, with the aim of providing a presentation of the data set in question, through a descriptive analysis. The general objective is to provide a complete view of the profile of the patients examined. In addition to simply cataloguing demographic parameters such as sex distribution, age groups and municipalities of residence of individuals, their medical history will also be taken into consideration. This involves examining data on hospital admissions, emergency room visits and the presence of comorbid conditions, assessed through the Charlson Comorbidity Index (CCI). Through a thorough examination of these aspects, it is possible to create a clear picture of the patient group, laying a solid foundation for subsequent more sophisticated analyses.

As mentioned previously, the data utilized pertains to patients who have utilized healthcare services provided by ASL4 (Local Health and Social Authority 4), a health company in the province of Genoa (Liguria). Its territory includes three socio-health districts and a single hospital structure, the "Tigullio Hospital", including three centres (located in Rapallo, Lavagna and Sestri Levante). ASL4 Liguria is at the forefront of a digitalisation project called "Tigullio, luogo di salute", aimed at pioneering a novel model of territorial proximity healthcare: this initiative highlights the development of innovative services through telemedicine and the organizational processes implemented by the agency to exploit its potential (Romiti et al., 2023).

The dataset covers a timeframe spanning four years, from 2019 to 2022. This will also provide an opportunity to make observations on the impacts of the COVID-19 pandemic on patients. This temporal scope allows for an analysis of trends and changes in healthcare utilization, offering insights into the dynamic interaction between the pandemic and healthcare delivery systems. In this regard, the global COVID-19 pandemic has undoubtedly highlighted the importance of disease surveillance, diagnosis, treatment and research, thus accelerating the implementation of digitalization initiatives in this regard (Hsu et al., 2021), already underway in Italy albeit in an uneven and underdeveloped way (Romiti et al., 2023). Another significant push for digitalisation came from the National Recovery and Resilience Plan (NRRP), which also included healthcare among its digitalisation objectives. However, the Liguria Region anticipated national directives by regulating services and establishing a dedicated telemedicine platform. Subsequently, the Ligurian project “Tigullio, luogo di salute” gave further impetus to these efforts by outlining a strategic plan for the period 2021-2023 (Romiti et al., 2023).

This implies that, within the dataset under study, remote visits started in 2021. This will allow us to examine any changes before and after the integration of telemedicine visits in patients' behaviours regarding access to healthcare services. However, this will lead to a reduced sample size of telemedicine users compared to patients who have not used it, and to exacerbate this, remote options are available only for follow-up visits. Thus, achieving a balanced sample size from this point of view, particularly considering that remote options are only available for follow-up visits, becomes unattainable, posing potential challenges for statistical analysis.

The final dataset used for descriptive statistics in the following paragraphs and for model creation in the next chapter was obtained through manipulation and integration (using the STATA statistical software) of various separate datasets containing various patient information. This includes demographic data, information on direct and conventional pharmaceuticals, specialist visits, exemptions, emergency department visits, and hospital discharge records (indicated in Italian with the acronym “SDO”, Scheda di Dimissione Ospedaliera).

The study was conducted on a sample of patients belonging to a single medical care sector: patients with cognitive disorders (including Alzheimer's and Parkinson's) and dementias. The main reason for choosing this pathological area over most others stemmed from a relatively good number of observations in terms of telemedicine consultations, even in 2021 (i.e., the first year this technique was made available by ASL4). As one might reasonably expect, the sample predominantly refers to elderly patients: a demographic that, on one hand, could benefit from telemedicine due to potential difficulties in being transported to outpatient facilities (Dijk, 2022), and on the other hand, may exhibit aversion and discomfort due to limited familiarity with new technologies.

3.2 GENERAL PATIENT PROFILE

The total number of individual patients included in the study sample amounts to 2599, for a total of 10,396 observations within the final panel dataset. For each patient (identified by an identification code in the 'key_paz' variable), observations were considered for each year from 2019 to 2022, providing a temporal perspective on the patient's activity in terms of visits, hospitalizations, and medication intake.

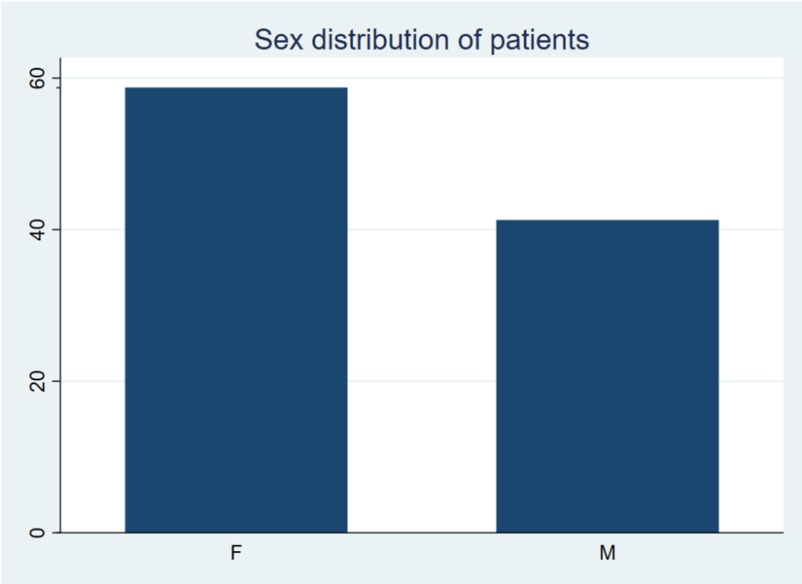
The data cleaning and sample selection process aimed to collect individuals who fell into the specialty category under study, specifically targeting patients with any form of dementia and cognitive disorders, including Alzheimer's disease and Parkinson's disease. This approach aimed to enhance the significance of the study. It is conceivable that an individual may have undergone specialist counselling in this area without real need, potentially distorting the pattern of behaviours exhibited by patients with the disorders under investigation.

Selecting the appropriate sample was not an instant process. Identifying patient conditions required careful consideration of not only the specific types of diagnoses documented in hospital discharge records, but also the exemptions and medications prescribed for each patient. To do this, the entire initial dataset was filtered according to ministerial guidelines which outline the rules for identifying the conditions listed in a table, expressed through alphanumeric codes for each exemption, diagnosis, and drug. Within this table three entries concern the specialist area in question: dementia, Alzheimer's disease and finally Parkinson's disease and parkinsonism.

Having determined the sample size, it is now possible to analyse the general demographic profile of patients from a basic standpoint. Unfortunately, the information available within the dataset is rather limited due to privacy constraints, allowing consideration only of the patients' biological sex and age range.

The distribution of patients by sex is depicted in the bar chart shown in Figure 3.1. Females (F) account for 58.74% of the sample, while males (M) represent 41.26%. There is a clear prevalence of the female gender in the studied population.

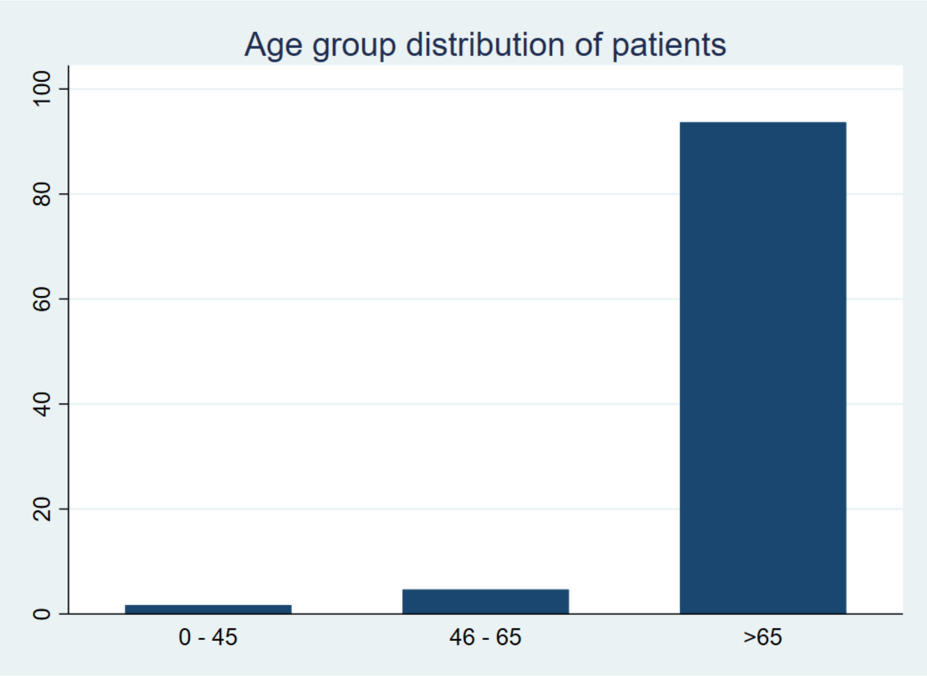
Figure 3.1: Sex distribution of the sample



This finding may be supported by several studies indicating a higher incidence of Alzheimer's disease and related dementias in adults aged over 70, especially among females. However, recent studies have highlighted that reducing gender disparities in access to education may alleviate sex differences in the future risk of dementia and cognitive decline (Bloomberg et al., 2021).

The distribution of the sample by age groups will be illustrated in Figure 3.2. The age groups were classified into three segments: the first goes from 0 to 45 years, the second from 46 to 65 years and the last includes individuals aged 65 years of age or older. The decision to use such wide age ranges is probably aimed at ensuring greater privacy for the patients under study. Although this approach may lead to a certain loss of precision in the statistical analysis, the results are largely expected given the Interestingly, 93.65% of the sample comprises individuals aged over 65, with only 4.66% falling within the 46-65 age range and 1.69% in the 0-45 age group, in line with the results of previous studies.

Figure 3.2: Age group distribution



Lastly, additional demographic information regarding the patients' municipality of residence can be provided: Chiavari accounts for 20.82% of the distribution, Rapallo for 18.98%, Sestri Levante for 12.59%, Lavagna for 9.51%, while the remaining 38.1% is attributed to other municipalities. It is important to note that, given the relative size of the sample, in the latter case there are few observations related to many Ligurian municipalities and, in rarer cases, individuals from other Italian regions.

To provide a general picture of the geographical distribution of patients in relation to the healthcare facilities where they receive care, it is possible to specify that the healthcare services of the ASL4, both via telemedicine and with in-person visits, were mainly provided at the following facilities: Ospedali Riuniti Leonardi and Riboli Lavagna (Municipality of Lavagna) with 42.07% of cases, Ospedale Civile di Sestri Levante (Municipality of Sestri Levante) with 25.03%, and N.S. of Montallegro (Municipality of Rapallo) with 32.90%. To provide a general picture of the distribution of patients in relation to the healthcare facilities where they receive care, it is possible to specify that the healthcare services of the ASL4, both via telemedicine and with in-person visits, were mainly provided at the following facilities: Ospedali Riuniti Leonardi and Riboli Lavagna (Municipality of Lavagna) with 42.07% of cases, Ospedale Civile di Sestri Levante

(Municipality of Sestri Levante) with 25.03%, and N.S. of Montallegro (Municipality of Rapallo) with 32.90%. However, it is necessary to point out that in some patients the code of the providing facility is not specified in the dataset.

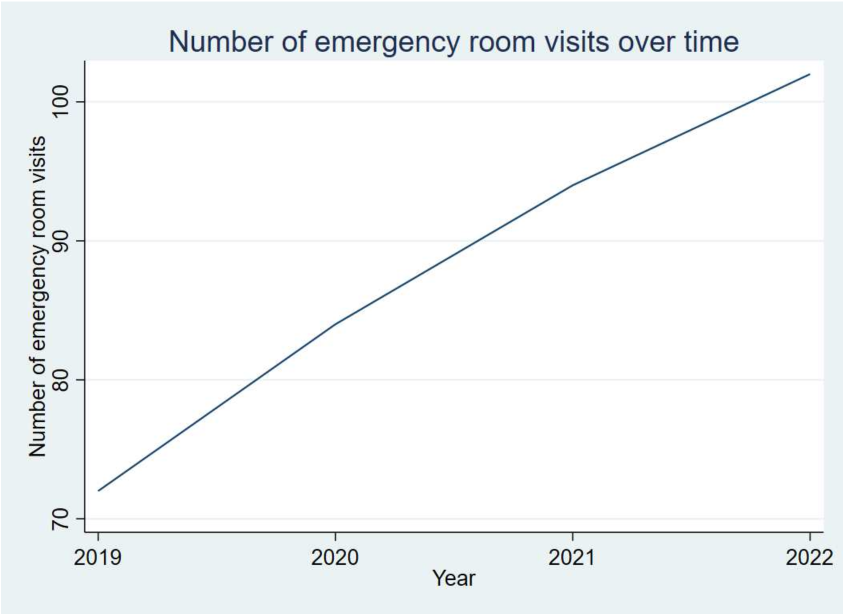
3.3 VISITS TO THE EMERGENCY ROOM

From 2019 to 2022, the sample of patients underwent a total of 352 visits to the emergency department, with a very low mean value of 0.034 per patient and standard deviation equal to 0.207. The minimum number of visits per year is 0, while the maximum number observed is 4. Particularly noteworthy is the increasing trend in the distribution of these visits over the years, as depicted in Figure 3.3: 72 visits in 2019, 84 in 2020, 94 in 2021, and 102 in 2022.

However, it is important to clarify that this is not a radical increase, but rather a gradual one. Furthermore, overall, this is a rather small number of visits, considering the sample size. The time frame in question photographs a snapshot of the Covid-19 period, from the year before the restrictions to the year following the lockdown in Italy. During the pandemic, a decrease in emergency room visits and overall hospital admissions for specific diseases has been reported worldwide (Santi et al., 2021). It is not easy to justify this result; a possible explanation could be attributed to the fear of contracting Covid-19 or adherence to social distancing measures, but further investigations are needed.

The mean value of the number of the emergency visits, in the whole sample in these four years, is 0.338, with a standard deviation of 0.207, minimum value of 0 and maximum value of 4 visits.

Figure 3.3: Number of emergency room visits over time.



Considering the main demographic variables in relation to emergency room admissions, results consistent with the statistics presented in the previous section are obtained. Specifically, Figure 3.4 and Figure 3.5 illustrate that the distribution by gender and age groups among patients who went to the emergency room at least once during these four years closely mirrors that of the overall sample. In particular, there is an even higher prevalence of individuals over the age of 65 who have visited the emergency room at least once (98.71%).

Figure 3.4: Sex distribution for patients who had at least one emergency room visits

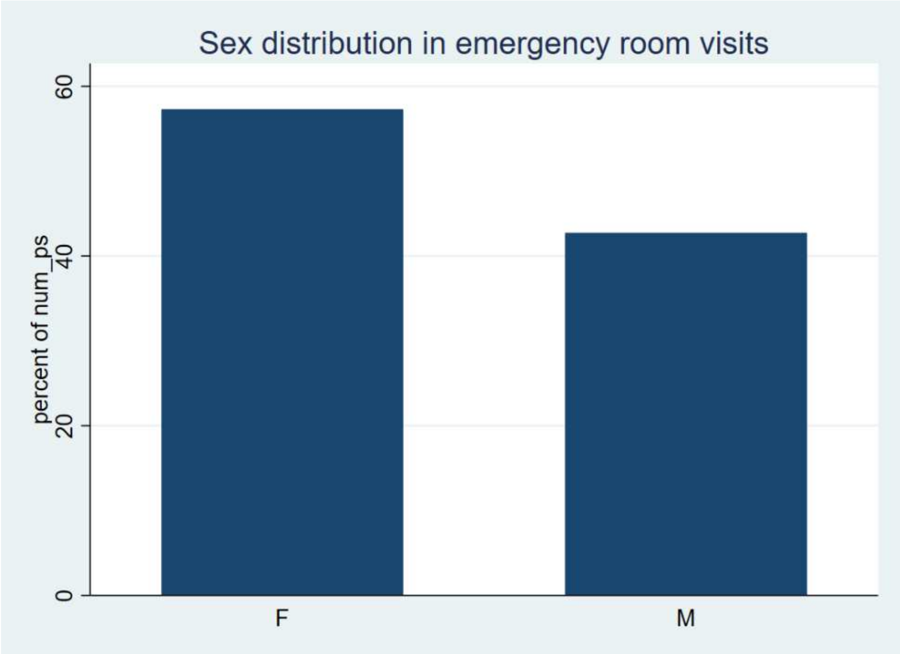
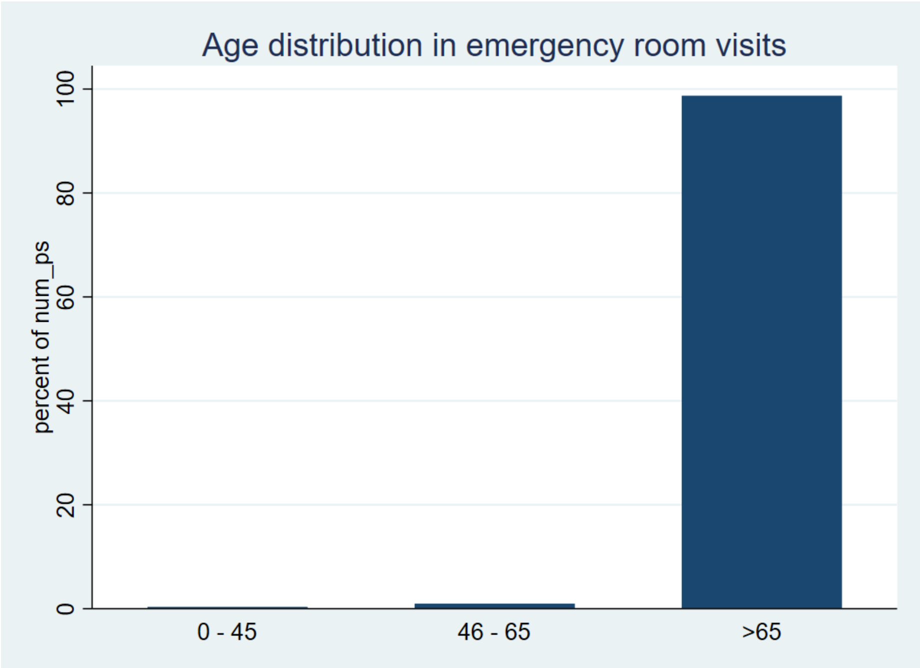


Figure 3.5: Age distribution for patients who had at least one emergency room visits



The following table (Table 3.1) provides an overview of the data relating to emergency room visits based on the main demographic variables observed.

Table 3.1: Emergency room accesses per patient (by sex and age).

Emergency room accesses	Mean	Std. dev	Min	Max
Sex				
Female	0.0337484	0.2099631	0	4
Male	0.0340485	0.2032101	0	4
Age				
0-45	0.0056818	0.0753778	0	1
45-65	0.0061983	0.0785664	0	1
>65	0.0357583	0.213017	0	4

Regarding sex, we observe that the average number of emergency room visits is slightly higher for men than for women, with a similar standard deviation for both groups. Both groups have minimum values of visits to the emergency room equal to 0, which indicates that a significant part of the patients did not visit them, while the maximum number of visits recorded is 4, suggesting some variability in the levels of emergency room use among individuals.

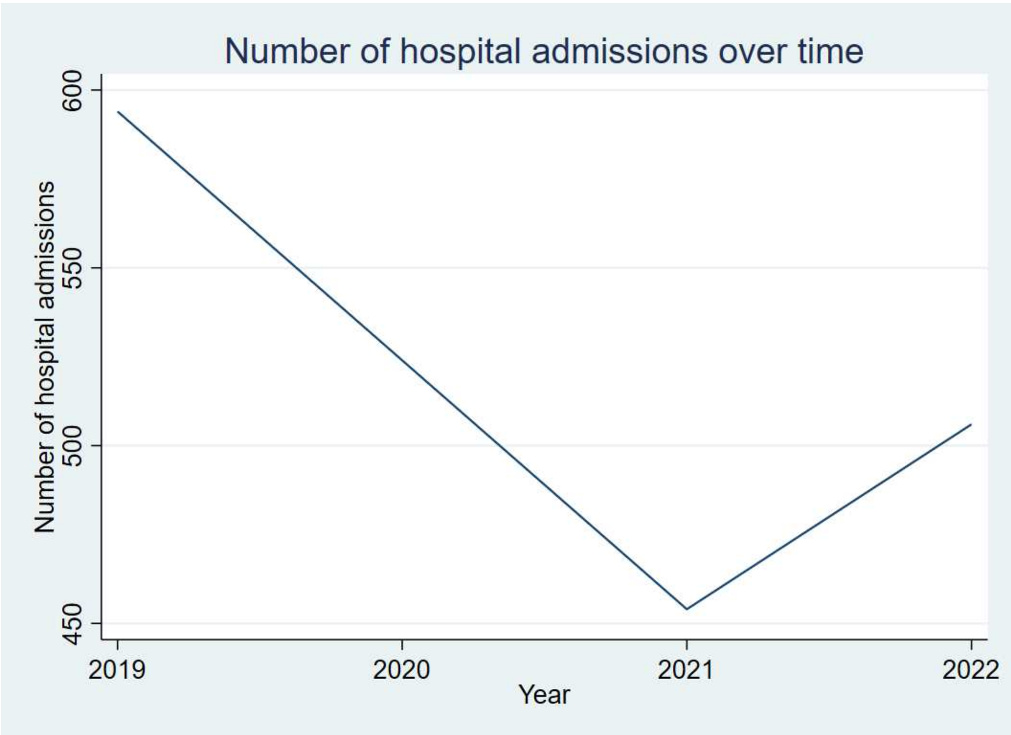
Regarding age, it is observed that the average number of visits to the emergency room increases with age: individuals over 65 have the highest average, followed by the 45-65 age group and the age 0-45. Again, all three groups show minimum visit values of 0 and maximum values of 1 for the first two groups and 4 for those over 65 (which also have a higher standard deviation value). These results are in line with previous graphs.

3.4 HOSPITAL ADMISSIONS

Regarding the number of hospital admissions spanning from 2019 to 2022, the dataset reveals a total of 2078 admissions (a figure significantly larger compared to emergency department visits), with a relatively low mean value of 0.199 per patient and standard deviation equal to 0.472. The minimum number of admissions per year is 0, while the maximum number observed is 6.

To break it down further, there were 594 admissions in 2019, 524 in 2020, 454 in 2021, and 506 in 2022. The annual distribution, as illustrated in Figure 3.6, closely reflects the trends observed in studies concerning the healthcare crisis prompted by COVID-19. Notably, the period prior to the lockdown in 2019 recorded the highest number of admissions, followed by a slight reduction in 2020 (the year when the first cases of coronavirus were reported in Italy), a more pronounced decline in 2021 (during the peak of the lockdown), and a subsequent uptick in 2022 (following the conclusion of the pandemic).

Figure 3.6: Number of hospital admissions over time



In a similar fashion to the analysis conducted for emergency room visits, Figures 3.7 and 3.8 depict the distribution by sex and age group for patients who underwent at least one hospitalization from 2019 to 2022. Once again, the results are generally consistent with the overall profile of the entire patient cohort: individuals identifying as female marginally surpass 60% (60.83%), and a substantial majority of those who experienced hospitalization were aged over 65 (96.85%). The only rather surprising difference observed in this instance is the higher number of hospitalizations among patients aged 0 to 45 compared to those aged 46 to 65.

However, this difference is marginal and lacks substantial significance: to be precise, it constitutes 1.88% compared to 1.27% of the sample that experienced more than zero hospitalizations during the examined time frame.

Figure 3.7: Sex distribution for patients who had at least one hospital admissions

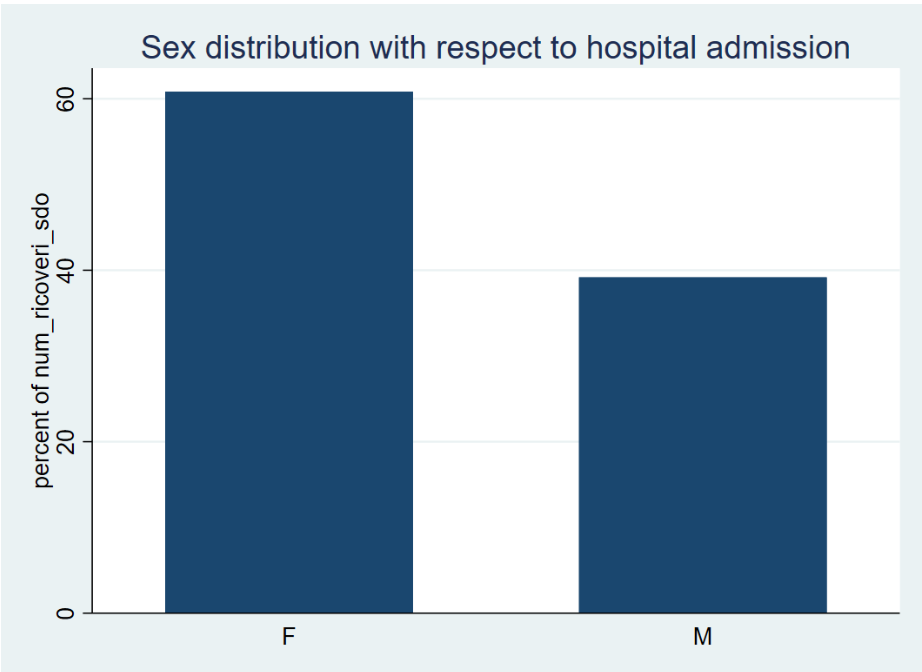


Figure 3.8: Sex distribution for patients who had at least one hospital admissions

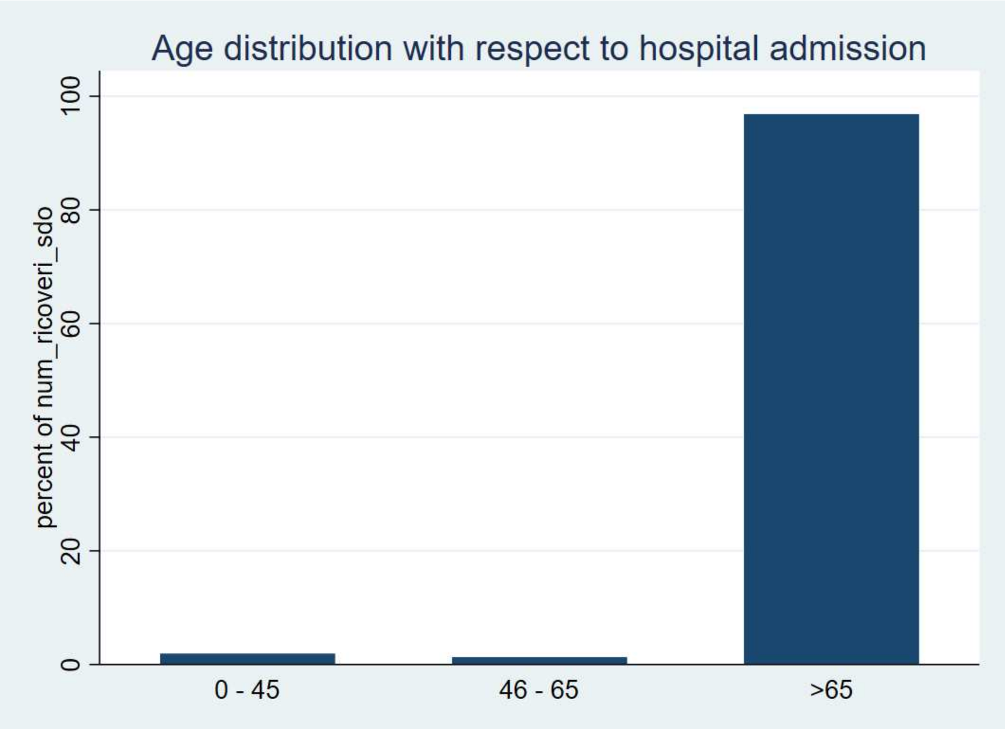


Table 3.2: Hospital admissions by sex and age.

Hospital admissions	Mean	Std. dev	Min	Max
Sex				
Female	0.2051114	0.4736547	0	5
Male	0.1923974	0.4688257	0	6
Age				
0-45	0.2386364	0.5755855	0	4
45-65	0.053719	0.2598108	0	3
>65	0.2064324	0.4765897	0	6

Table 3.2 provides an overview of hospital admissions by patient gender and age. It is interesting to note that the average hospital admissions by sex does not show a significant difference between males and females, with values fluctuating around 0.20. However, there is a slight variation in the standard deviation, indicating greater dispersion of data in female patients compared to male patients. In both groups, the

minimum number of admissions is 0 and the maximum number is 5 for males and 6 for females.

As regards age, the average number of hospital admissions is higher for the 0-45 group, followed by the over 65s and the 46-65 group. However, the first group has a significantly higher standard deviation, indicating greater variability in hospital admissions in this age group compared to the others. It should be noted that the maximum and minimum values indicate that, although the majority of admissions occur in a relatively low range, there are cases where the number of admissions may be higher, especially among individuals over the age of 65.

3.5 CHARLSON COMORBIDITY INDEX (CCI)

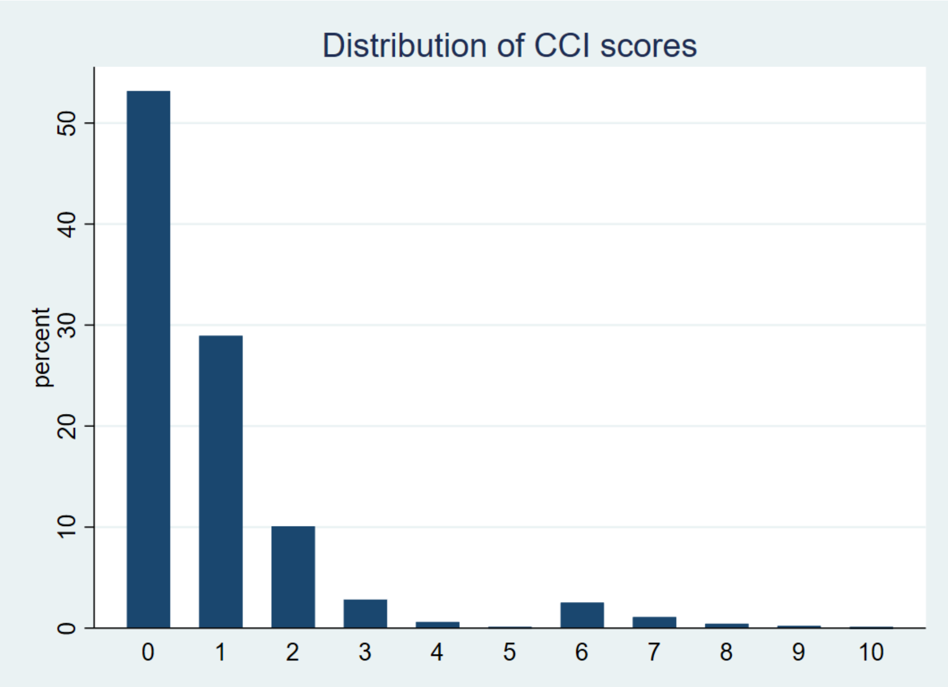
Another variable included on this study is the Charlson Comorbidity Index (CCI). The CCI is a tool used to measure comorbidity, a term introduced in scientific literature by Feinstein in the 1970s to indicate the presence of additional or coexisting medical conditions in an individual who already has an observed disease (Maroscia e Terribili, 2012). This index simplifies the complexity of comorbid conditions into a single numerical score (in this case from 0 to 10). In clinical practice, this score has found widespread application in clinical investigations and it aids healthcare providers in categorizing patients into different subgroups according to disease severity, shaping tailored care models, and allocating resources efficiently (Roffman et al., 2016).

Taking into consideration the dataset under study and observing the percentage distribution of scores obtained by patients with dementia and other cognitive disorders (Figure 3.9), the result may appear anomalous: despite the vast majority of individuals studied being elderly, 53.17% of them show no relevant comorbidities, assuming a score of 0. Considering the age and and to the fact that dementia can cause severe disability, a prevalence would be expected of a score even higher than 1 (Chen et al., 2016).

However, it is important to note that the calculation of the CCI score depends on diagnoses related to hospital admissions and emergency room visits. In the preceding paragraphs, these variables have shown low values compared to the overall population of the sample; thus, the obtained result is consistent (bearing in mind the negative impact of the health crisis in this regard).

The mean value of the Charlson Comorbidity Index score is 0.890 (indicating that each patient has, approximately, at least one additional comorbidity), with a standard deviation of 1.486 (confirming a high level of data dispersion). The observed scores ranged from a minimum of 0 to a maximum of 10.

Figure 3.9: Percentage values of CCI scores in the sample

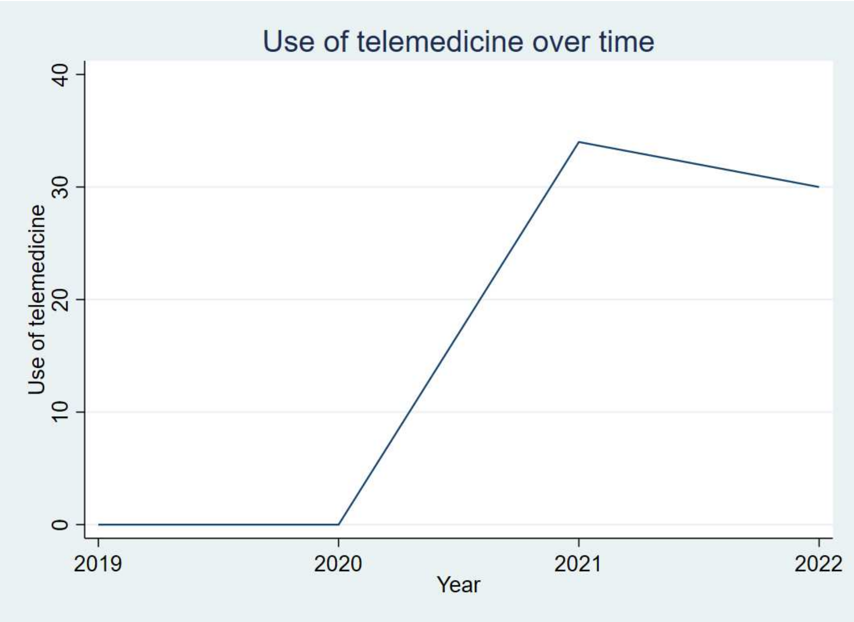


3.6 USE OF TELEMEDICINE

Before delving into the statistical description relating to the use of telemedicine for specialist visits related to dementia and cognitive disorders, it is essential to clarify that the data cleaning procedures have led to having a dataset composed exclusively of individuals affected by the pathologies examined. Consequently, this led to a reduction in the number of observations for this variable, which initially counted 98 remote visits in 2021 and 91 in 2022 (as explained above, no values are available for years prior to 2021). To ensure an adequate level of statistical significance, it was therefore decided to exclude from the sample all patients who underwent such visits even though they were not suffering from dementia, Alzheimer's or Parkinson's. After data cleaning, the total number of remote visits detected amounts to 64, of which 34 in 2021 and 30 in 2022. Extremely low numbers, compared to the size of the sample.

Considering a two-year time span (from 2021 to 2022), the average number of visits carried out is 0.0123, with a standard deviation of 0.110, with a minimum number of 0 and a maximum of 1 visits.

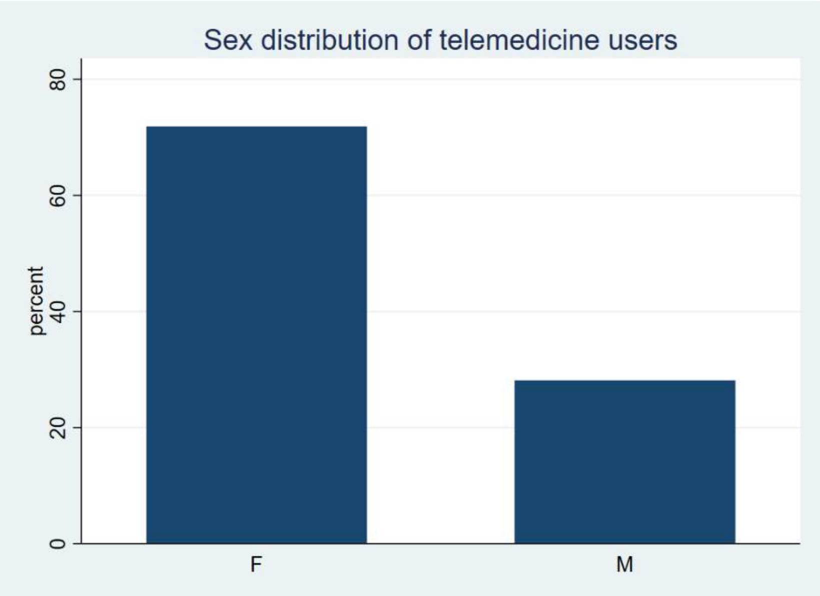
Figure 3.10: Number of telemedicine visits over time



It is important to take into account that the observations refer to the first and second year after the introduction of this technique: there may be an issue of unfamiliarity simply due to its novelty. Particularly, given the average age of the reference sample, it is plausible to assume a lack of familiarity with modern telecommunication systems, which may discourage usage (Mikula et al., 2024). Additionally, as previously stated, the use of telemedicine in this specific context is limited to the second follow-up visits. These are some of the potential reasons why the observed values are quite low.

Referring to the graph depicted in Figure 3.11, when considering exclusively the subset of patients who utilized telemedicine, a female predominance of 71.88% is observed.

Figure 3.11: Sex distribution of telemedicine users



From the same perspective, Figure 3.12 illustrates the age distribution among telemedicine users, highlighting a significant majority of individuals aged over 65 (98.44%) and the complete absence of the younger age group.

Figure 3.12: Age group distribution of telemedicine users

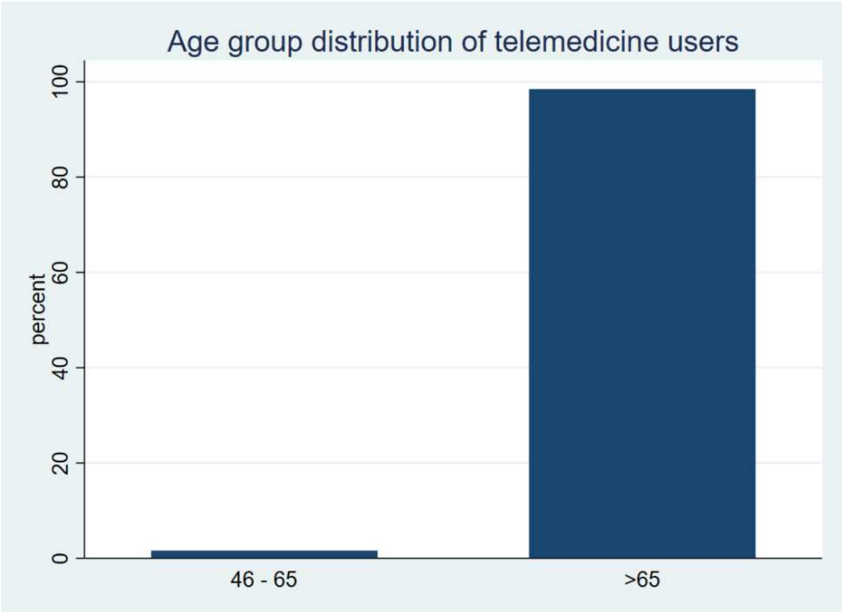


Table 3.3: Telemedicine visits by sex and age.

Telemedicine visits	Mean	Std. dev	Min	Max
Sex				
Female	0.0150721	0.1218597	0	1
Male	0.0083955	0.0912629	0	1
Age				
0-45	0	0	0	0
45-65	0.0041322	0.0642824	0	1
>65	0.012947	0.1130574	0	1

Looking at the mean values in Table 3.3, it can be seen that the average of telemedicine visits is higher for female patients than for males, with a value of approximately 0.015 for women and 0.008 for men. However, the standard deviation indicates greater variability in visit data for female patients than for male patients.

Regarding age, visits via telemedicine are more common among patients over the age of 65, with an average of approximately 0.013. Visits are less frequent in other age groups, with an average close to zero. However, the standard deviation indicates greater variability in visit data for patients aged 45 to 65 compared to other age groups. Of note, the maximum and minimum values indicate that the majority of visits are limited to a single event, with a few exceptions where multiple visits occurred, especially among patients older than 65 years.

4 ASL4 CASE STUDY: IMPACT OF TELEMEDICINE ON THE USE OF HEALTHCARE SERVICES

4.1 CHOICE OF MODELS

This final chapter will delve into the heart of the statistical and econometric analysis aimed at measuring and understanding whether there is indeed a significant connection between the utilization of telehealth assistance by the collected sample of patients suffering from dementia and other cognitive disorders, and a potential increase or decrease in their number of emergency room visits and hospitalizations from 2021 to 2022 (i.e. starting from the year in which telemedicine was introduced in ASL4). This will be achieved through the implementation of statistical models.

To conduct this study, two models were employed and compared for each dependent variable (emergency room visits and hospital admissions). First, a Poisson regression analysis fitted to the longitudinal data was performed. Longitudinal data refers to information collected over multiple time periods (with an annual time variable from 2021 to 2022) for the same individuals, whose observations are grouped into a panel variable representing patient identification codes. This model was chosen because it is suitable, as in this case, for dependent counting variables (i.e. variables that can only take on discrete values, such as 0, 1, 2, etc.) concerning the occurrence of any event within a fixed time period, making it ideal for behavioural studies of a population (Coxe et al., 2009).

The analysis of this model will not only involve observing the coefficients of the independent variables and their level of significance. The regression will also be conducted in terms of the incidence rate ratios (IRRs) for each variable. IRRs are generally a measurement tool used in epidemiology to compare two groups of populations, making a ratio between those who exhibit certain symptoms to the entire sample (Spronk et al., 2019). In this case, the model will compute this ratio for each independent variable (for example, those who underwent telemedicine visits compared to the total population).

The second model considered is a Zero-Inflated Poisson (ZIP) regression. This model resembles the features of the Poisson regression discussed earlier but differs in that the outcome is represented by two separate components: one that models the probability of excess zeros and another that accounts for non-excess zeros and counts different from zero (Loeys et al., 2012). This model is therefore suited for datasets with an excess of zeros, as indicated by the descriptive analysis in the previous chapter, where several variables in the study sample (including the one of primary interest concerning telemedicine) predominantly exhibit observations equal to 0. For this reason, including the ZIP model in this study may be beneficial.

For both models, the independent variables considered will be the use of telemedicine, the Charlson Comorbidity Index (CCI) score, the patient's sex (a dummy variable identifying female patients), age (a dummy variable indicating individuals over 65 years old) and, finally, the year (a dummy variable indicating individuals over 65 years old). variable identifying the observations relating to the year 2022).

4.2 EXPECTED RESULTS

It is quite complicated to imagine the results that can be expected from this study, since it is highly specific in its context and variable depending on the social and national contexts of different health systems. A further complication arises from the historical context in which this study is placed, adjacent to the pandemic, a period of great uncertainty and crisis for all healthcare systems worldwide. Furthermore, it is necessary to take into account (as already mentioned) the fact that telemedicine still represents a novelty in Italy (or at least in the time frame taken into consideration), which is why observations are still few.

To formulate expectations, several articles were consulted regarding this relationship. Among these, one particularly noteworthy study conducted by Ayesha Jamal and published in 2023 is worth considering. This study employed a machine learning approach to examine the effects of telemedicine on healthcare expenditures and utilization, focusing on a sample of patients diagnosed with chronic mental illnesses.

Among the results of various tests conducted in this article, it emerged that the use of telemedicine is associated with an increase in outpatient care utilization, a result similar to another study conducted by Dahlgren et al. in 2024 (in which it is found that telemedicine appointments tend to increase the total number of medical consultations in the context of primary healthcare). However, substantial changes in medical spending or an increased likelihood of emergency department visits or hospitalization were not observed. According to this study, there is no significant evidence that the use of telemedicine is associated with an increased probability of emergency department visits or hospitalization. However, as indicated in Jamal's article, the study refers to a timeframe from 2009 to 2018, predating the pandemic. This latter detail, along with the different national context compared to that of Liguria and the model used, may prove decisive in obtaining different results in the study within this thesis.

4.3 HOSPITAL ADMISSIONS MODELLING

Below, the Poisson regression output for the dependent variable 'hospital admissions' is shown (Table 4.1), indicating the standard error (in brackets) and the significance level.

Table 4.1: Poisson regression output for hospital admissions

VARIABLES	(1) Hospital admission
Telemedicine	0.757***
	(0.199)
CCI	0.139***
	(0.0163)
Female	-0.0467
	(0.0655)
Age over 65	0.136
	(0.170)
Year 2022	0.109*
	(0.0646)
Constant	-1.891***
	(0.174)
/lnalpha	-15.64
	(702.5)
Observations	4,604
Number of id_patient	2,302

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

First, it can be observed that the independent variable of primary interest, representing telemedicine visits, is highly significant at a 1% significance level ($p < 0.01$), yielding a positive coefficient of 0.757. This implies that the number of hospitalizations for an individual who underwent a telemedicine visit is 75.7% higher than for someone who did not undergo such visits (other being factors equal). Similarly, regarding the Charlson Comorbidity Index (CCI), the coefficient is positive and significant at the 1% level of significance: an increase of one unit in the Charlson CCI is associated with a 13.9% increase in the number of hospitalizations, holding the other variables in the model constant.

The variable relating to patient sex (Female) has a negative coefficient of -0.0467 but is not statistically significant, suggesting that female sex does not have a significant impact on the number of hospitalizations.

The coefficient of 0.136 for being in the over 65 age group is not statistically significant, indicating that age over 65 may not have a significant impact on the number of hospitalizations, controlling for other variables in the model.

Regarding the variable Year 2022, the positive coefficient of 0.109, significant at a significance level of 10% ($p < 0.1$) suggests that the year 2022 is associated with an increase in the number of hospitalizations. However, this is a weak level of statistical significance.

The constant term has a highly significant negative coefficient ($p<0.01$) of -1.891, indicating the expected number of hospitalizations when all other variables in the model are zero or irrelevant.

The coefficient of the term '/lnalpha', representing the natural logarithm of the scale parameter of the Poisson distribution, is negative, suggesting a potential effect of reducing the dispersion of data around the mean, but it is not statistically significant.

Table 4.2: Poisson regression output for hospital admissions, considering incident rate ratios (IRR)

VARIABLES	IRR Hospital admissions
Telemedicine	2.132***
	(0.424)
CCI	1.149***
	(0.019)
Female	0.954
	(0.062)
Age over 65	0.146
	(0.195)
Year 2022	1.115*
	(0.072)
Constant	0.151***
	(0.026)
/lnalpha	-15.64
	(702.5)
Observations	4,604
Number of id_paziente	2,302

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.2 shows the output of the same regression but considering the incident rate ratios (given by the exponential of the regression coefficient associated with the independent variable). Naturally the significance levels indicated will be the same.

The highly significant IRR related to telemedicine use of 2,132 suggests that an individual who has had a telemedicine visit has, on average, a hospitalization rate that is increased by 113.2% compared to those who have not had such visits.

The IRR, strongly significant, of the CCI score of 1.149 indicates that a one-unit increase in the Charlson CCI is associated with a 14.9% increase in the hospitalization rate, holding other variables in the model constant.

As regards sex and age, with incident rate ratios of 0.954 and 1.146 respectively, there is no significant impact on the hospitalization rate.

The IRR relating to the dummy associated with the year 2022, of 1,115, would indicate an increase in the hospitalization rate of 11.5% compared to the previous year.

In this case, the constant represents the expected hospitalization rate when all other variables in the model are held constant or at their reference levels. Since its IRR (highly significant) is less than 1, this will indicate a negative relationship with respect to the dependent variable.

The Table 4.3 presents the results of the Zero-Inflated Poisson regression concerning the number of hospital admissions with respect to the same independent variables considered so far. The first column displays the coefficients of the variables, along with the robust standard errors and levels of significance. The second column relates to the 'inflate' function in STATA, where the variables used to model the probability of the count of admissions being zero rather than greater than zero are inserted. Therefore, in this section, the Telemedicine and CCI variables are included, as (also noted in the descriptive analysis in the previous chapter) they mostly contain values of zero for observations, thus resulting in a higher probability of zeroing the number of admissions.

Table 4.3: Zero-Inflated Poisson regression output for hospital admissions

	(1)	(2)
VARIABLES	Hospital admissions	inflate
Telemedicine	0.772*	0.232
	(0.405)	(1.861)
CCI	0.0869***	-1.723
	(0.0219)	(1.270)
Female	-0.0349	
	(0.0643)	
Age over 65	0.0825	
	(0.200)	
Year 2022	0.109	
	(0.0697)	
Constant	-1.611***	-0.929***
	(0.226)	(0.360)
Observations	4,604	4,604

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

With this model generally similar results can be observed, but with some differences. In particular, the Telemedicine variable maintains a positive effect, with a coefficient slightly higher than that obtained in the simple Poisson regression, and remains statistically significant, albeit with a significance level reduced by only 10%. As regards the "inflate" section, this variable has a positive coefficient of 0.232, but is not statistically significant. Therefore, it is reasonable to conclude that it does not have a significant role in determining the absence of hospital admissions.

As for the CCI variable, the level of significance remains high at 1%, with a coefficient of 0.0869 (still positive), slightly lower than the previous model. Regarding the 'inflate' section, the coefficient is negative (-1.723), but again, this variable is not significant in determining excess zeros.

In this model as well, the patient's sex and age do not appear to be statistically significant, with coefficients of -0.0349 (slightly higher than the previous model) and 0.0825 (slightly lower than the previous model), respectively.

The intercept of the model remains highly significant, with a significance level of 1%, indicating its strong influence on the predicted value of the dependent variable. Additionally, it is also significant at the 1% level regarding the probability of zero counts within the data. The negative sign of the coefficient (-0.929) suggests that, overall, there is a tendency towards a lower probability than average of observing zeros in the data when other variables in the model are not present or not relevant.

4.4 EMERGENCY ROOM VISITS MODELLING

Using the same methodology, in this paragraph the same models will be applied, shifting the focus to the second dependent variable under examination: the emergency room visits suffered by the sample of patients from 2021 to 2022.

Table 4.4: Poisson regression output for emergency room visits

	(1)
VARIABLES	Emergency room visits
Telemedicine	1.304***
	(0.372)
Female	0.0929
	(0.162)
Age over 65	0.987
	(0.602)
CCI	0.217***
	(0.0414)
Year 2022	0.0878
	(0.143)
Constant	-4.511***
	(0.609)
/lnalpha	0.740**
	(0.298)
Observations	4,604
Number of id_patient	2,302

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As evident from Table 4.4, regarding the simple Poisson regression for the panel data set, there is a similarity in the output compared to the modelling of hospital admissions, especially regarding the statistical significance of the coefficients. The Telemedicine variable appears in fact to be statistically significant, with a significance level of 1%, presenting a positive coefficient equal to 1.304: the number of visits to the emergency room for a subject who has undergone a telemedicine visit is 75.7% higher compared to those who did not undergo such visits, all other factors being equal.

This time, the coefficient of the variable related to the sex of the patient (0.0929) is positive, but still not significant.

The coefficient related to the age is positive (0.987), but not significant at any significance level.

The coefficient associated with the Charlson comorbidity index is positive (0.217) and, as in previous models, statistically significant at the 1% level: an increase of one unit in the Charlson CCI is associated with a 21.7% increase in the number of emergency room visits, holding other factors constant.

The time variable ‘Year 2022’ has a positive coefficient of 0.0878, but it is not statistically significant.

Finally, in this case as well, the intercept coefficient is negative (-4.511) and highly significant, at the 1% level. The coefficient for the natural logarithm of the scale parameter of the Poisson distribution, is positive (0.740), indicating that the independent variables would have a "dispersion-increasing" effect, and it is statistically significant at a 5% significance level: changes in the independent variables are associated with greater variation in the observed data.

Table 4.5: Poisson regression output for emergency room visits, considering the IRR.

VARIABLES	IRR Emergency room visits
Telemedicine	3.686***
	(1.373)
Female	1.0974
	(0.178)
Age over 65	2.684
	(1.616)
CCI	1.242***
	(0.051)
Year 2022	1.092
	(0.157)
Constant	0.109***
	(0.067)
/lnalpha	0.740**
	(0.298)
Observations	4,604
Number of id_patient	2,302

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Looking instead at Table 4.5, the highly significant Incidence Rate Ratio related to telemedicine use of 3.686 suggests that an individual who has had a telemedicine visit has, on average, an emergency room visit rate that is increased by 268.6% compared to those who have not had such visits.

The patient's gender and age exhibit an IRR greater than 1, implying a positive relationship with the dependent variable, with values of 1.0974 and 2.684 respectively. However, both are not statistically significant at any level of significance.

The IRR for the Charlson comorbidity index (1.242) implies a positive relationship and is significant at the 1% level: a one-unit increase in the Charlson CCI is associated with a 24.2% increase in the emergency room visit rate, holding other factors constant.

The IRR of the variable Year 2022 (1.092) shows a positive relationship with the number of emergency room visits, but it is not significant.

The constant, on the other hand, has an IRR less than 1 (0.109), implying a negative relationship and is significant at the 1% level.

Finally, moving on to the last model, Table 4.6 displays the output of the Zero-Inflated Poisson regression of the same dependent variables considered thus far, regarding the number of emergency room visits made by the patients examined from 2021 to 2022. In this case, it is possible to notice some differences compared to every other model considered so far.

The variable related to telemedicine usage exhibits a positive coefficient of 1.088 (with a smaller impact compared to that estimated by simple Poisson regression) is significant at the 5% level ($p < 0.05$). Furthermore, the negative impact on the probability of zeroing the number of emergency room visits, indicated by the coefficient -1.165, is not significant.

Surprisingly, the estimated coefficient for the CCI is negative (although low), yet it does not reach statistical significance. However, the coefficient related to the 'inflate' section is significant at the 5% level, negatively impacting the probability of zeroing the number of emergency room visits.

Similar to the Poisson regression, the coefficients for female sex, age, and the Year 2022 variable are positive (0.135, 0.548, and 0.0895 respectively), but they do not reach statistical significance at any level.

In this case as well, the intercept of the model is highly significant, with a significance level of 1%, indicating its strong and negative influence on the predicted value of the dependent variable (with a coefficient of -3.101). Additionally, it is also significant at the 1% level regarding the probability of zero counts within the data. The negative sign of the coefficient (-1.851) suggests that, overall, there is a tendency towards a lower probability than average of observing zeros in the data when other variables in the model are not present or not relevant.

Table 4.6: Zero-Inflated Poisson regression output for emergency room visits

	(1)	(2)
VARIABLES	Emergency room visits	inflate
Telemedicine	1.088**	-1.165
	(0.431)	(1.289)
CCI	-0.0422	-3.791**
	(0.0910)	(1.863)
Female	0.135	
	(0.163)	
Age over 65	0.548	
	(0.566)	
Year 2022	0.0895	
	(0.144)	
Constant	-3.101***	1.851***
	(0.648)	(0.438)
Observations	4,604	4,604

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5 CONCLUSIONS

As can be seen from the analysis carried out in the previous paragraph, the results obtained from both models used seem to share a common general trend both in terms of the number of hospital admissions and the number of emergency room visits. Indeed, considering all the results provided by the coefficients and their level of statistical significance, it is possible to conclude that the main factors significantly impacting both dependent variables in this study (in addition to the model intercept, which has a negative impact in all cases) are two: the first is represented by the variable of primary interest for this study, concerning the utilization of telemedicine visits, while the second is given by the Charlson Comorbidity Index (CCI) score. Both seem to positively influence both the number of hospital admissions and the number of emergency room visits for the sample of patients with dementia and cognitive disorders.

As regards the CCI, the result is not at all surprising: this index assigns a score to each individual to measure the severity of the patient's health conditions considering the presence of comorbidities, and it is natural that a progressive increase in additional pathologies compared to that main reference (i.e. as the score increases) requires greater use of health services. This implies a greater number of emergency room visits and hospitalizations to treat these pathologies and deal with more critical conditions of certain patients.

The results regarding telemedicine appear to be more interesting. The study took a different path than Jamal's, which served as a baseline for outcome expectations. The latter found no significant effects of telemedicine on hospitalizations and the number of visits. However, it was noted that focusing on the period before the COVID-19 pandemic could have limited a more accurate comparison with the current reality, overlooking potential regulatory changes in the healthcare system and incentives to promote telemedicine in recent years (Jamal, 2023). However, this study, together with that conducted by Dahlgren et al., arrived at a result partly similar to that of this thesis: the correlation between the use of telemedicine and the increase in the use of outpatient services and the number total number of medical consultations in primary care. Consequently, it is reasonable to conclude that telemedicine has a positive impact on access to healthcare services. This result may seem counterintuitive in some respects:

shouldn't a medical visit, even if remote, have a positive effect on patients, thus reducing hospitalizations and emergency room visits?

Considering that in the context examined, telemedicine mainly includes teleconsultation, televisit and health telecooperation services (Dijk, 2022), the result is consistent: the remote visit method has evidently favoured access to a greater number of visits and, overall, to health care services for vulnerable individuals, often with mobility or transport difficulties that hinder in-person visits to hospitals or centres of ASL4. By expanding the possibility for these patients to undergo medical visits, it is plausible that they have acquired a deeper awareness of the conditions requiring treatment, consequently leading to an increase in hospitalizations and emergency room visits, as highlighted by the models analysed in this chapter.

Finally, this result would seem to confirm what was stated in the first half of this thesis: in most cases, at the moment telemedicine cannot be considered as a substitutive alternative to traditional medical services, but rather as an effective and integrative complement, especially in contexts in which its adoption is guided by a careful assessment of the patient's needs and available resources, with the aim of optimizing access to health services and improving the quality of care provided.

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