Transforming lives and the Healthcare Business

Remote patient 5G-IoT Technology monitoring solution for the Home Hospitalization service

The Portuguese case

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Title: Transforming lives and the Healthcare Business
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Abstract

Nowadays, we live in an evolutionary world driven by technology and reliant on internet connectivity. 5G is the new cellular wireless technology imminent in the market, and it's expected to enable innovation and transformation across many vertical industries. One of the most promising is the Healthcare industry once it's facing an enormous digital and structural transformation. While a new business model is emerging (VBHC), new ways of providing care are also evolving, as the Home Hospitalization service. Portugal is following the global market trends, thus, recently, the government created a financial incentive to encourage the service deployment across public hospitals with the aim of reducing the hospitalization costs, the bed shortage crisis, and enhancing care quality and patients' satisfaction. Consequently, many hospitals across the country are implementing the service. Therefore, this dissertation's topic arise, with the aim of accessing, whether 5G-IoT Technology's use in a remote monitoring products' kit, for the Home Hospitalization service represents a real Business Opportunity. A cross-sectional descriptive-exploratory research was performed through 6 in-depth expert interviews and 3 online surveys to understand the different stakeholders' perspectives regarding the service proposed. The results showed a great interest from all the inquired: 82% of Hospital Managers claimed a great interest in acquiring; 75% of the general population stated that was very likely they would choose it; and 88% of Healthcare Professionals agreed that its integration in the HH service was useful. Accordingly, it was concluded that the Portuguese market has great potential.

Keywords: 5G-IoT Technology, Home Hospitalization Service, New Business Opportunity; Remote Monitoring Medical Devices

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Resumo

Atualmente, vivemos em constante evolução, impulsionados pela tecnologia e dependentes da conectividade. O 5G é a nova tecnologia de comunicação móvel iminente no mercado, e espera-se que potencialize a inovação e transformação digital de muitas indústrias verticais. Uma das indústrias mais promissoras é a da saúde, porque está a experiênciar uma enorme transformação digital e estrutural. Um novo modelo de negócio e novas formas de prestar cuidados de saúde estão a emergir, como a Hospitalização Domiciliária. Portugal está a seguir as tendências do mercado global e, recentemente, o governo criou um incentivo financeiro para encorajar a implementação deste serviço em hospitais públicos com o objetivo de reduzir custos com hospitalização, fazer face à falta de camas e melhorar a qualidade dos serviços e a satisfação dos pacientes. Consequentemente, muitos hospitais em todo o país estão a implementar o serviço. Assim, surge o tema desta dissertação, que visa estudar a oportunidade de negócio que o uso da tecnologia 5G-IoT poderá trazer se incorporada num kit de produtos de monitorização remota. Desta forma, foi executado um estudo descritivo-exploratório com 6 entrevistas e 3 questionários online, para tentar compreender as perspectivas dos diferentes intervenientes no serviço. Os resultados demonstram um grande interesse por parte de todos os inquiridos: 82% dos gestores hospitalares alegaram um grande interesse em adquirir; 75% da população geral afirmou que era muito provável escolherem; e 88% dos profissionais de saúde concordaram que sua integração no serviço era útil. Assim, concluiu-se que o mercado português tem um grande potêncial.

Palavras-chave: 5G-IoT Technology, Home Hospitalization Service, New Business Opportunity; Remote Monitoring Medical Devices

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HH – Home Hospitalization
VBHC – Value-Based Healthcare
TH – Traditional Hospitalization

1. Introduction

1.1 Background Trends

Currently, we live in a dynamic, fast-paced, digital world driven by innovation (Deloitte, 2013a) on the edge of an evolutionary era towards Networked Society (Ericsson, 2016). Hence, customers are increasingly demanding for "speed, convenience, contextualization and non-stop connectivity" (World Economic Forum & Accenture, 2016). Consequently, a new generation reliant on internet connectivity is emerging, Generation C ("connected, communicating, content-centric, computerized, community-oriented" generation) (PWC, 2010).

In this unprecedented atmosphere of dynamic change (Deloitte, 2013a), strategic planning is harder and continuous strategic innovation is a success requirement (D'aveni, Battista Dagnino, & Smith, 2010). Action-reaction relationships among competitors (Hoskisson et al., 1999) led strategy to be now a set of dynamic manoeuvres towards "continuously matching the rapid evolution of the firm with a rapidly evolving environment" (D'aveni et al., 2010). Necessarily, innovation and strategy have become complementary tools to create competitive advantages and new business opportunities, increasing profitability and boosting growth. Companies' capacity to innovate, to provide new and enhanced services/ products, is now the key enabler for value creation and long-term success (Dobni, 2010). Incumbent firms perish when get exhausted of continuous transformation and innovation, get complacent by success, trusting in inexistent sustainable advantages, or fear self-cannibalization ending up in a "*blinded and myopic*" inertia (D'aveni et al., 2010). Therefore, in today's world, to triumph, a firm must manage its temporary volatile advantages, anticipate the market and self-displace the industry's leadership, incessantly innovate and look for new business opportunities, once products, resources and capabilities have a short life cycle (D'aveni et al., 2010).

A new cellular wireless technology network is imminent, 5G, and its deployment is expected to enable one of the largest waves of innovation, transformation and development ever seen (AT&T Business, 2019; Deloitte, 2017; McKinsey, 2018a), the *fourth industrial revolution* (World Economic Forum & Accenture, 2016). Its combinatorial effects with the different technologies arising in the market are exponentially accelerating the pace of change (Exhibit 1) by providing supreme opportunities for value creation across multiple industries (World Economic Forum & Accenture, 2016). Therefore, operators will be able to capitalize significant new revenues on other industries' digital transformation and growth (PWC, 2010). Among the most promising vertical industries' transformations is the Healthcare sector's

disruptive progress, as this sector isn't only facing an enormous digital transformation but is, as well, undergoing a great structural transformation (Deloitte, 2018a; KPMG, 2016).

1.2 Problem Statement and Research Questions

This dissertation's main purpose is to access, from a strategic management view, whether 5G-IoT Technology's use in a remote monitoring products' kit, for the Home Hospitalization (HH) service, represents a real Business Opportunity in the Portuguese market. By providing an evidence-based insight, one will study the Portuguese market potential and acceptance degree regarding the proposed new hospitalization service. Particularly, three different perspectives will be tested (Portuguese hospital managers; healthcare professionals; and possible future patients (end-users)), once only the combination of interests can lead to a business opportunity. Specifically, the following research questions will be answered:

- **Research Question 1:** *What are the current challenges of HH service in Portugal?*
- **Research Question 2:** *Can 5G-IoT Technology fulfil today's HH service challenges?*
- **Research Question 3:** *Can 5G-IoT Technology enhance the HH service through the creation of a remote patient monitoring products' kit?*
- **Research Question 4:** *Are Portuguese Hospitals interested in acquiring new remote patient 5G-IoT Technology monitoring solutions for the HH service?*
- **Research Question 5:** *Is the Portuguese population interested in using the HH service with a 5G-IoT based remote monitoring products' kit?*

1.3. Academic and Managerial Relevance

First and foremost, this master dissertation findings provide a preliminary evidence of the business opportunity existence in the use of 5G-IoT technology in the HH service, by doing an evidence-based experimental test reinforcing its usability in current days. Furthermore, it contributes to the development of the entrepreneurship and strategy literatures, once it provides great novel evidence that not always background matters when perceiving a business opportunity, since people with different knowledge backgrounds agreed there is a business opportunity in the new service proposed, bringing the literature forward.

1.4. Scope of Analysis

This master's dissertation was sponsored by Vodafone Portugal, therefore, the study will be run for the Portuguese market. Vodafone Group is one of the world's largest telecommunications companies. It operates in 30 countries and has more than 500 million customers worldwide. Innovation and transformation, by means of creating a better world and empowering people, are in its DNA (Vodafone, 2019c). Vodafone wants to intelligently and securely connect places, people, information and things, to deliver reliable solutions, and to transform and improve customer experience (Vodafone, 2019a). Vodafone is the worldwide Telecom leader in IoT technology for 'Managed M2M Services', being the highest operator positioned for 'ability to execute' and 'completeness of vision' (Exhibit 2) (Gartner, 2018). Like many other operators around the world, Vodafone Portugal is preparing to invest heavily in 5G spectrum. Consequently, this dissertation' primary aim is to identify a new and profitable revenue source that benefits from both technologies, in order to, achieve a faster return to the future investment, showing that there is a business opportunity inherent to these technologies' use. Since the Healthcare industry is undergoing a transformation towards digitalisation and great returns are expected, the request was to investigate the business opportunity within this industry.

1.5. Methodology: Research Methods

Once this dissertation is testing a new service in the market, both qualitative and quantitative data were gathered, through in-depth expert interviews and online surveys, respectively. This dissertation will follow a *cross-sectional descriptive-exploratory research*.

1.6. Dissertation Outline

This dissertation is structured as follows:

First, in the Literature Review, an overview of the two markets under study (Telecommunications and Healthcare) was carried out. Subsequently, a brief analysis of the HH service and 5G technology was performed. Then, a specific section for the Portuguese context analysis was made. Secondly, in the methodology chapter, the research and data collection methods in addition to the instruments used, were presented. Thirdly, in the results' analysis chapter, the data collected was rigorously analysed in order to respond to the research questions defined in the introduction chapter. Finally, in the last chapter, the conclusions, limitations and future research suggestions were made.

2. Literature Review

For the development of this literature review, whenever possible, sources from top management, healthcare, technology, innovation and entrepreneurship journals were used. Nevertheless, little research has been carried out regarding this topic. Therefore, to ensure the information reliability, the rest of the papers used are from large companies known in the market for having great knowledge-based experience.

2.1 Business Opportunity

For many years, numerous scholars have done research regarding 'Business Opportunity', due to its central role in the strategic management and entrepreneurship literatures. All studies done fall into three main interconnected topics: Discovery & Formation; Evaluation; and Exploitation. However, this dissertation will only address Discovery & Formation.

According to the literature, strategy is the ongoing process of aligning the organizational resources (competences and resources) with the external environmental opportunities and threats (Venkatraman & Camillus, 1984). Moreover, entrepreneurship is "an activity that involves the discovery, evaluation and exploitation of opportunities" (S. A. Shane, 2003), aiming to generate future goods and services (Choi & Shepherd, 2004; S. Shane & Venkataraman, 2000), enter into new markets, or create new ventures (McMullen & Shepherd, 2006). In this sense, a new business opportunity must be "attractive, durable, and timely", in addition to create or add value for the buyer or ultimate user (Craig & Lindsay, 2002). Therefore, entrepreneurship is a part of strategy. Existing firms in the market strive to find business opportunities. According to Chandler (quoted in (Venkatraman & Camillus, 1984)), there are four main growth business strategies: 'Volume expansion'; 'Geographic dispersion'; 'Vertical integration'; and 'Diversification' to meet market opportunities. In this sense, "individuals, small firms, large firms, new firms, old firms, family firms, and publicly traded firms" can all be entrepreneurial (Alvarez, Barney, & Anderson, 2013).

2.1.1. Business Opportunity: Discovery & Formation

The main goal with business opportunity discovery and formation is to identify new sources of valuable economic wealth (Kirzner, 1997). This process is a function of three criteria: the 'nature of the opportunity', the 'nature of the entrepreneur', and the 'nature of the decision-making context" (Alvarez & Barney, 2007; S. Shane & Venkataraman, 2000). Depending on these 3 criteria, there are two major theories for business opportunity discovery and formation process: the 'discovery' and the 'creation' theories (Barreto, 2012). There is also a third theory, less addressed called: 'recognition' theory (Baron & Ensley, 2006).

All theories recognize the same definition of Business Opportunity and are based on the premise that entrepreneurs who work on these Business Opportunities have intrinsic individual characteristics and different access to knowledge and information, making them the perfect candidates for its exploitation. The Business Opportunity definition remotes to the 'neoclassical economic theory', which suggests that under conditions of perfect competition economic actors (individuals or firms) can't generate economic wealth (Alvarez et al., 2013; Venkataraman, 1997). Therefore, a business opportunity occurs in disequilibrium conditions (Kirzner, 1997), and is a 'competitive imperfection' in the market which allows the creation of potential economic wealth (profits) (Alvarez & Barney, 2007; Alvarez et al., 2013; Venkataraman, 1997). However, they differ when it comes to "the origin of these competitive imperfections" (Alvarez & Barney, 2007).

The discovery theory was the most discussed in the literature (Alvarez & Barney, 2007), and follows the objectivist perspective (Wood & Mckinley, 2010). The theory argues that a competitive market imperfection is a "temporary absence of full adjustment between input and output markets" (Kirzner, 1997), and can be represented by "inefficiencies within existing markets" (Venkataraman, 1997), changes in political, economic, social, technological, legal and environment (Alvarez et al., 2013; Barreto, 2012; Venkataraman, 1997), as well as, "new knowledge" creation from fresh inventions and discoveries (Venkataraman, 1997). These market inefficiencies are formed by exogenous market shocks and then discovered by entrepreneurs exogenously, being formed and exploited afterwards (Alvarez & Barney, 2007; Alvarez et al., 2013; S. A. Shane, 2003). Therefore, opportunities are created independently of the entrepreneur and exist objectively in the market (Wood & Mckinley, 2010).

The creation theory is based on a constructivist perspective (Wood & Mckinley, 2010). It states that a 'competitive imperfection' in the market is formed endogenously and created by entrepreneurs' actions. As a result, business opportunities don't exist independently of human perceptions and actions and only exist after being created by an entrepreneur (Alvarez et al.,

2013). They begin as ideas, both desirable and feasible regardless of the entrepreneur's resources, rather than objectified opportunities in the market (Wood & Mckinley, 2010). Accordingly, "rather than searching for a clear opportunity to be exploited" in the market, entrepreneurs "engage in an iterative learning process" that leads to opportunity creation (Alvarez & Barney, 2007). This learning process consists of testing in the market the entrepreneur's beliefs regarding a perceived business opportunity, as entrepreneurs create business opportunities based on their social constructions (prior beliefs) (Alvarez et al., 2013). This 'sensemaking' can be done through market research and "peer group's knowledge base business opportunity idea objectification" (Wood & Mckinley, 2010).

The recognition theory suggests that the discovery of a 'competitive imperfection' in the market involves 'pattern recognition', which is "the cognitive process through which individuals identify meaningful patterns in complex arrays of events or trends" (Baron & Ensley, 2006). It claims that entrepreneurs "discover opportunities through recognition rather than search" due to their prior knowledge (Corbett, 2007). Examples of events and trends are: advances in technology, changes in markets, and shifts in government policies. In this new business opportunities' discovery process, entrepreneurs identify opportunities through interpretation (Dutton, Fahey, & Narayanan, 1983), using their unique acquired life experience and relevant cognitive frameworks to establish connections and detect patterns between apparently independent and unrelated events and trends, "suggestive of new products or services" (Baron & Ensley, 2006). This theory suggests that any individual involved in the entrepreneurial context, who has the "knowledge and/or know-how", will universally recognize the business opportunity's existence, "if not for them, then for" others. This recognition process has two phases: "the generic opportunity recognition phase and the situational opportunity recognition phase" (Craig & Lindsay, 2002). While the first phase regards the opportunity identification, the second one respects its fit against situational criteria. Then, a business opportunity is worth following if it is "in strategic alignment with the corporation" and "in an attractive market", which "the corporate entrepreneurial team" understands and knows (Craig & Lindsay, 2002).

Concluding, after analysing the three theories, one chose to base this dissertation's business opportunity discovery and formation in the recognition theory. Thus, justifying the existence of a business opportunity through pattern's recognition and respective match between the market trends of the two industries under study.

2.1.2 Business opportunity in a Technological environment

The emergence of new technologies is an important source of innovation, performance enhancement and, thus, wealth creation, enabling countless business opportunities. However, before exploring the predictable inherent value of exploiting a new technology, entrepreneurs must identify the markets in which their technology meets customer demands (Gruber, MacMillan, & Thompson, 2008). However, while sometimes technology is designed only for a particular application area, there are times where the same technological functionality is envisioned to enable value creation across multiple use cases in different markets (Markides & Williamson, 1996). In these cases, market opportunity identification, which is the creation of a link between technological resources and market needs, is crucial for entrepreneurs to choose the most favourable market conditions to implement the business opportunity. The importance of studying the market characteristics lays on its great impact on the potential earnings (Gruber et al., 2008). The goal is to reduce uncertainty and risk in the decision-making of whether to pursue a business opportunity in a specific market.

2.2 Telecommunications sector Overview

Since its creation, in the 20th century, until the present days, the telecommunications' industry underwent tremendous progress, growth and several structural and environment transformations, going from local monopolies to high competition and new entrants from adjacent businesses (Deloitte, 2014). Telcos always had a very important and central role as main drivers of society's development and evolution (McKinsey, 2017b), transforming "every facet of life", the way we "work, learn, travel, shop, and stay connected" (BCG, 2015). However, not always were able to capitalize on fair returns (Capgemini, 2017; PWC, 2017). Nonetheless, its impact today is no different. According to the estimate made by the GSMA association, in 2016, this industry, conjointly directly and indirectly, through its impact on society, "made a contribution of approximately $3.3 trillion in value-added terms, equivalent to 4.4 percent of global GDP" (McKinsey, 2017b).

Currently, new technologies are creating new business opportunities for operators, once they rely on connectivity to operate, but also, some advanced data analytics techniques, as machine learning, artificial intelligence and network equipment, are improving operators' cost structure, leading to great cost savings (McKinsey, 2017a, 2017b). Despite only providing a short-term competitive advantage, costs' reduction can enable Telcos to invest in new sustainable revenue sources (McKinsey, 2017b). As the value of connectivity gained appreciation in new sectors (Capgemini, 2017), such as "automotive, banking, consumer

packaged goods, education, energy and utilities, government, healthcare, insurance, manufacturing, mining, public sector, retail, transportation and logistics as well as smart home" (Czarnecki & Dietze, 2017), due to the age of the digital consumer and digital economy, new business opportunities start emerging for operators (Capgemini, 2017). Thus, value creation start moving to other stages in the value chain and into completely different markets, and Telcos have turned into "large complex organizations with multiple layers" (Capgemini, 2017).

The telecommunications value chain has now four major strands: 'Basic Communications'; 'End User Applications'; 'M2M Applications'; and 'Professional Applications' (Czarnecki & Dietze, 2017). In these vertical markets, Telcos new revenue streams are mainly related to Cloud-based and Machine-to-Machine (M2M) solutions (Czarnecki & Dietze, 2017). Accordingly, IoT technology is the next major new industry trend and will enable the creation of a fully connected, intelligent world (Capgemini, 2015) (Appendix 1). However, very high up-front investment needs, lack of vertical knowledge, capabilities and scale, the struggle to meet customer demands and global competition, make it hard to succeed. Consequently, operators are moving from a 'product-centric' to a 'customer-centric' approach. While, previously, the focus was to create and offer a commonly used product/ service, now the strategy is to design "customized solutions, tailored to the needs of each customer or customer-segment, which could be a specific vertical industry", competing, thus, with unique and differentiated services (Czarnecki & Dietze, 2017). Finally, clever partnerships, acquisitions and strategic investments will be the key drivers to the industry long-term success (Czarnecki & Dietze, 2017) in a "hyper-connected world" (ITU, 2013). In an IoT context, the position that the operator adopts in the value-chain will be crucial to its success (Appendix 3). But still, today's IoT's adoption is very below the expected due to some challenges (Appendix 2) it is facing. Among these challenges is the need for a new communication technology, which enables greater network capacity and interoperability (Deloitte, 2018b, 2018d; McKinsey, 2014, 2015; Vodafone, 2017).

2.2.1 5G Technology

5G is the fifth generation of cellular wireless technology network (AT&T Business, 2019a; Deloitte, 2017b; McKinsey, 2018a) and its emergence is inevitable (Boccardi et al., n.d.). As its "developments and improvements didn't cease" yet (Andrews et al., 2014), it is expected to appear in the market around 2020 (Politis et al., 2016). Despite its standards not being yet clearly defined (Politis et al., 2016), it is already clear that 5G isn't "an incremental advance on 4G" (Andrews et al., 2014). The reason why 5G is such a disruptive technology with so many already known use cases (Huawei, 2016), is that while in previous communication technology generations the technology was design first and then possible use cases were studied, 5G technology design was thought in collaboration with vertical industries, thus bringing to the market the exactly demanded capabilities (Arthur D. Little, 2017). Hence, it is believed that 5G will enable great digital transformation in multiple vertical industries, being, therefore, considered to be the major driver of the *fourth industrial revolution*. The expected 5G technology technical features are the following:

1	Ultra-low latency: 1-10ms	9	Reduced cost: mmWave spectrum 10–100x cheaper per Hz
2	Ultra-high reliability: <1 out of 100M packets lost (99.999%)	10	Mobile data volumes: 1,000x greater
3	Strong security and resilience	11	Battery life of remote cellular devices stretched to 10 years or more (1/10x in energy consumption) – Increased energy efficiency
4	Higher data rates and lower delay: up to 100x faster (more than 10 Gbps); ≥ 50 Mb/s	12	Higher capability: (1 mln per 1 sq. km)
5	Mobility & speed: ≥ 500km/h for ground transportation	13	Possibility of use of several bands from 400 MHz to 100 GHz
6	Capable of IoT terminals ≥ 1 trillion	14	1,000x in number of connected devices reaching a density ≥ 1M terminals/km^2
7	High-rate coverage	15	Position accuracy: 10m -< 1m
8	Highly integrative with LTE and WiFi	16	High bandwidth

Table 1: 5G's expected technical features - (5G PPP, n.d.; Andrews et al., 2014; Arthur D. Little, 2017; Compagnucci, Porta, Marcotullio, & Massaro, 2016; Politis et al., 2016)

Summarizing, 5G will enable the ubiquitous continuous connection, real-time communication with no perceived delay (fast speed and low latency), in addition to energy efficiency, great data volume, critical services, secure network and IoT massification (high capacity to carry massive number of connections simultaneously) (Deloitte, 2017b; McKinsey, 2018a). Moreover, a great benefit of 5G is the network flexibility. For each type of use case the network can adapt and provide exactly the application's requirements (Andrews et al., 2014). The are 3 main 5G use cases (McKinsey, 2018c):

- ***enhanced Mobile Broadband* (eMBB):** which encompasses all the applications that need faster speed, lower latency, and greater capacity;
- ***massive Machine Type Communications* (mMTC):** which include all machine to machine communications, having higher capacity, "up to one million per square kilometre, at very low power");
- ***Mission Critical Control*:** which are ultra-reliable and low latency communications (as medical devices).

Because the development costs of 5G technology ("spectrum, radio access network (RAN) infrastructure, transmission, and core networks") for telecommunication companies are very high (McKinsey, 2018c), it is essential to find easy to implement use cases with high yields and low incremental costs. However, similarly to what had already happened with other IoT projects and explained previously, the potential that 5G can bring to operators is dependent on the type of business model they are able to implement, in addition to the position they take in the value-chain.

There are 3 positions that operators can occupy: Network developer and connectivity provider; Service enabler (which accumulates the positions of connectivity provider and digital integrative platforms' developer); and Service creator (which is responsible for the activities previously mentioned in addition to creating new digital services). Accordingly, to yield the desired returns on investment, operators need to design new B2B2X business models and carry out the most integrative position in the value-chain (service creators). This business model is based on providing solutions to vertical industries that then sell the solution to end-users (Ericsson, 2017).

There are 10 industries where 5G is believed to have multiple use cases: Agriculture; Energy and utilities; Manufacturing; Public safety; Healthcare; Public transport; Media and entertainment; Automotive; Financial services; and Retail. According to Ericsson and Arthur D. Little, the expected potential aggregate revenues across these industries for ICT players is USD 1, 307 billion, which 12% is earmarked for the Healthcare industry (Ericsson, 2017).

Having this industry so much potential and so little research on it, the potential of 5G integration on it will be studied.

2.2.2 Portuguese Telecommunications market context

The Portuguese telecommunications' market has followed the world trends and patterns illustrated above (Anacom, 2016). 95,7% of the people residing in Portugal are customers of the mobile service, and 70% are effective internet users (Anacom, 2018). In Portugal, there are three main players in the Telecom industry: Altice (MEO); Vodafone; and NOS. Each of them has respectively 42,7%, 30,3%, and 24,7% market share (Anacom, 2018). The operating revenues of these three operators are decreasing as the consumption of traditional voice and SMS traffic is declining, while the use of OTT services increases (Anacom, 2016). Therefore, due to the deployment of new communication technologies, as 5G, and its applicability to vertical industries, operators are looking for new revenue streams to capitalize from other industries' digital transformation and grow.

2.3 Current Healthcare Sector Global Overview

The healthcare sector is one of the largest and most important in the world, corresponding, in Europe, to 9-10% of national Gross Domestic Product (GDP) (5G PPP, n.d.). Currently, this sector is facing a great transformational and disruptive phase worldwide (5G PPP, n.d.; Ericsson, 2017). For some years now, the sector's major concern has been its embedded high costs, especially related to the greater cost share which is associated with hospitalization (J. Eapen & H. Jain, 2017). Additionally, new socio-demographic trends are reshaping the industry. Better living conditions, associated with better lifestyles and better healthcare services provided are leading to increased average life expectancy. However, the growing aging population isn't illness free. The increase in the number of care dependent people with chronic diseases are further increasing the industry's costs (Deloitte, 2018a), as well as creating a bed and physicians shortage crisis, causing hospitals to struggle to cope with demand (Deloitte, 2018a; Orsini et al., 2014). Moreover, it is estimated that global spending will continue to grow at an annual rate of *5.4%*, culminating in *USD $ 10,059 trillion* in 2022 (Deloitte, 2019).

On the other hand, patients, which are more informed than ever, aren't only demanding for better treatment experiences and personalized services, but also interested in being empowered and actively engaged in their treatment process (Deloitte, 2019). Finally, as in all activity sectors, the healthcare sector is also being impacted by technological progress.

Technology advances such as "blockchain, cloud-based computing, virtual health, AI and robotics, digital reality, and the Internet of Medical Things (IoMT)" are greatly improving treatment methods and revolutionizing the way healthcare is provided (Deloitte, 2019). Consequently, innumerable business opportunities and new trends are emerging in the market. Among this new trends are the Health 4.0, the Connected Health (cHealth) (PwC, 2019), the Mobile Health (m/e-Health) (Politis et al., 2016), the Telehealth (Huawei, 2016), the use of Wearable Devices for real-time Remote Monitoring (Arthur D. Little, 2017; AT&T Business, 2019a), the Smarter Medication and Medicine Administration, and the Remote Surgery (5G PPP, n.d.).

To address these challenges, a new business model has emerged: *Value-Based Healthcare* (VBHC). This new business model it's a patient-centered, outcome-driven, prevention-focused and follows a tailored approach (Elf et al., 2017). Its major purpose is to shift from a volume-based to a value-based care delivery structure (Deloitte, 2017a). According to Porter (quoted in (Elf et al., 2017)), one of its founders, value regards to the "health outcomes achieved per dollar spent". Hence, taking advantage of the technological progress, the VBHC business model aims to create financial sustainability, through costs reduction and operational efficiency, at the same time it intends to enhance healthcare quality and patient satisfaction, through enabling choice, better access and affordability (Deloitte, 2019). Consequently, a new trend is emerging in the market: '*Decentralized care*'. This trend corresponds to "the transition from institution-centric to patient-centric treatment and care" (Bitterman, 2011), which regards to "providing care closer to the patient and outside the hospital setting through urgent care centers, walk-in clinics, outpatient surgery centers, and home healthcare settings" (AT&T Business, 2019b).

In this ecosystem of change and disruptive transformation, old medicine concepts that have had little adherence until now, are gaining appreciation in the market. Among these, is the HH service (Marsteller et al., 2009). Hence, a new concept alloyed to the VBHC business model emerged: Patient-Centered Medical Home (PCMH) (Ferrante, Balasubramanian, Hudson, & Crabtree, 2010). This concept is considered a "model of primary care transformation that seeks to meet the health care needs of patients and to improve patient and staff experiences, outcomes, safety, and system efficiency" (Jackson et al., 2013).

2.3.1 The Conceptualization of the HH service

The *HH service* or *Hospital at Home (HaH) service* (Marsteller et al., 2009) is a care model, considered an alternative to the TH service, that delivers acute medical care in the patient's home (Direção-Geral da Saúde, 2018; Leff et al., 2006). There are 2 main models to provide this service: The model of complete tradition hospitalization's replacement; and the model related to the patient's Early Discharge, which aims to reduce the cost associated with the length of stay (LOS) by sending patients home after a period of initial clinical stabilization (SPMI, n.d.).

Traditionally, the HH service is based on the following strategic pillars: inherent TH complications' reduction (such as nosocomial infections); hospital beds pressure and TH costs' reduction; more and better accessibility to care; better quality of care delivered (Marsteller et al., 2009); personalized care and improved healing process; delivery of care in a better psychological environment for the patient's recovery (Direção-Geral da Saúde, 2018), improving the patient's state of mind, enabling greater privacy, comfort, autonomy and freedom; higher patients and their families' convenience and satisfaction (Leff et al., 2006); and patient's empowerment and more active family's role in the patient's treatment, preventing family rejection and abandonment (Direção-Geral da Saúde, 2018).

However, even today, there are challenges that prevent the service's wide adoption. Accordingly, the lack of medical human resources and its unreliability, the inadequate cost allocation, the need for access and continuity of care, which is associated with improved clinical outcomes, the lack of interoperability and technology adoption (Carrier, Gourevitch, & Shah, 2009), as well as, patient's lack of confidence in the service and patient's too significant role in its recovery process (Kilo & Wasson, 2010), constitute the service's main barriers. Conceptually, the service's main applications are associated to "chronically ill and patients with compound illnesses", particularly "congestive heart failure, chronic pulmonary disease and the final stages of a terminal illness" (Marsteller et al., 2009). Until very recently, there were only 3 "widely accepted approaches for outpatient monitoring: patient reported outcomes (PRO), telemonitoring and quantifying self-hybrid models (QSHM)" (Appelboom et al., 2014). In order to improve care outcomes, safety and the service sustainability (Hernández et al., 2018), the use of life-critical smart medical devices (Appelboom et al., 2014; Money et al., 2011) with improved technology is pointed out (Mattox, 2012). "Advances in information communication technology (ICT), computing and remote home monitoring, electronic medical records, sensing technologies, wireless technology, virtual reality and robotics" are among the technologies mentioned in the literature to enhance the service (Bitterman, 2011). Particularly, the market is

increasingly interested in using smart wearable body sensors (SWS) for remote patients' monitoring. This devices acknowledged benefits are (Appelboom et al., 2014):

	Devices Benefits
1	Allowing patient mobility;
2	Monitoring physiological vital signs, body movements, and organic substances;
3	Drug Monitoring and Use;
4	Transferring data directly to a personal device or to an online storage site.

Table 2: Devices Benefits

However, its risks and limitations have been major barriers to its widespread adoption. The devices' main risks and limitations are (Appelboom et al., 2014; Hassanalieragh et al., 2015):

	Devices' main Risks and Limitations
1	Sensor systems and data processing software lack of reliability, accuracy and efficiency;
2	Lack of a reliable infrastructure enabler of wireless technologies integration;
3	Need for high collaboration between physicians, patients and engineers;
4	Healthcare professionals' mentality, who are afraid that their position will be disregarded;
5	The fact that there is no "one size fits all solution" and the difficulty in matching products, technologies and treatment methods;
6	Need for health professionals, patients and respective families (caregivers) training;
7	Legal and ethical challenges regarding data privacy, protection and ownership.

Table3: Devices' main Risks and Limitations

2.4 5G Technology & HH

5G Technology's main goal for the healthcare sector is to achieve universal access to remote healthcare (AT&T Business, 2019a). Its greatest impact on the HH service will come from enabling the massive Internet of Medical Things (IoMT) (Politis et al., 2016). The IoMT is the "connected infrastructure of medical devices, software applications, and health systems and services", which enables to connect "people (patients, caregivers and clinicians)", data, "processes (care delivery and patient support)" and enablers (sensor and connected medical devices) (Deloitte, 2019). It will enable the emergence of plenty revolutionary medical innovations, such as: augmented reality, virtual reality, artificial intelligence (AI), remote medical learning, and remote patient monitoring (AT&T Business, 2019b). Specifically, it will "enhance live-stream video conferencing", "provide even faster remote access to electronic health records, improve online and live remote consultations, enable more efficient data transfers through mobile apps, and even help support remote procedures and robotic surgeries" (AT&T Business, 2019b). Furthermore, it will improve medication adherence and management, allow reliable, real-time mobile remote monitoring, and enhanced patient experience, increasing its satisfaction.

5G Technology features that most impact this service are (Arthur D. Little, 2017; AT&T Business, 2019a):

1. Lower battery consumption (increases devices battery life, reducing network power usage);
2. Low latency (higher speed), which allows the transmission of data in real time;
3. Uninterrupted, consistent and ubiquitous connectivity. Greater coverage and capacity that will allow a greater number of connections to the network simultaneously and the total mobility of patients without restrictions;
4. Greater interoperability between eHealth solutions.

Due to these characteristics, 5G's key conceivable use cases in healthcare are: Bioelectronic medicine; Personal health systems; Telecare and telemedicine; Connected ambulance; Smart medication; and Mobile surgical robots (Arthur D. Little, 2017).

However, to enable real value creation, in this type of complex environment, collaboration and partnerships will be essential to promote the conception of innovative services (Ericsson, n.d.). Furthermore, a bundled-based innovative business model should be used to stimulate care coordination across the value-chain (Hernández et al., 2018).

2.5 Portuguese market context

Currently, Portugal has 10.3 million inhabitants (Instituto Nacional de Estatística, 2018), 21% of whom are individuals over 65 years old (Serviço Nacional de Saúde (SNS), 2018). As previously mention regarding the global healthcare trends, also in Portugal the population is aging due to the increase in average life expectancy, which had reached 81.3 years old in 2015. Consequently, there has been an increase in the percentage of some diseases such as chronic, oncological, hypertension, diabetes and obesity (Serviço Nacional de Saúde (SNS), 2018). In 2017, *EUR 17.3 million* were spent on healthcare (PORDATA, 2017), and 850,8 thousands hospitalizations were recorded. In 2018, *225 hospitals* were operating in Portugal, of which *107* are public and *118* are private hospitals (Serviço Nacional de Saúde (SNS), 2018).

Also in Portugal there has been the growing concern of individuals with lifestyle and quality of life improvements (Serviço Nacional de Saúde (SNS), 2018). All around the world the healthcare sector is under transformation (Deloitte, 2018a), and the new VBHC business model emerged. Also, in Portugal hospitals are adopting this new model, and 2 have already started changing their strategy to implement it: Hospital da Luz Lisboa and Centro Hospitalar São João (Jornal de Negócios, 2017). Also the Portuguese national health system (SNS) is keeping up with the global market trends, trying to modernize, thus, having recently created a new patient-centered program called (*SNS + Proximidade*) (Serviço Nacional de Saúde, 2018a). One of the program's main objectives is to bring care to patients, being the implementation of HH units a priority. In this context, the Portuguese government created a financial incentive measure ('*Programa de Incentivo à Integração de Cuidados e à Valorização dos Percursos dos Utentes no Serviço Nacional de Saúde*") (Administração Central do Sistema de Saúde, 2017), providing a total amount of *EUR 35 million* to Public Hospitals that presented initiatives of organizational change, as the creation of a HH Unit (Serviço Nacional de Saúde, 2017). As a result, 23 Public Hospitals have received funding and were, therefore, forced to signed a commitment which stated that until *March 2019* they had to ensure the implementation of a HH unit. Moreover, the remaining public hospitals will also have to submit by *June 2019* a plan to create such a unit (Serviço Nacional de Saúde, 2018b). This service creation is specially a priority for the Portuguese government due to the desire to reduce hospitalization costs and the need to solve the existing bed shorted crisis (Diário da República, 2018; European observatory, 2017).

HH service is a relatively recent practice in Portugal. Nowadays, 7 Portuguese Public Hospitals have already created a HH Service (Garcia De Orta, 2018; Jornal de Negócios, 2018a, 2018b; Radio Barcelos, 2019; Serviço Nacional de Saúde (SNS), 2019). Nevertheless, the first

Hospital to fully implement a HH Unit was Hospital Garcia de Orta in November 2015 (Garcia De Orta, 2018). Its average cost per patient home hospitalized is €1 058 versus €2 285 in TH, thus confirming the costs reduction related to the service (Delerue, 2018). Being the first hospital to adopt the service, this hospital was responsible for creating the country's service guidelines (Direção-Geral da Saúde, 2018).

Most hospitals only carry out in-person and on-site monitoring with health professionals, relying in the caregiver for the rest of monitoring time, with access to a 24-hour emergency phone number. However, there is already a pilot project implemented in Portugal that uses a monitoring product's kit in a HH Unit. The *Centro Hospitalar e Universitário de Coimbra* (CHUC) is the hospital which has the products' kit, and it includes a tablet and a set of measuring equipment (oximeter, thermometer, sphygmomanometer and pedometer / physical activity monitor). The company that provides this products' kit is Hope Care in partnership with NOS PT. However, this products' kit is still archaic, once the products aren't connected with each other neither directly with the platform that the company provides, having the caregiver or healthcare professional to manually entry the patient's data so that it is available to the physician to see (Serviço Nacional de Saúde (SNS), 2017).

3. Methodology

3.1 Research Design

This dissertation will follow a *cross-sectional descriptive-exploratory research*. Firstly, an exploratory research will be conducted both through a thorough market research and in-depth expert interviews, in order to get an overview of the current markets under study. Subsequently, to further perceive the real market potential of using 5G-IoT Technology in a remote monitoring products' kit, for the HH service, a descriptive research will be done by performing 3 different surveys targeted to different samples. Finally, a cross-sectional study will be performed to present the results only with regard to the current time period, in order to know today's existing market demands.

3.2 Research Approach

3.2.1 Concept Testing

A concept testing method will be performed because this dissertation intends to test the viability of implementing a new method of providing the HH service in Portugal. Both qualitative (first) and quantitative (later) research will be done to understand the potential of implementing this new method of providing the HH service from the three perspectives under study.

3.2.2 Deductive approach

A deductive approach was used to reach the desired answers to the 1st, 2nd and 3rd research questions. The reason why this approach was selected is because one will apply the general theory found in the Literature Review and see its application for the Portuguese specific case. Hence, one hypothesis was defined for each research question.

To test the 1st research question, the following hypothesis was created:

H1: The HH service challenges in Portugal match the challenges identified in the Literature Review.

To test the 2nd research question, the following hypothesis was created:

H2: 5G-IoT Technology can fulfil the identified HH service challenges.

To test the 3rd research question, the following hypothesis was created:

H3: 5G-IoT technology, if incorporated into remote patient monitoring devices, will enhance the HH service.

3.2.3 Inductive approach

An inductive approach was used to reach the desired answers to the 4th and 5th research questions. The reason why this approach was selected is due to the fact that there is very little Literature Review regarding the specific topic under study. Hence, to draw conclusions a specific phenomenon will be tested. The phenomena will be the creation of a specific remote monitoring 5G-IoT Technology products' kit for the HH service in Portugal. To enable a more objective analysis of the potential service usage intentions, a set of existing products in the Medical Devices' market was selected to integrate in the products' kit, adapting some of its features to what hypothetically could appear in the near future if the 5G-IoT technology would be integrated into the products. Hence, the goal is to extrapolate the potential of the Portuguese demand, based on the real usage intentions regarding this specific products' kit. To explain the specific phenomena, specific measurements were used and the respective outcomes were collected and examined on the next chapter.

3.3 Research Methods

3.3.1 Data collection methods

3.3.1.1 Primary data

3.3.1.1.1 Qualitative Research

During this dissertation's exploratory phase, qualitative methods of data collection were used because it enables the researcher to get a broader vision of the market for the idea's generation process, helping in the survey's construction and its respective results' analysis, simultaneously. The qualitative method that was chosen respects to semi-structured in-depth expert interviews with the goal of getting to know what is the markets' current situation. Due to the interviewee's convenience different types of interviews have been carefully chosen to make it easier for respondents to answer the questions and to minimize the possibility of biased and misleading results. 6 interviews were conducted, being two respondents from each market category under study.

Firstly, 4 respondents are Portuguese. From the Telecommunications industry were interviewed: Mário Peres, who is the IoT Country Manager at Vodafone PT; and Pedro Machado, who is responsible for the IoT Business Development team at NOS PT. The goal of these interviews was to understand the degree of companies' involvement in the HH market, as well as the specific potential of 5G-IoT Technology if associated with the creation of a remote patient monitoring products' kit. Moreover, from the Healthcare industry were interviewed: Dr. Alexandre Lourenço, who is the president of the *Conselho Regional do Sul da Ordem dos*

Médicos; and Dr. João Correia, who is coordinator of the HH Unit at Hospital Garcia de Orta (the first Portuguese hospital to include the HH service in its health services' offer). These interviews' goal was to comprehend how exactly is the HH service offered to patients, in addition to understanding the current main concerns and barriers regarding the service in the Portuguese market.

Finally, 2 respondents aren't Portuguese, and respect to the Medical Devices' industry, once this industry in Portugal only has one player that one has identified and this player wasn't available to be interviewed. Hence, were interviewed: Glenda Womack, who is American and the *Senior Director, Specialty Customer Solutions*, at Cubixx Solutions (AmerisourceBergen), and Enric Samper Sosa, who is Spanish and a *Modality Specialist Connected Care Solutions at Monitoring & Analytics and Therapeutic Care* at Philips Ibérica. These interviews' goal was to recognise what was the real progress regarding the technologies used in the Medical Devices' industry and to test whether the business idea was feasible in the short/medium term. All the interviewees were meticulously selected, and are part of the nucleus core of the industries under study. Therefore, their insights were essential for this dissertation structuring.

3.3.1.2 Quantitative Research

Then, a quantitative analysis was performed. 3 online surveys with different research intentions were created specifically targeted to different types of individuals. The sample technique used was the non-probability sampling, due to the difficulty in randomly sampling the entire population that fulfilled the requirements to be part of the samples. However, due to the researcher's high efforts to include in the samples collected all the accessible subjects, making the sample the best possible representation of the entire target population, it can be assumed that specifically was performed a consecutive sampling technique. It was chosen *Qualtrics software* to collect the intended data once it allows the survey's easy structuring, execution, sharing and analysis.

The first survey was intended for healthcare professionals, with the intention of having support in the remote monitoring products' selection process, in addition to understanding their perspective regarding the main challenges of the HH service and, finally, their interest in integrating the products' kit into the service, in Portugal. The survey's sharing process was done in different ways: firstly, all the healthcare professionals known by the researcher were contacted via e-mail; secondly, due to the generalized interest around the service's idea the subjects themselves shared the survey with colleagues, contributing to the collection of a greater

number of answers; thirdly, a few more healthcare professionals were contacted via LinkedIn in order to achieve the largest and most diverse sample possible.

The second survey was directed to hospital managers and was conducted with the purpose of studying their degree of interest in integrating a remote monitoring 5G-IoT Technology products' kit into the HH service at their hospital. This survey, on the other hand, was shared in a very selected way. A database was created with 22 different hospitals, and each one was contacted by the researcher via e-mail. Additionally, all the hospital managers known by the researcher were contacted, as well, via e-mail.

Finally, a survey targeted for the general Portuguese population was conducted with the goal of studying the likelihood of an individual choosing to use the HH service with access to a remote monitoring 5G-IoT Technology products' kit, in case they had to be hospitalized. This survey's sample was collected through different social media platforms (Facebook, Instagram, and LinkedIn) and in person with the goal of gathering a sample as representative of the Portuguese population as possible. This analysis is particularly important to run because according to a regulatory decree proposed by the *Direção-Geral da Saúde*, the HH service admission of a patient is entirely dependent on its will (Direção-Geral da Saúde, 2018). This means that a patient will only be admitted to the service on a voluntary basis. Consequently, regardless of whether this service entails high profits for Telecommunication companies and vast cost reductions for hospitals, if the Portuguese population isn't interested in using the service, there won't be any customers and, thus, it would no longer constitute a business opportunity.

Concluding, this dissertation will access the interest regarding the creation of this new HH service based on three different perspectives all equally important because without one of them, it wouldn't constitute a business opportunity. Hence, only the interest combination of hospital managers, healthcare professionals and the general Portuguese population, simultaneously, can make this new service's implementation a new business opportunity.

3.3.1.3 Secondary data

A thorough market research was conducted through online material in order to recognise the existent medical devices in the global market. The goal was to collected data on the technical characteristics of the products in order to understand the feasibility, potential and need to incorporate 5G-IoT technology into the market.

Were found 17 remote monitoring vital signs wearable-products, 6 remote medication adherence monitoring products, 1 drug refrigeration and monitoring product, 3 Chatbot AI

platforms, 5 telemedicine platforms for virtual appointments, 2 Ambulatory Infusion pumps CADD, and 2 Elastomeric pump infusion. For different product types different variables were studied.

3.4 Measurement Scales

Since the Likert scale is considered one of the most reliable scales to measure hard-to-quantify data, the scales used in the surveys use this rating system. This type of scale conceptually has a symmetrical number of positive and negative responses. Furthermore, there are two type of response options: unipolar and bipolar, and both were used as well.

The unipolar scales used were the following: health status (Very bad; Bad; Reasonable; Good; Very good); TH service satisfaction and HH service satisfaction (Terrible; Very bad; Bad; Regular; Good; Very good; Great); degree of agreement (Strongly disagree; Disagree; I don't agree or disagree; Agree; Strongly agree); Probability degree, which doesn't really have a true neutral scale-point (Not likely; Unlikely; Likely; Very likely; Extremely likely).

The bipolar scales used were the following:

- **Five-point frequency scale** for: interest healthcare topics; interest in technology topics; degree of appreciation; degree of innovation; degree of functionality; degree of utility; and degree of importance.
- **Eight-point frequency scale** for: Priority level.
- **Ten-point frequency scale** for: degree of appreciation; degree of importance; degree of interest; degree of need; degree of recommendation; degree of preference; probability degree; degree of business potential; and degree of satisfaction.

4. Results' Analysis

This chapter is composed by two main sections.: data sampling characterization and analysis; and main results' presentation. The descriptive sampling was performed in Excel and the logistic model was done using the Stata software for the researcher's convenience.

4.1.Preliminary Analysis

4.1.1. Data Collection

Survey 1: *Healthcare Professionals*

For this survey responses were collected within a period of 15 days. 107 complete responses were given, however, after the researcher's filtering, only 92 responses were considered viable. The reason why the researcher cleared some answers is due to the validation variables included in the survey, such as: "Healthcare Professional"; "Doctor or Nurse" and "Works in Portugal". Consequently, in 15 cases these variables weren't respected being, therefore, the answers excluded from the analysis. 8 of these cases were excluded because they weren't Healthcare Professionals and 5, even though they were Healthcare Professionals, weren't doctors or nurses. Finally, 2 final answers were excluded because being this a study for the Portuguese market, 2 Healthcare Professionals didn't work in Portugal.

Survey 2: *Hospital Managers*

For this survey responses were collected within a period of 12 days. 15 complete responses were given, however, after the researcher's filtering, only 14 responses were considered valid. Of the 15 respondents, only 11 are Hospital Managers. However, 3 out of the left 4 were considered valid because, even though they aren't hospital managers, 2 are Medical Service Directors and 1 is a Clinical Director being, thus, considered to have decision-making power regarding the implementation of the service in the hospitals they work at. The only respondent who was removed from the sample was removed for being a nurse and thus not being considered to have decision-making power at the hospital he works at.

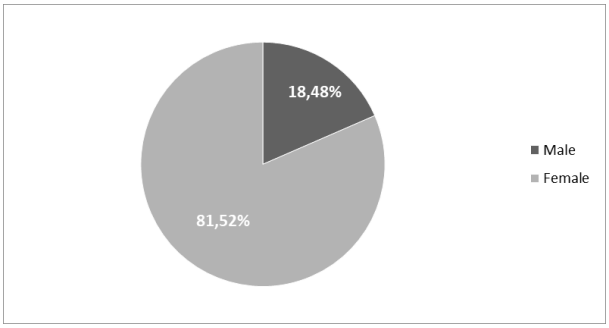
Survey 3: *Possible future Patients (end-users)*

For this survey responses were collected within a period of 14 days. 554 complete responses were given, however, after the researcher's filtering, only 538 responses were considered valid, once 16 of the respondents didn't live in Portugal, therefore, not belonging to this study's target, they were removed from the sample.

4.1.2. Demographics Analysis & Characterization

Survey 1: *Healthcare Professionals*

In the 92 Health Professionals' sample, exist 26 different medical specialities and 25 different hospitals across Portugal. 96% work in Public Hospitals and 4% work in Private Hospitals. 53% are doctors and 47% are nurses. 18% are men and 82% are women. 32% of them are aged between 24 and 30, 41% are between 31 and 50, and, finally, 27% are between 51 and 65. 98% of them have Portuguese nationality and only 2% have another nationality but live and work in Portugal.



FIigure 4: Healthcare Professionals' gender

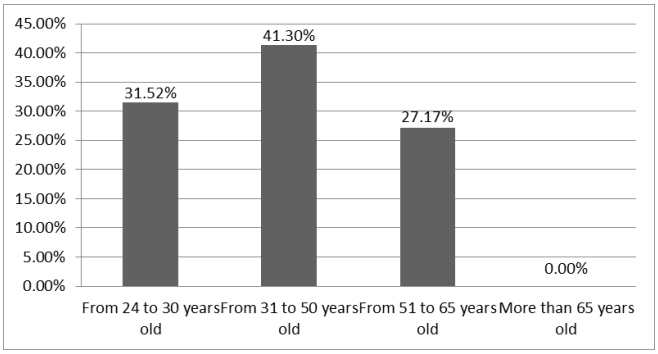


Figure 5: Healthcare Professionals' age

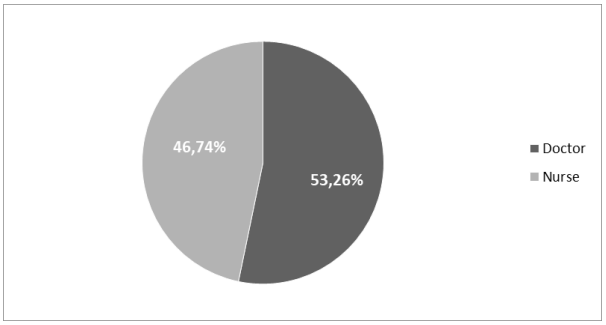


Figure 6: Type of Healthcare Professional

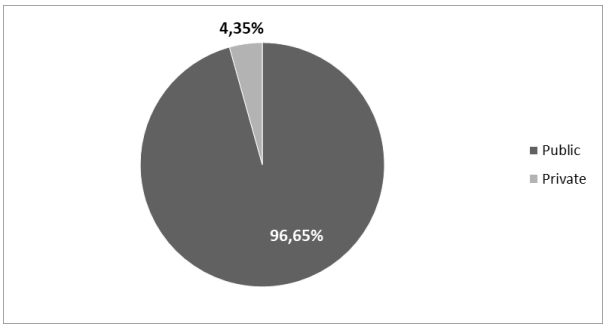


Figure 7: Hospital type

85% of respondents know the concept of HH compared to 15% that don't know. 33% of respondents stated that in the hospital they work at there is a HH Unit, 43% stated that in the hospital they work at there is not a HH Unit and 24% claimed that they didn't know. 97% never worked in a HH Unit compared to 2% who currently work and 1% who have worked but not anymore. All those who have worked in this service have characterized it as being in a

development process, and justified their response based on the statement that said that the monitoring was performed in-person and from time-to-time by health professionals with the help of a caregiver, who in case of emergency could use a 24/7 available telephone line to inform health professionals of the patient's condition. 98% of the respondents would advise a hospital to integrate 5G-IoT based remote monitoring products' kits into their HH Unit, compared to 2% who would advise not to.

Survey 2: *Hospital Managers*

Because this survey has very few answers, due to its restricted and difficult to approach circle of targeted people, its analysis will be made based on the absolute values.

All respondents work in Portugal, of which 10 are men and 4 are women. None of the respondents is in the age range of 24 to 30 years old, being 5 of respondents aged between 31 and 50, 7 between 51 and 65, and 2 over 65 years old. These respondents are from 12 different hospitals across 6 different Portuguese districts. 12 work in public hospitals and 2 in private hospitals. 2 work at large size hospitals (more than 500 beds available for TH), 8 work at medium size hospitals (300-500 beds available), and 4 work at small size hospitals (less than 300 beds available). 13 reported that the hospital's main strategic objective is to provide quality, innovative and differentiating services, compared to 1 that aims to expand and diversify the available services.

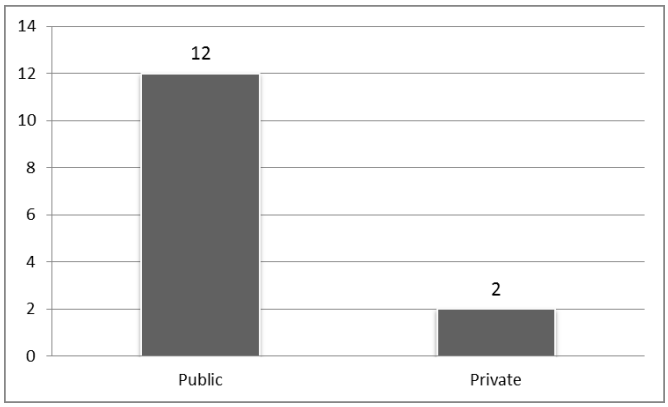


Figure 8: Hospital type

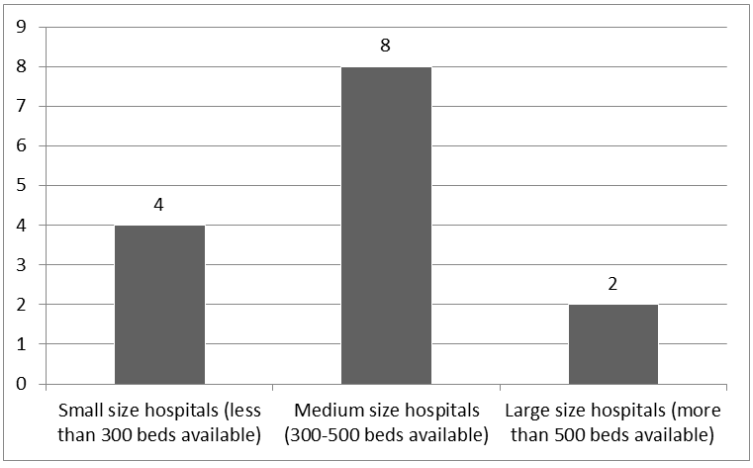


Figure 9: Number of beds

All respondents stated that they had knowledge regarding the HH service concept and its current situation in Portugal, with the exception of 1 who didn't knew, but wanted to know. 5 confirmed that their hospital was beneficiary of the financial incentive given by the Portuguese government, compared to 9 that didn't. 6 of the respondents stated that the hospital they work at already provides the HH service, compared to 8 that said it didn't, however, 3 of them intend to implement the service in the short-term (less than 1 year), 2 intend in the long-term (more than 1 year) and 3 don't intend to implement the service. None of the respondents knew the potential benefits of the 5G-IoT technology for the HH service. Finally,10 respondents fully agreed with the statement that the integration of remote patient monitoring products is essential in order to ensure safety and service's quality. 6 out of 14 hospital managers showed interest in receiving this dissertation indicating their interest regarding the topic addressed.

Survey 3: *Possible future Patients (end-users)*

From the 538 participants, 72% are women and 28% are men, in which 99% are Portuguese, and 1% are foreigners who live in Portugal. A total of 15 Portuguese districts were reached, despite Lisbon's great predominance (79%). Concerning age, the dominant range is between 22 and 24 years old with 39%, followed by 41-65 (25%), 18-21 (14%), 25-30 (9%), 31-40 (7%), under 18 (5%), over 65 (2%). Regarding the education level, the sample's great majority has the bachelor degree (45%), followed by the mater degree (25%).

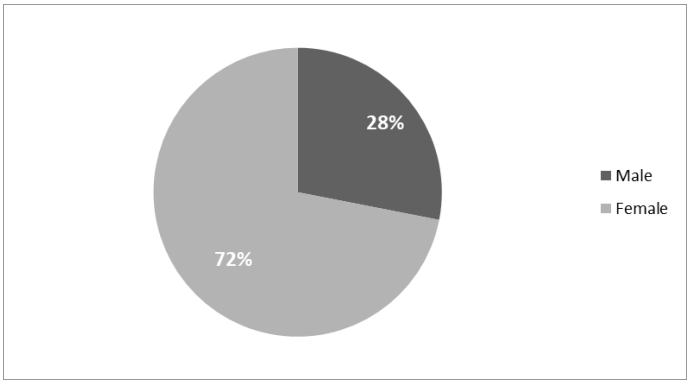


Figure 10: Patients' gender

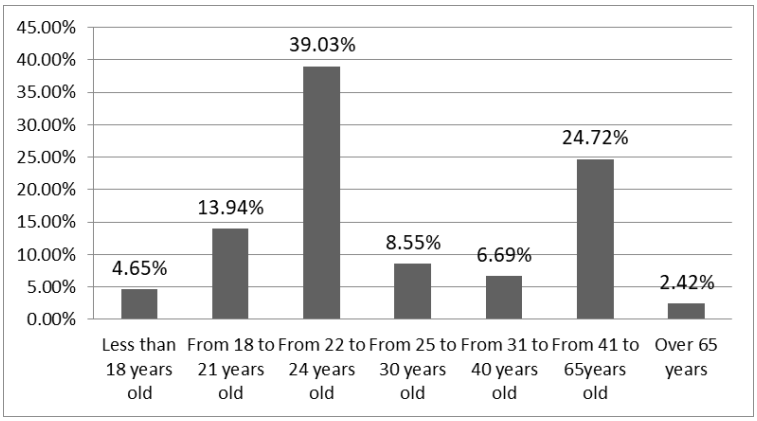


Figure 11: Patients' age

Additionally, the dominant range of the monthly net income is from 3 001€ to 3 700€. Moreover, most of the sample works for others (47%), followed by students (39%). Additionally, 80% of the sample has health insurance, compared to 20% that doesn't have. In the event of having to seek health care, 62% would seek a Private Hospital, compared to 38% that would seek a Public Hospital. Only 3% of the sample already needed to be hospitalized but didn't have room.

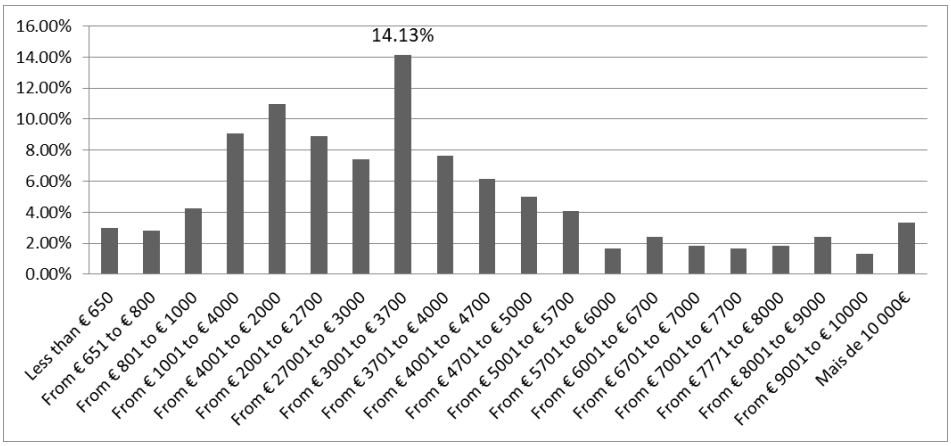


Figure 12: Patient's monthly net income

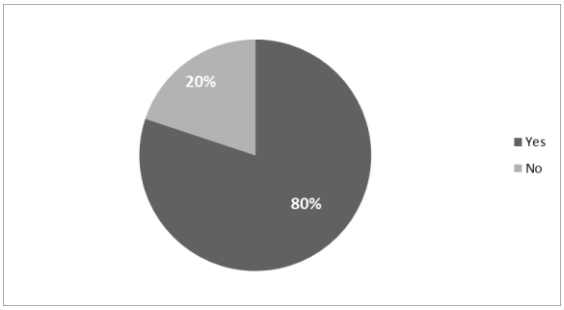


Figure 13: Health insurance

Furthermore, 52% has already been hospitalized in a hospital, and only 2% (10 people) has been hospitalized at home. Of these people, only 1 used a medication adherence monitoring product, and another 1 used a telemedicine platform to do virtual appointments, compared to 5 people who claim that have only been monitored from time to time, in person, by healthcare professionals with the aid of a caregiver, and 3 who cannot remember. Concerning these people's satisfaction regarding the HH service, 2 classified it as excellent, 2 very good, 2 good, 3 regular, and 1 bad. Everyone claimed that would like to see the integration of new technologies in the HH service in Portugal, however, only 7 claimed that was likely (or more than likely) they would choose the HH service with access to the products' kit if they had to be hospitalized once more, 2 stated it was unlikely, and 1 nothing likely. Besides, 6 people stated that have no fear of using the HH service, compared to 4 which have some fears. Of these 4 people, all fear not having access to a healthcare professional's team in case of emergency in a timely manner, 3 fear not having immediate assistance in case of cardiac arrest, 2 fear not being properly monitored and 1 fears not complying with the medication plan and stipulated treatment.

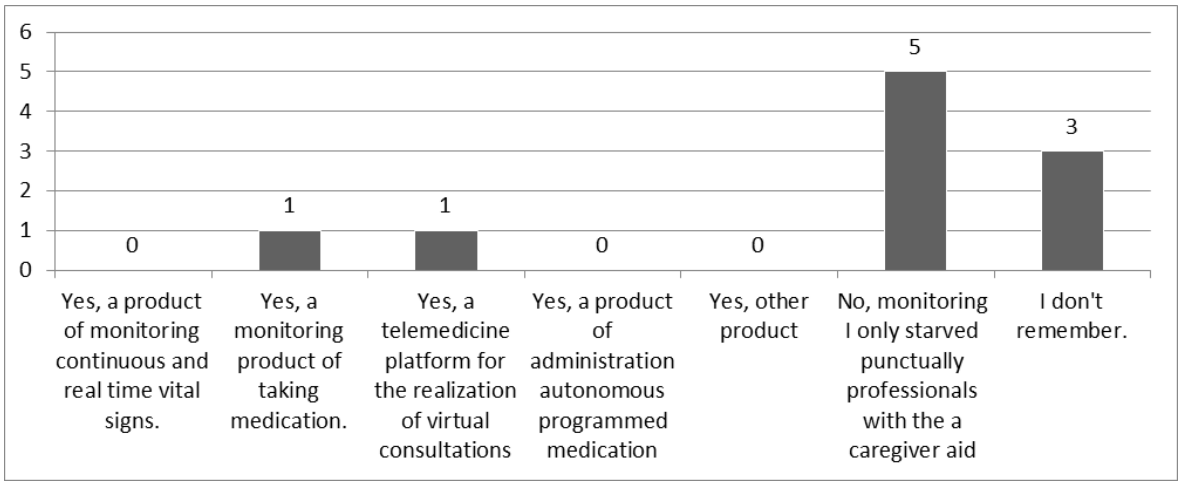


Figure 14: Monitoring technologies used

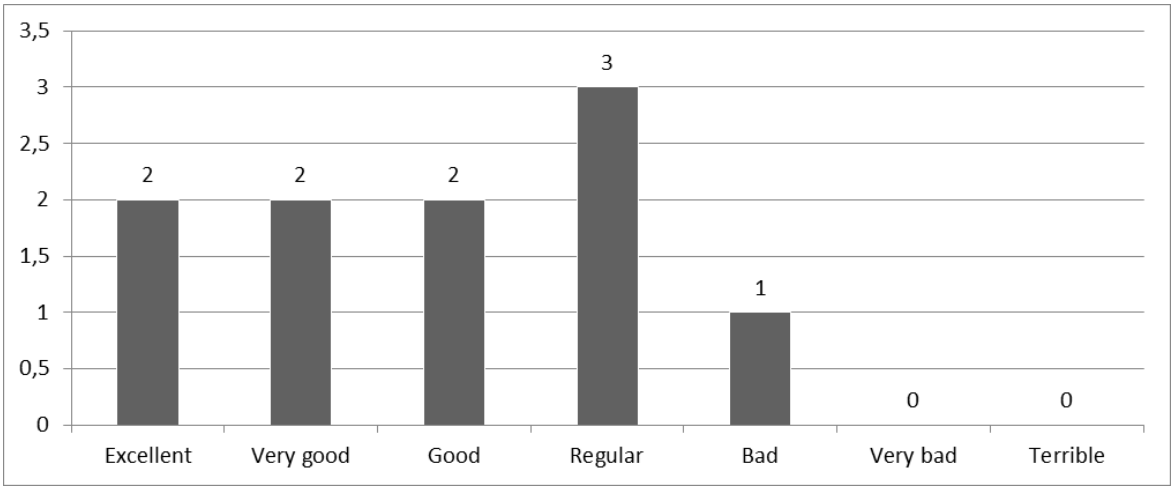


Figure 15: HH service satisfaction level

4.2. Main results' analysis

4.2.1. Research Question 1: What are the current challenges of HH service in Portugal?

In order to answer this 1st research question, and test the first hypothesis (H1), one will match the global challenges identified in the Literature Review with the perspectives of 4 experts, 2 from the Telecommunications and 2 from the Healthcare industries.

After carefully analysing the answers given by the experts during their interviews, it is possible to conclude undoubtedly the authenticity of 5 challenges identified in the literature, since all the experts have validated them: "service unreliability"; "inadequate cost allocation"; "need for access and continuity of care"; "lack of interoperability"; and "low technology adoption". The challenge that was validated subsequently was the "lack of medical human resources". One decided to validate this challenge as well, because the two healthcare experts interviewed mentioned it during their interviews. Although the two experts from the Telecommunications industry didn't refer this challenge in their interviews, it is the researcher's opinion that the other two experts have more inside regarding this specific type of challenge due to dealing in a daily basis with this reality. Following the same line of reasoning, another challenge was validated: "patient's too significant role in its recovery process". Despite two experts not having mention this challenge during their interviews, the other two interviewees, being one from each industry, reported it. Given that these two interviewees work directly in the HH service, compared to the other two who don't work directly in this market, one decided to validate this challenge as well for the Portuguese market. Finally, only one challenge identified in the literature remained unvalidated ("patient's lack of confidence in the service") since only one interviewee mentioned it.

Home Hospitalization service Challenges					
Literature Review	**Telecom View**		**Healthcare View**		
	Pedro M.	**Mário P.**	**Dr. João**	**Dr. Alexandre**	
Lack of medical human resources			**Yes**	**Yes**	
Service unreliability	**Yes**	**Yes**	**Yes**	**Yes**	
Inadequate cost allocation	**Yes**	**Yes**	**Yes**	**Yes**	
Need for access and continuity of care	**Yes**	**Yes**	**Yes**	**Yes**	
Lack of interoperability	**Yes**	**Yes**	**Yes**	**Yes**	
Low technology adoption	**Yes**	**Yes**	**Yes**	**Yes**	
Patient's lack of confidence in the service	**Yes**				
Patient's too significant role in its recovery process	**Yes**		**Yes**		
Other:					
Healthcare professionals negative mentality, behaviour and attitude towards the service			**Yes**		
Telemonitorization in Portugal is associated with large, heavy and expensive hardware				**Yes**	

Table 4: HH Challenges

Hence, in an attempt to validate this challenge, one tested the market, asking possible future patients (end-users) whether they would feel safer in using the HH service monitored continuously by medical devices, rather than in-person by healthcare professionals. According to the Figure 16, as 43% of the sample agrees with the statement, compared to 22% who disagree and 35% who don't agree or disagree, one concluded that this challenge was also true for the Portuguese market. The output of this question can be seen below:

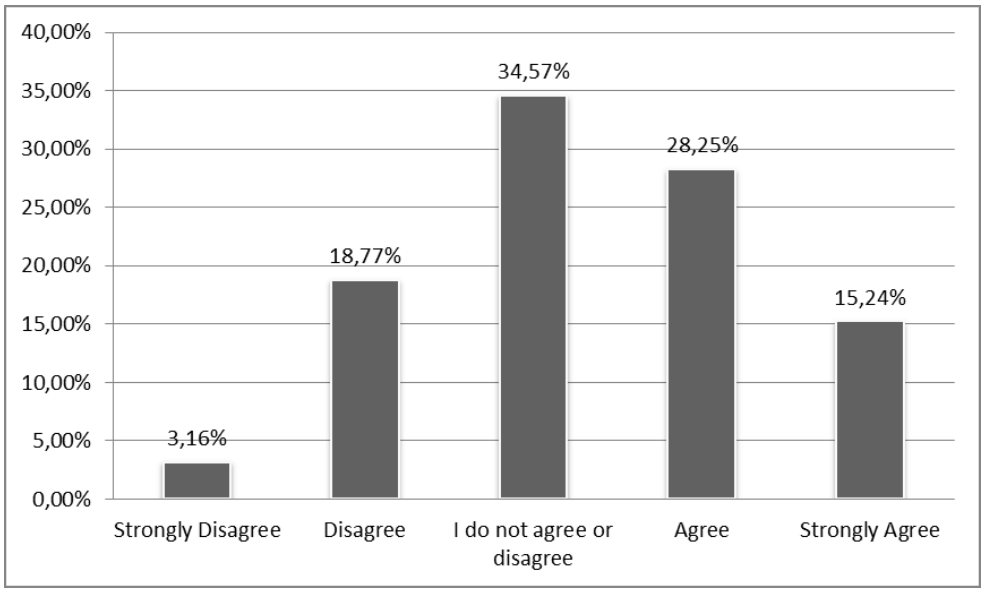


Figure 16: Degree of feeling safer and more confident in using the HH service if monitored continuously, in real time, autonomously and remotely by medical devices, rather than in person and from time to time by health professionals.

Hence the data collected corroborates the following hypothesis:

H1: The HH service challenges in Portugal match the challenges identified in the Literature Review. ➡ **Valid**

Regarding the two suggestions made, one decided to validate them ("healthcare professionals negative mentality, behaviour and attitude towards the service"; "Telemonitorization in Portugal is associated with large, heavy and expensive hardware") through both the surveys made to the healthcare professionals and to the hospital managers. As shown in Figures 17 and 18, 24% of healthcare professionals and 33% of hospital managers, respectively, believe that healthcare professionals negative mentality, behaviour and attitude towards the service constitute a service challenge. Therefore, as a relatively considerable percentage of the inquired confirmed that this is indeed a challenge, one confirms the truthfulness of this challenge. Lastly, no hospital manager corroborated the statement that "telemonitoring hardware is still very large, heavy and expensive", and only 15% of healthcare professionals did, which is not significant. Hence, one was forced to invalidate this suggestion of challenge for the service in the Portuguese market. The outputs of these questions can be seen below:

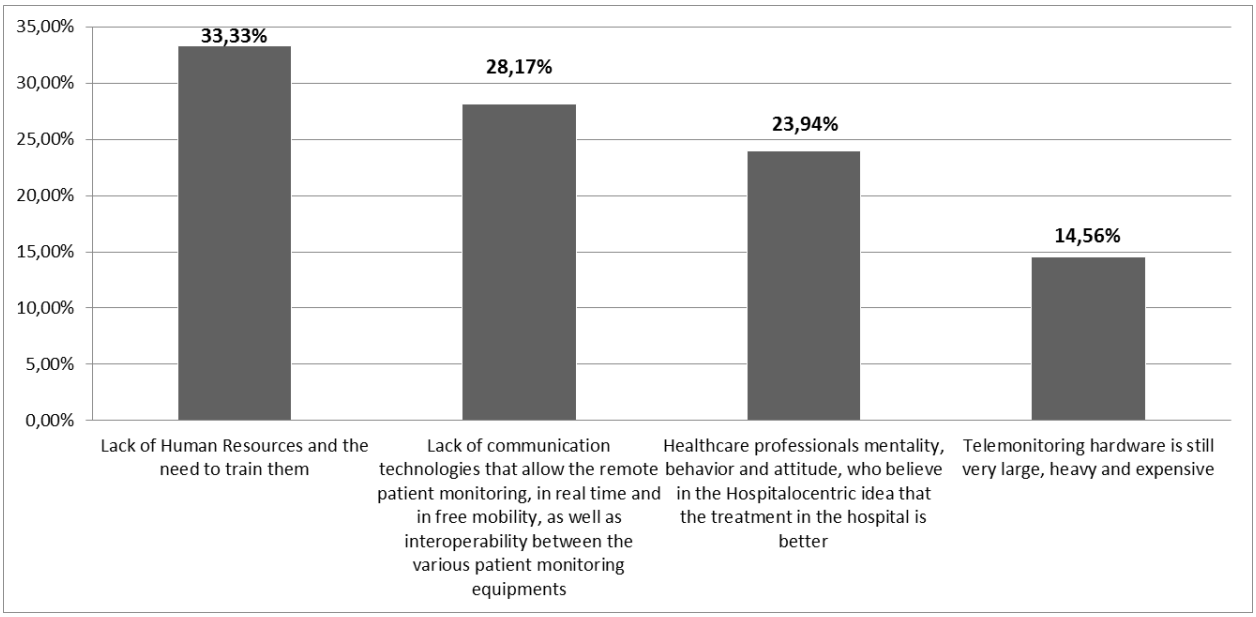


Figure 17: Healthcare Professionals' perceived challenges

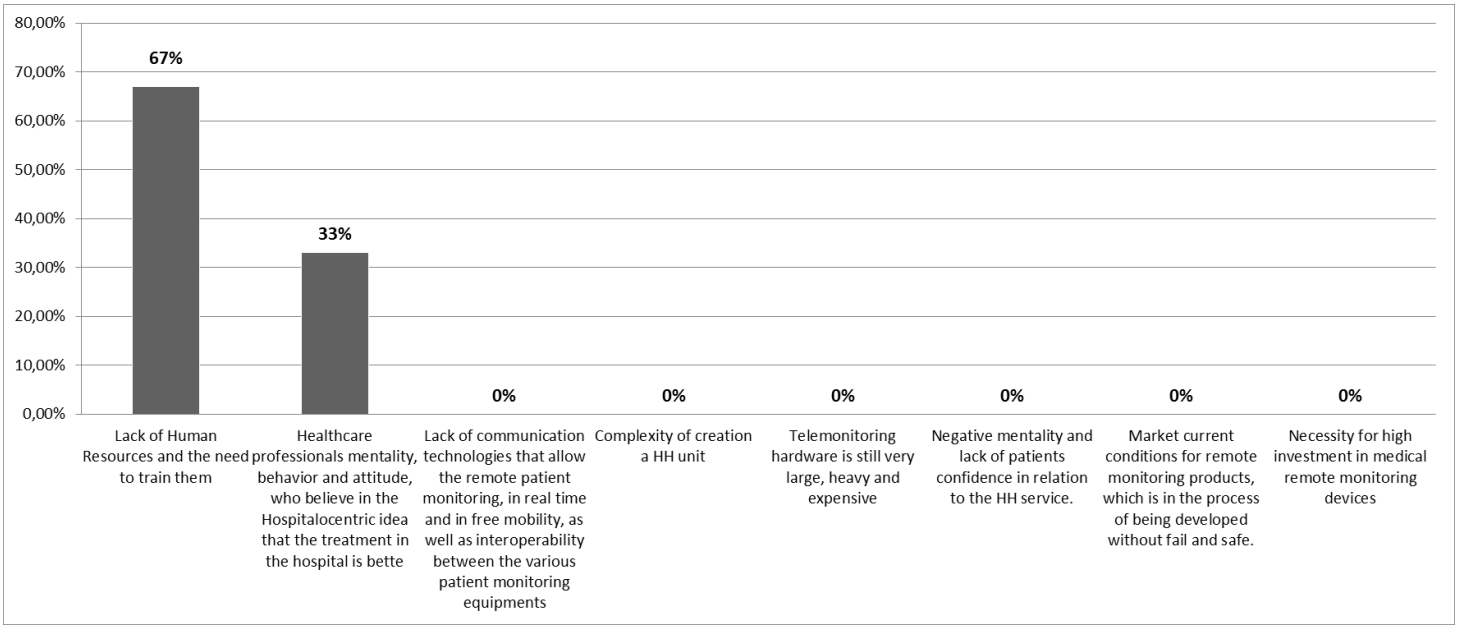


Figure 18: Hospital Managers' perceived challenges

4.2.2. **Research Question 2: Can 5G-IoT Technology fulfil today's HH service challenges?**

In order to answer this research question and test the second hypothesis (H2), one will match the global challenges identified in the Literature Review (plus the challenge suggested by a interviewee) and validated in the first research question, with the perspectives of 2 experts from the Telecommunications industry. After carefully analysing the answers given by the experts during their interviews (Table 5), it is possible to conclude indisputably the authenticity of 6 technology's characteristics (Enable the emergence of innovations; Uninterrupted, ubiquitous continuous, ultra-reliable connection; Low cost technology; Real-time remote monitoring; Greater coverage and capacity; Low latency) that can fulfil 6 of the presented challenges, once both interviewees have validated it. The remaining 5G benefits were only validated each by one of the interviewees, so being thus validated as real 5G benefits but with less certainty.

H2: 5G-IoT Technology can fulfil the identified HH service challenges. ➡ **Valid**

Service Challenges	5G's Benefits stated in the Literature Review	Telecom View		
		Mário P.	Pedro M.	
Lack of medical human resources	Enable the emergence of plenty revolutionary medical innovations, such as: augmented reality, virtual reality, artificial intelligence (AI), remote medical learning, and remote patient monitoring	**Yes**	**Yes**	
Service unreliability	Uninterrupted, ubiquitous continuous, ultra-reliable connection	**Yes**	**Yes**	
Inadequate cost allocation	Low cost technology	**Yes**	**Yes**	
Need for access and continuity of care	Enables Wearable Devices to do real-time Remote Monitoring	**Yes**	**Yes**	
Lack of interoperability	Highly integrative with LTE and WiFi	**Yes**		
Low technology adoption	Lower battery consumption (increases devices battery life, reducing network power usage)		**Yes**	
Patients' lack of confidence in the service	Greater coverage (great data volume), and capacity that will allow a greater number of connections to the secure network and IoT massification simultaneously and the total mobility of patients without restrictions	**Yes**	**Yes**	
Patient´s too significance role in its recovery process	Low latency (higher speed), allows real-time mobile remote monitoring	**Yes**	**Yes**	
Healthcare professionals negative mentality, behaviour and attitude towards the service				

Table 5: 5G-IoT Technology Benefits fulfilment

4.2.3. **Research Question 3: Can 5G-IoT Technology enhance the HH service through the creation of a remote patient monitoring products' kit?**

This dissertation's main goal is to propose the creation of a 5G-IoT Technology remote patient monitoring products' kit in order to enable a business opportunity. Nevertheless, this products' kit purpose is to collect real-time information from patients in order to massively enhance the effectiveness and the efficiency of the service, through the transformation of products in automatized smart medical services, with very little human interaction. The concretization of this products' kit also assisted in objectifying the research, making it possible to collect data that otherwise, would be impossible to, due to the lack of information and general knowledge regarding the topic. Hence, a market research was conducted to get a clear vision of the current remote monitoring medical devices' market, understanding its main benefits and limitations. Therefore, general search engines such as Google, Google Scholar; Pubmed and Science Direct were used to extensively search for medical devices.

One was able to determine which types of medical devices were more likely to make sense for the HH setting, through two sources: literature review and the interview with Dr. João Correia. Thus, the chosen types of products to research were:

	Products' Types
1	Continuous and real-time monitoring product of patients' vital signs, which alerts and notifies healthcare professionals and caregivers whenever a value is out of normal.
2	Product that stores medication in a temperature-controlled continuously monitored environment.
3	Autonomous and remote cardiac resuscitation product.
4	Telemedicine platform with videoconferencing functionality that allows virtual medical appointments.
5	Chatbot - Artificial Intelligence platform that assists patients, helping them to determine the best course of action by communicating and interacting through automated messages.
6	Oral medication adherence monitoring product.
7	Autonomous and programmed medication administration product (antibiotic): Ambulatory CADD infusion pump.
8	Autonomous and programmed medication administration product: Elastomer pump for continuous infusion.

Table 6: Products' Types

After a thorough search, 17 vital signs monitoring products, 5 oral medication adherence monitoring products, 3 Chatbot - artificial intelligence platforms, 5 telemedicine platforms, 2 Ambulatory CADD infusion pumps, and 2 Elastomer pumps for continuous infusion were found. Subsequently, after analysing the characteristics of each product, one realized that with the exception of vital signs monitoring products, which the signs monitored vary a lot, the remaining products, in the same category, were very similar to each other. In regard to the products that were similar to each other, the variables used to exclude the products and to arrive at a final product, by category, were variables conceptually known and so it was the researcher that excluded the products one by one until arriving at a single product per category. The main exclusion variables used were: quality certification (FDA, CE, FCC, HIPAA); compatibility with other devices; data encryption; need for manual entry or patient action; event detection, already on the market, compatibility with both iOS and Android; easiness of use, data storage mode (whether cloud or SD memory card); communication technology used, battery-life time, payment method and price. Regarding the vital signs monitoring products, in order to choose the best and most suitable product, one asked in the Healthcare Professionals' survey which vital signs were more important to monitor in a general hospitalization setting, as well as, other product characteristics. To really get to know the products and the medical device's market, one had two interviews with individuals from big companies around the world, and exchanged informational e-mails with more 8 different companies.

After this review, one came up with the following products:

	Products' Name	Company' Name	Image
1	IntelliVue Guardian: Wearable medical biosensor	Philips	
2	myCubixx	Cubixx Solutions AmerisourceBergen	
3	LifeVest wearable cardioverter defibrillator (WCD)	Asahi Kasei ZOLL Medical (AZM) part of the Asahi Kasei Group	
4	Doxy.me	Doxy.me	
5	Chatbot platform	Sensely	
6	DoseSmart	DoseSmart Inc.	
7	CADD - Solis Ambulatory Infusion	Smiths-Medical	
8	Elastomeric pump ELASTOSAM	Samtronic	

Table 7: Products' Kit Description

To facilitate the analysis and to create a generic basis kit where other types of products would then be added to accommodate each treatment needs, one asked in the healthcare professionals' survey which of the products were the most essential to have in a generic products' kit for the HH service. The 3 most favoured products were: the vital signs monitoring product (20%), the oral medication adherence monitoring product (18%) and the telemedicine platform (15%). Therefore, all the analysis related to the interest in using (patients) or acquiring

(hospital managers) were made based on this kit consisting of these 3 remote monitoring products.

Based on the market research done, one could understand that the main communication technologies currently used in the medical devices' market are Bluetooth and WiFi, and both represent a limitation which prevents the service to reach its full potential. Whether devices rely on the patient's home internet connection to transmit data or are dependent on other devices to operate (e.g. tablet; mobile phone; router), having coverage limitations, low battery-life and very poor interoperability capabilities, these technologies represent reliability failures (Ferrante et al., 2010). 5G is the answer, once it is completely independent (being embedded into the devices, enabling it to send and receive data), and it is expected to have a lower cost, lower battery consumption, ultra-low latency (which enables real-time data transmission), uninterrupted, consistent and ubiquitous connectivity, greater coverage and above all greater capacity enabling the massive IoMT adoption.

H3: 5G-IoT technology, if incorporated into remote patient monitoring devices, will enhance the HH service. ➡ **Valid**

4.2.4. Research Question 4: Are Portuguese Hospitals interested in acquiring new remote patient 5G-IoT Technology monitoring solutions for the HH service?

As discussed in the literature review, in the Portuguese market context, due to new market trends and the financial incentive that the Portuguese government created, it is notable that there is a great latent interest from hospitals to implement the HH service. Therefore, what this question intends to understand is whether Portuguese hospitals are interested in acquiring 5G-IoT technology remote monitoring products' kits, in order to incorporate it in the HH service.

According to Figure 18, 78% of the hospital managers surveyed stated that they were interested in integrating remote patient monitoring products into the HH service. Despite none of the respondents knowing the potential benefits of 5G-IoT technology for the HH service, after being confronted with its benefits, all stated it is necessary to integrate 5G-IoT technology into remote monitoring products. This degree of appreciation on behalf of hospital managers reflects that if well informed, they will greatly value the potential of 5G-IoT technology. 82% of the interviewed strongly agreed on the need to include the remote monitoring products' kit in order to make the service safer, effective and efficient. 90% of respondents showed interest in integrating 5G-IoT technology into remote monitoring products, and all considered that

integrating into de HH service a remote monitoring 5G-IoT technology products' kit was a great business idea. Moreover, 90% of the respondents showed great appreciation for the integrated way the solution would be made available. In addition, despite only 36% considering a great business opportunity for the hospital, 82% of the hospital managers claimed a great interest in acquiring a 5G-IoT technology remote monitoring products' kit to integrate in the HH service.

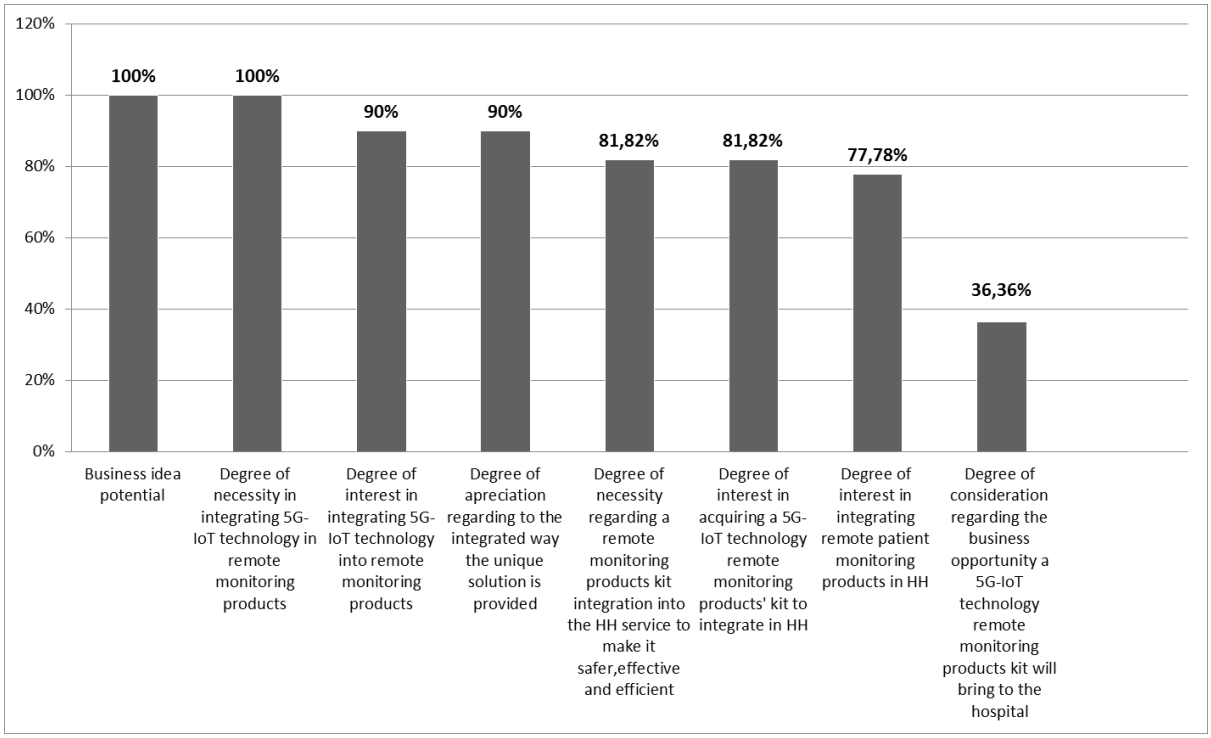


Figure 18: Hospital Managers' perceived idea of the Products' Kit (Values regard to the response range (>7))

Finally, on average, hospital managers' willingness to pay per patient, per day, for the products' kit is € 46, and their forecast for the number of patients expected growth rate, on average, in the first 5 years is 53%, and in the following 5 years is 63%.

	Minimum	*Mean*	*Maximum*
Willingness to pay	€ 5	€ 46	€ 100
Growth Rate for the first 5 years	10%	53%	100%
Growth Rate for the following 5 years	5%	63%	100%

Table 8: Willingness to pay and Growth Rate

Summarizing, all these data contributed to create clear positive outlook for market growth and evidence regarding the high willingness of the Portuguese hospitals in acquiring the solution.

4.2.5. Research Question 5: Is the Portuguese population interested in using the HH service with a 5G-IoT based remote monitoring products' kit?

To answer this final research question the responses given by the possible future patients (end-users) in the conducted survey were taking into account. According to Figure 20, all the interest indicators regarding the remote monitoring products' kit have percentages above 50%, reinforcing the positive idea that the sample has of the service. Over 61% feel the need to integrate this products' kit to feel calm, confident, safe and satisfied while using the HH service.

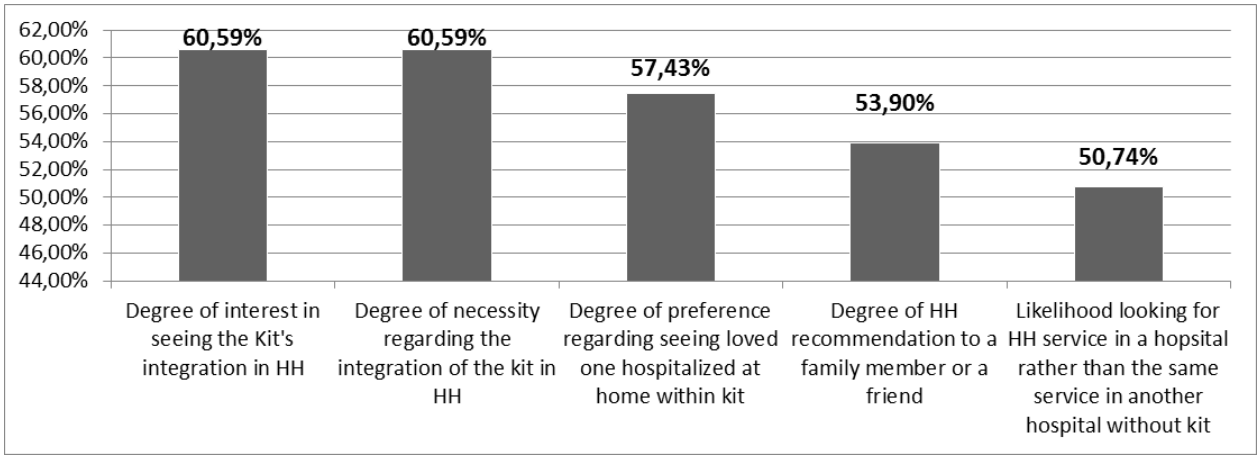


Figure 20: Patients' perceived idea of the Products' Kit (Values regard to the response range (>7))

Figure 21 is the ground proof that the Portuguese population is interested in using the HH service with a 5G-IoT based remote monitoring products' kit, as 75% classified their likelihood of choosing this service as very likely (or more).

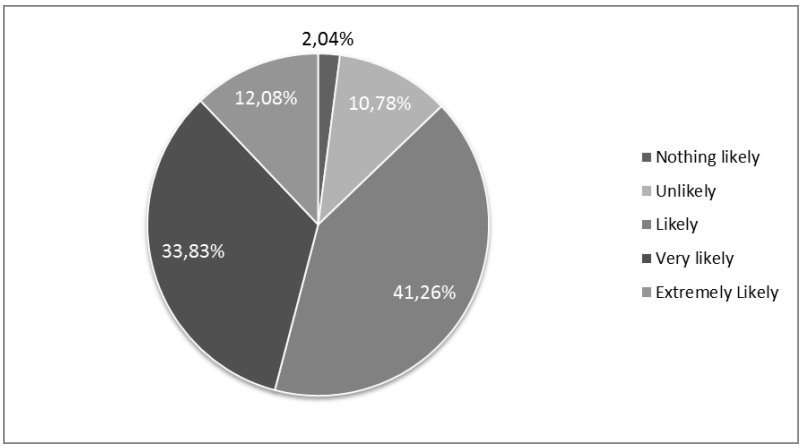


Figure 21: Patients likelihood of choosing to use the HH service with access to the 5G-IoT remote monitoring products' kit

Furthermore, to do a more detailed study, one conducted a logistic model using Stata software to determine the probability of an individual to choose to use the HH service with a 5G-IoT based remote monitoring products' kit. Using the survey conducted to the *Possible future Patients (end-users)*, data regarding over 70 variables was collected. Using conceptual reasoning, one chose the most relevant variables to predict the probability under study. Hence, the initial model was composed by the dependent variable and 36 independent variables. To be able to run the regression (when categorical and continuous) and to facilitate its interpretation (when discrete), the dependent variable and 23 out of the 36 independent variables were transformed. The dependent variable chosen was the **HH_with_Kit_NV**, which respects to the likelihood of using the HH service with access to the products' kit (Appendix 4). After performing the unrestricted model with the previous presented variables (Appendix 5), one conducted the restricted model with all the statistically significant variables in the unrestricted model and five variables, that despite not being significant, one strongly believes in its importance not only to predict the likelihood of the dependent variable, but also because of its correlation to one or more explanatory variables. Thus, avoiding the **omitted variable bias**.

Restricted Model

$$HH\ with\ KIT = \beta o + \beta 1 * TI\_Interest + \beta 2 * Health\_Status\_NV + \beta 3 * Hospital\_Stay\_NV + \beta 4 * Home\_Hospitalized\_NV + \beta 5 * Easiness\_Caregiver\_NV\ \beta 6 * Trust\_Technology\_NV + \beta 7 * Feel\_Safer\_NV + \beta 8 * Innovation + \beta 9 * Degree\_of\_Interest + \beta 10 * Likelihood\_HH + \beta 11 * Willingness\_to\_pay\_NV + \beta 12 * HH\_No\_KIT\_NV + \beta 13\ Level\_of\_Education\_NV + \beta 14 * No\_Room\_Hospital\_NV + \beta 15 * Concerns\_HH\_NV + \varepsilon$$

After reaching the final model (Appendix 6), the significant variables were: TI_Interest, Home_Hospitalized_NV, Trust_Technology_NV, Feel_Safer_NV, Likelihood_HH, HH_No_Kit_NV and Level_Education_NV. All the variables affect positively the outcome (seen in *Coef.*), except from Home_Hospitalized_NV, which affects negatively the outcome. This may seem like a big surprise, but it may be explained by the high level of satisfaction given by patients that have already been home hospitalized, since having already used the service satisfactorily may not feel the need of having the products' kit, thus justifying its negative impact on the probability under study.

Additionally, one can see that the *NagelKenke R^2* (pseudo R^2) is 32,19%. This means that 32,19% of the variability of the dependent variable is explained by the variability of the explanatory variables. This value should be as close to 100% as possible. Hence, since it is quite far from it, the model is considered to have a relatively low predictive power. However, this can be justified by the characteristics of the product. Since it is a new high-tech service that is still away from the user's experience, its acceptance is difficult to measure. Additionally, there are possibly incoherent answers in the survey due to **behavioural bias**. For example, a respondent might trust technology and have a high degree in seeing the products' kit integrated into the service, but then do not wish to use it at the end, as it might be biased by its current good health condition.

Nevertheless, if we evaluate the overall significance level of the model through *Chi^2 test*, it is possible to conclude that the model is statistically significant since the *p-value* is 0% and, thus, the null hypothesis is rejected.

$Ho: \beta 1 = \beta 2 = \cdots = \beta x = 0$ *(Null Hypothesis)* $\quad H1: \beta 1 \neq 0\ V\ \beta 2 \neq 0\ V \ldots V\ \beta x \neq 0$ *(Alternative Hypothesis)* $\quad 1 \leq x \leq 36$

Finally, the most important usage of the logistic regression is to compute the probability of choosing to use the HH service with access to the 5G-IoT remote monitoring products' kit given certain characteristics of the end-user.

This probability will be given by:

$Probability\ of\ HH\_with\_KIT = \frac{e^{f(x)}}{1+e^{f(x)}}$ where f(x) is given by the equation of our final model.

According to the direction that the effects of each variable have on the dependent variable, it is believed that the individual with the following characteristics is the one who is most likely to choose the proposed service.

End-user characteristics:

End-user characteristics			
1	TI_Interest	5	Higher level of interest in topics related to Health and Well-being
2	Health_Status_NV	1	Lowest considered level of health status
3	Hospital_Stay_NV	0	individual who believes that has been hospitalized less than or equal to the necessary time, or is not sure
4	Home_Hospitalized_NV	0	individual who has never been home hospitalized
5	Easiness_Caregiver_NV	1	individual who finds easy to find a caregiver
6	Trust_Technology_NV	5	individual who strongly trusts on technology with medical quality certification to monitor its health status with hospital-grade accuracy
7	Feel_Safer_NV	5	individual who feels safer enjoying the HH service if monitored by medical devices
8	Innovation	5	individual who thinks that this products' kit is innovative
9	Degree_of_Interest	10	individual who is extremely interested in seeing this products' kit integrated into the HH service
10	Likelihood_HH	10	individual who is extremely likely to choose the HH service at a hospital which has the products' kit
11	Willingness_to_pay_NV	1	individual who is willing to pay for the HH service more or the same as in the traditional service
12	HH_No_KIT_NV	1	individual who is likely to choose to use the HH service without the products' kit
13	Level_of_Education_NV	1	individual who has an education level equal or superior to the Bachelor degree
14	No_Room_Hospital_NV	1	individual who already needed to be hospitalized but the hospital where he/she was at didn't have room
15	Concerns_HH_NV	0	individual who has no concerns regarding the HH service

Table 9: End-users characteristics

Substituting the coefficients' values and these values as well in the function presented before, will lead to the following probability:

$$Probability\ of\ HH\_with\_KIT = 0.999915$$

Therefore, according to the selected model, an individual with all the characteristics mentioned above has a probability of 99.99% of choosing to use the HH service with access to the 5G-IoT remote monitoring products' kit.

5. Conclusions, Limitations, Recommendations & Future Research

This chapter starts with the dissertation's main conclusions, then presents its principal limitations and recommendations, and finally suggests ideas for future research on the topic.

5.2. **Conclusions:**

A new cellular wireless technology network is imminent and its deployment is expected to enable one of the largest waves of innovation, transformation and development ever seen, the *fourth industrial revolution*. Its name is **5G**.

Among the most promising vertical industries' transformations is the Healthcare sector's disruptive progress, as this sector isn't only facing an enormous digital transformation but is, as well, undergoing a great structural transformation once its business model is changing. From a volume-based to a value-based is the new **VBHC** business model's motto. It aims to be a patient-centered, outcome-driven, prevention-focused and tailored approach model, create financial sustainability and enhance healthcare quality and patient satisfaction. A major trend in the healthcare market that follows the principles of this new business model is emerging: **HH service**. This new service is full of promises regarding costs reduction, more and better access to healthcare services, gains in efficiency, patient's empowerment, family involvement, preventing abandonment, and healthcare quality improvement.

However, still nowadays this service's adoption rate is very little, and one of the reasons identified was the lack of medical-grade surveillance tools to continuously monitor at home patients, as well as, non-timely interventions due to medical device's current used communication technologies' unreliability, having a negative impact in the patient's recovery and increasing the costs. 5G is the answer, once it is completely independent (being embedded into the devices, enabling it to send and receive data), and it is expected to have a lower cost, lower battery consumption, great interoperability, ultra-low latency (which enables real-time data transmission), uninterrupted, consistent and ubiquitous connectivity, greater coverage and above all greater capacity enabling the massive IoMT adoption. Particularly, 5G-IoT technology will improve accurate documentation, decrease hospitalization costs, enable the remote real-time surveillance of patients, and improve patient outcomes.

In Portugal, the trends are parallel. All the excitement about 5G and HH is prevalent. Portuguese government trying to keep up with the global market trends, created recently a financial incentive measure. As a result, the demand for HH solutions has never been higher. In this context, this dissertation's topic arise, intending to study the business opportunity that

using 5G-IoT technology in a remote monitoring products' kit could bring if integrated into the HH service. This is a pioneering study for the Portuguese market, regarding the specific use of 5G-IoT technology in the HH service, thus fulfilling a gap on the existing literature.

This dissertation provides a glance over the Portuguese market potential, once it analyses the perspectives of both hospital managers and general population regarding the willingness to integrate and use, respectively, the proposed service. It is important to take both perspectives into account because in Portugal the HH service admission of a patient is entirely dependent on its will. According to the samples' results, 82% of the hospital managers claimed a great interest in acquiring a 5G-IoT technology remote monitoring products' kit to integrate in the HH service, and 75% of the general population classified their likelihood of choosing this service as very likely (or more). By doing a logit regression, the end-user's profile that is most likely to choose to use the HH service with a products' kit was determined, and its probability was calculated: 99.99%. Additionally, 90% of the hospital managers inquired expressed very high appreciation regarding the integrated way this unique solution is provided, thus reinforcing the operators' position in the value-chain. Finally, it seems that with this business idea implementation there will be benefits for all stakeholders involved:

	Stakeholders' Benefits
1	Patients will get better care at a better price;
2	Doctors and nurses will be able to do their job easily, in a more efficient and effective way;
3	Telecommunications companies will be able to capitalize on a technology that they are already investing in, without having to invest much more;
4	Hospitals will have their hospitalization costs reduced due not only to the increase in the number of patients hospitalized (over the limited capacity of the hospital ward), but also will benefit from the opportunity cost of having healthcare professionals performing other activities instead of monitoring patients;
5	Medical devices companies will have the opportunity to increase their sales.

Table 10: Stakeholders' Benefits

Concluding, there is undeniably a market pull and a technology push for the creation of this new enhanced service, waiting to be explored. So the question is: To whom do we entrust the challenge of finding the right solution?

5.3. **Limitations**

Like any other research project, this dissertation has a few limitations.

Firstly, being this a very recent theme, there is very little literature done by academics on the topic, being mainly the companies involved the ones to develop research on it. As well, it is relevant to refer that in the limited researcher's time, only 34 medical devices were studied and, hence, there may be other with different characteristics on the market that weren't included in this research, limiting the possibilities of the service to the potentialities of the devices found. Moreover, many medical devices found still don't exist in the market because they are still in test stages, and many don't have yet quality certifications.

Secondly, the greatest obstacle in this dissertation was to overcome the secrecy involving the 3 industries studied. All the information, due to data protection, is confidential, not available online, being essential NDAs' signing. However, as in the dissertation's context this isn't possible, it highly limited the researcher's analysis. Initially, one wanted to do a financial analysis from the perspective of telecommunications companies, but no quantitative reliable data was available. Products' prices were very hard to attain, and the ones attained were based on the communication technology used, on the estimated number of end-users per year, and in the country where they were produced and, therefore, hadn't integrated distribution and storage costs for the Portuguese market. Furthermore, the incremental value of the current communication technology replacement for 5G technology wasn't measurable. Finally, it wasn't conceivable to estimate the costs of creating an integrating platform for the telecommunication companies.

Thirdly, the 3 surveys performed in the course of this study were built upon the in-depth expert interviews' responses and not based on already tested literature constructs, thus possibly creating a selection bias. In addition, the samples collected have a small dimension and may not represent the Portuguese population. Also, in the regression performed only the data without missing values was used, reducing the number of observations.

Fourthly, there is no doubt that the implementation of such a service will require capabilities that fall beyond the traditional purview of healthcare, telecommunications and medical devices organizations. Therefore, these players should contemplate the creation of an ecosystem of collaboration and partnership to fulfil the knowledge gaps. As well, the vision given regarding the benefits and capabilities of 5G technology was slightly over-positive because being it an innovation not yet tested in the market, only the expected network requirements are known and, thus, its benefits are stipulated. Hence, the 5G mMTC technology that I propose to use in the service is still an elusive utopia.

5.4. Recommendations & Future Research

Regarding future research, a question remains after this dissertation concerning the viability of this service's implementation regarding costs. Therefore, as a future direction, it is advised the execution of a financial feasibility study for all players involved, in order to perceive the real business opportunity this service can enable. Additionally, it is suggested to study the applicability of a bundle-based innovative business model, simultaneously with the interest of each value-chain participant in collaborating and partnering to enable the fastest and easiest implementation of the service. Furthermore, it is recommended to do an applicability study within a real context, to perceive the extent of benefits and the unexpected problems, as well as, patient's satisfaction.

Moreover, to achieve the highest service scalability possible, it is also advised to do further research regarding the addition and removal of products from the products' kit, in order to calculate the exact number of kits to be created and, thus, satisfying the needs of all treatment methods for all the pathologies included in the service. Also, a study concerning the implementation of the products' kit in a hospital context should be conducted to realize the full potential gains this products' kit can generate.

Finally, due to the current Portuguese market proved potential, it is recommend to study the possibility, benefits and limitations, of incorporating in the short-term, rather than 5G, another communication technology already existent in the market: Narrowband IoT (NB-IoT). It seemed to the researcher that the characteristics of this communication technology are identical to those expected of 5G with the exception of capacity, since it is built upon 4G network. It is advised that operators not only invest in 5G networks, as 5G New Radio and 5G core, but also in business development, go-to-market models and organizational adaptation, as business and monetization models will need to evolve in order to capture the maximum value.

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7. Appendix

Exhibits:

Exhibit 1

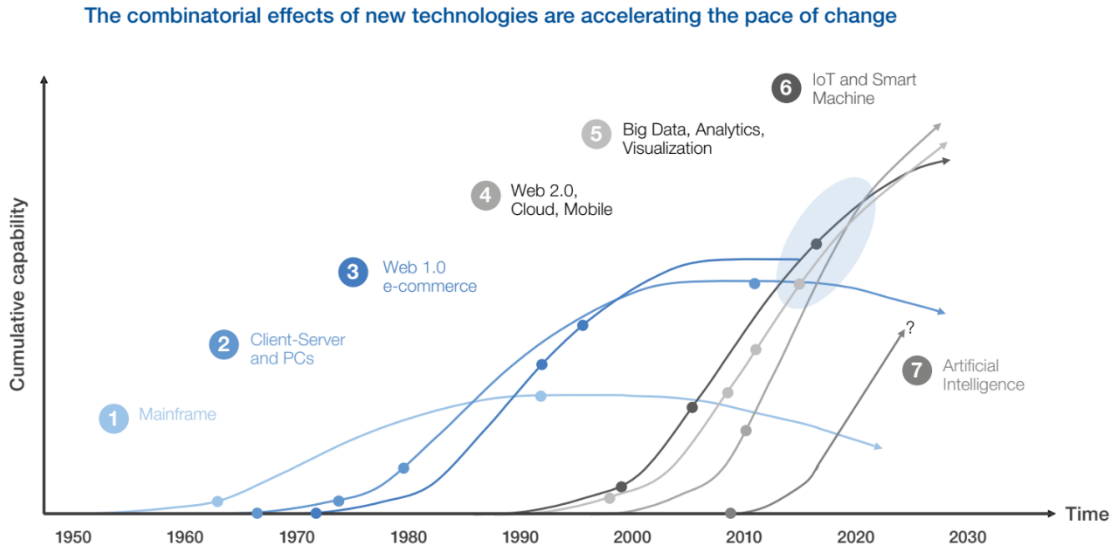


Figure 1: The combination effects of new technologies are accelerating that pace of change : (World Economic Forum & Accenture, 2016)

Exhibit 2:

Figure 2:Magic Quadrant for Managed M3M Services Worldwide(Gartner, 2018)

Exhibit 3:

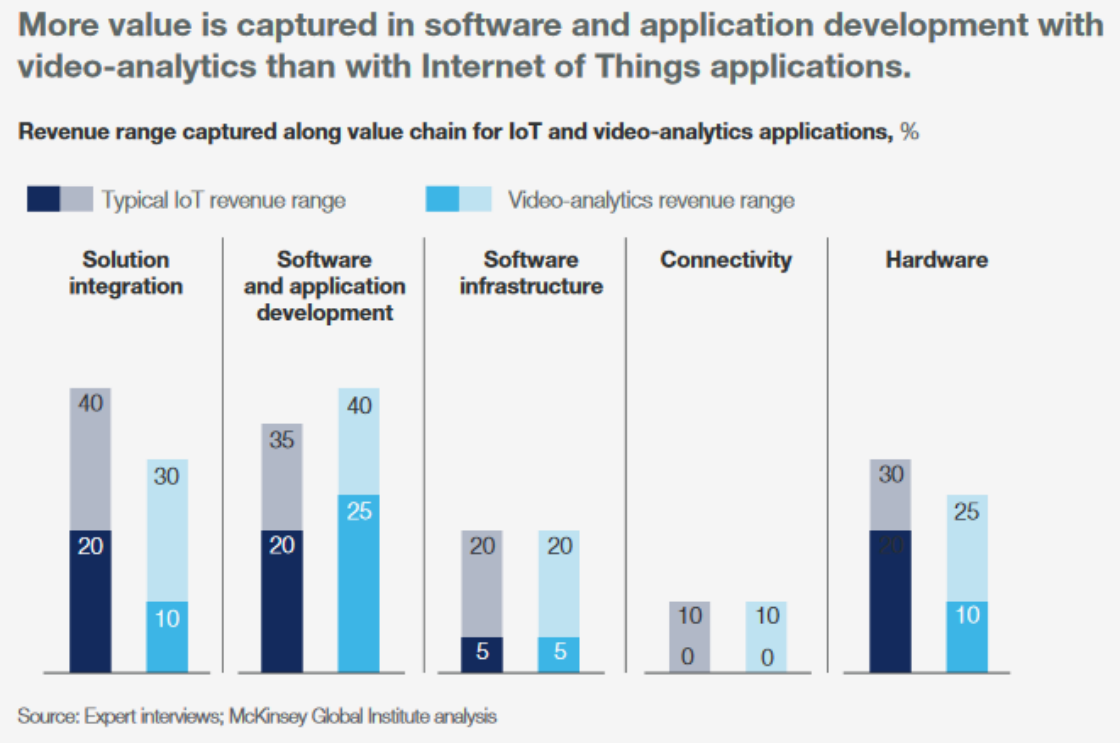


Figure 3:More value is capture in software and application with video-analytics than with Internet of Things applications (McKinsey, 2018b)

Appendix 1

IoT Technology

The Internet of Things (IoT) is a disruptive technology which uses embedded software, connectivity, sensors and actuators to connect physical objects (hardware) to the internet, allowing them to communicate, collect and exchange data with one another and with humans, by emitting, accepting and processing signals, to create actionable insights (Deloitte, 2018d; EY, 2016; Gartner, 2017; McKinsey, 2018b; Vodafone, 2019b). In this process of ongoing interaction, sensors collect data and actuators transmit that data (Hoffman & Novak, 2017).

IoT is a combination of "various technologies including embedded sensing, device identification and management, wireless sensor networks and M2M managed connectivity platforms and communications" (Accenture, 2015). IoT technology's main goal is to monetize data (Vodafone, 2017), transforming it in currency (McKinsey, 2018b). Thus, it isn't a standalone technology (Vodafone, 2017). Only when used in conjunction with other complementary digital technologies ('combinatorial innovation'), such as advanced data

analytics, augmented reality (AR), cloud and machine learning, as artificial intelligence (AI) (Forbes, 2017; Gartner, 2017; Vodafone, 2017, 2019b), it can derive greater value and reach its utmost potential (Gartner, 2017; Vodafone, 2019b). By engaging with these other technologies, IoT products become 'smart' devices with capacity to exercise agency ("capacity to affect, and be affected by"), autonomy ("capacity to function independently"), and authority ("capacity to control other entities and make its own decisions") (Novak & Hoffman, 2018).

IoT technology has the potential to be used in multiple sectors as: manufacturing (track products from end-to-end), transportation (driverless IoT- connected car), utilities (smart water, gas and electricity), healthcare (connect with patients via wearable devices), agriculture (smart farming), retail (connect with customers, grow brands, and improve customer experience), banking (mobile banking), and government (smart cities) (Deloitte, 2013b; EY, 2016; Forbes, 2017).

Over the years, IoT technology adoption rate has been accelerating (Accenture, 2015; Vodafone, 2017, 2019b) globally and across all industries (Vodafone, 2017), due to several factors: sensors have increase in number, capability, and sensitivity (Deloitte, 2018c) and are getting smaller, faster and cheaper (Deloitte, 2013b); ubiquitous computing is improving; chips processing power is becoming higher; IoT enablement platforms' availability is growing (Vodafone, 2019b); and there has been a continuous drop in devices (Accenture, 2015) and connectivity costs, from new cost-effective connectivity options (Vodafone, 2019b).

Appendix 2

IoT's main concerns

IoT concerns can be divided into technical, structural and behavioural (McKinsey, 2015).

The technical concerns are as follows: privacy and security (Deloitte, 2018b; EY, 2016; McKinsey, 2015; Vodafone, 2017); authentication (McKinsey, 2014); connectivity (Deloitte, 2018b, 2018d; McKinsey, 2014, 2015; Vodafone, 2017); battery life (McKinsey, 2014; Vodafone, 2017); interoperability (McKinsey, 2015), data compatibility (EY, 2016; Forbes, 2017; Vodafone, 2019b) and portability (Czarnecki & Dietze, 2017) due to the lack of standards (EY, 2016; Forbes, 2017; Vodafone, 2019b); scalability (EY, 2016); and software infrastructure (Deloitte, 2013b, 2018b).

The structural concerns are as follows: regulatory and legal (Czarnecki & Dietze, 2017; EY, 2016; Forbes, 2017; McKinsey, 2015); and IoT data monetization business models (Vodafone, 2019b).

The behavioural concerns are as follows: consumers' trust in IoT-based systems (McKinsey, 2015); reliability (Vodafone, 2017); lack of IoT data-driven approaches embracement for decision making by companies; use of data; confidentiality and integrity (McKinsey, 2015); data's rights ownership (EY, 2016; McKinsey, 2015; Vodafone, 2019b); liability of each IoT's value-chain participant (McKinsey, 2015); and the lack of knowledge enterprises have regarding IoT's use and benefits for their businesses (Gartner, 2017).

These concerns are all interconnected. Until "connectivity protocols have been established to prevent hacking, loss of intellectual property, or other potential breaches", IoT technology will hardly use in critical environments as industrial or medical (McKinsey, 2014). On top, the lack of regulation and standards in the IoT environment (Czarnecki & Dietze, 2017; Deloitte, 2018b; EY, 2016; Forbes, 2017; McKinsey, 2015) allows different devices, companies and industries to use different forms of connectivity (Vodafone, 2017). These creates incompatibility issues, making communication between devices sometimes very complex (EY, 2016; Vodafone, 2017), as well as, it means that a flexible IoT infrastructure is needed to support it (Vodafone, 2019b). Interoperability among IoT systems and applications is expected to be responsible for 40% of the potential value generated by IoT (McKinsey, 2015). Additionally, as the number of connected devices increases, also the connectivity demands on the network grow (Vodafone, 2017). Current network data rates (McKinsey, 2014), coverage and capacity are limitating IoT's growth (Deloitte, 2018b) and large scale adoption (EY, 2016). The number of use cases are expected to increase exponentially with the deployment of better connectivity technologies (Samsung, 2016). According to Vodafone IoT Barometer 2019, 52% of IoT adopters are considering using 5G (Vodafone, 2019b) and 36% of IoT adopters consider 5G the best new connectivity option for IoT projects (Vodafone, 2017).

Appendix 3

IoT Technology value-chain & the operators' place on it

There are four authors who have written about IoT's value-chain and all express similar visions regarding its participants:

Author	1st Participant	2nd Participant	3rd Participant	4th Participant	5th Participant	6th Participant	7th Participant
(Accenture, 2015)	Embedded Technology Provider	Hyper-Connector	IoT Platform Provider	IoT App Provider	IoT Integrator		
(Czarnecki & Dietze, 2017)	Device/ Module	Connectivity	Access Enabling	Solution Enabling	Vertical Solutions	Integration	
(Deloitte, 2018c)	Device and Sensor Manufacturers	Software Vendors	Connectivity Network Providers	Connectivity Management Providers	Cloud Providers	Analytics Platform Providers	Orchestrators
(McKinsey, 2018)	Hardware	Connectivity	Software Infrastructure	Software and Application Development	Solution Integration		

Table 10: IoT's Valuechain

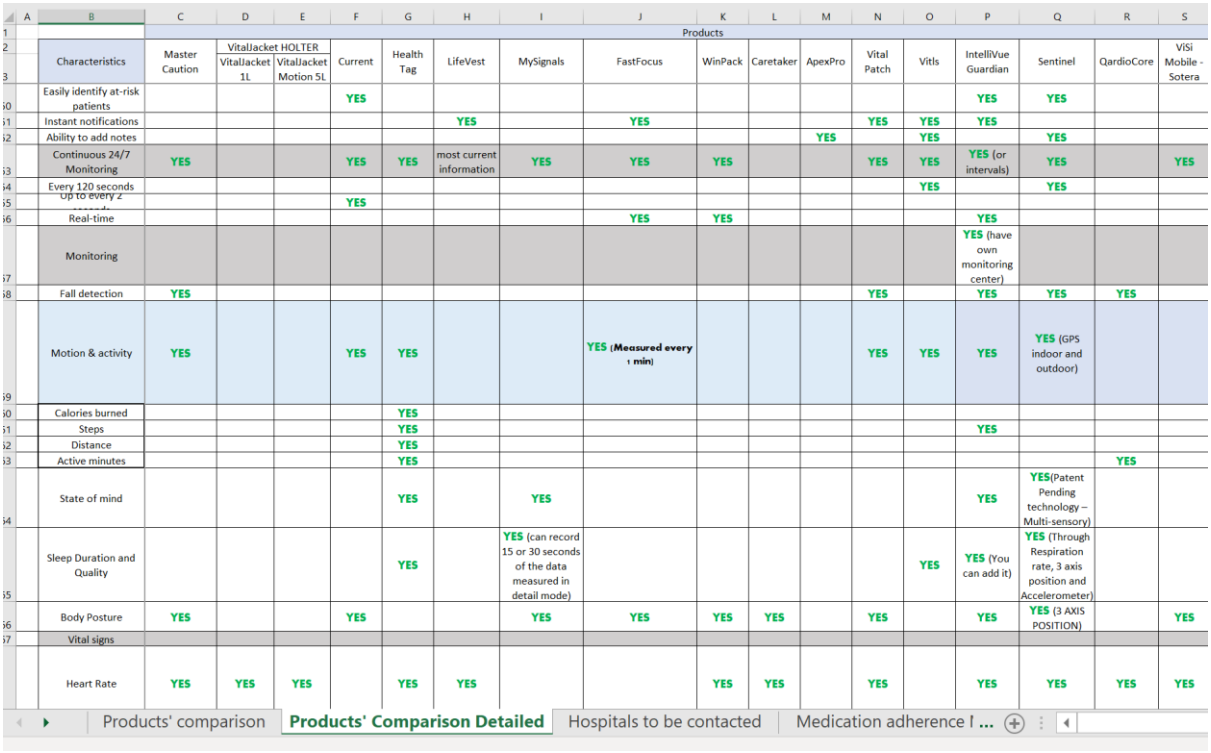
After carefully analysing all the perspectives, one was able to verify what they all have in common. They all agree that there must be a device / hardware technology provider, a connectivity network and management provider, an IoT software platform provider, an IoT application development provider, and an IoT integrator (Accenture, 2015; Czarnecki & Dietze, 2017; Deloitte, 2018d; McKinsey, 2018b). Within the IoT value-chain, as connectivity providers, operators can either be 'Wholesale Providers', only providing connectivity, 'Managed Connectivity Providers', providing connectivity and access enabling, or 'Managed Connectivity and Solution Providers', providing connectivity, access enabling and solution enabling, depending on higher risks in relation to higher margins (Czarnecki & Dietze, 2017). However, the connectivity network and management provider role is the one that is expected to receive the least revenue in the revenue range of IoT projects (McKinsey, 2018b) (Exhibit 3), thus operators are thinking of moving up in the value-chain (Czarnecki & Dietze, 2017). The IoT integrator must be responsible for the end-to-end integration of IoT solutions (Accenture, 2015), as well as, for partnerships' management with the aim of developing trust-based business relationships (Deloitte, 2018d).

Appendix 4

	A	B	C	D	E	F	G	H	I	J	K	L	M
1			Company										
2		Source	Origin	Date it was founded	Name	Products	Characteristics		Image	Contacts	Pictures	Price	Questions
12	9	https://www.caretakermedical.net/	USA (Virginia)	2014	Caretaker Medical	Caretaker4 Wireless Vital Signs Monitor - simple finger cuff	1. Measures: Blood Pressure; Heart Rate; Blood Oxygen Level; Respiration Rate; Body Temperature; 2. Data transmition : Telecommunication Technology: cellular networks or Bluetooth 3. FDA Approved 4. CE Certification 5. Secure Android App, HIPAA-compliant Cloud			(EMEA) +44 780 3141577 or (USA) +1 434-978-7000 Email: inquiry@caretakermedical.net or Email: inquiry@caretakermedical.net	Thesis 9	?	
14	11	https://vitalconnect.com/solutions/vitalpatch/#data-	USA	2011	Vital Connect	Vital Patch - Adhesive Patch with integrated Sensor Module	1. Discrete; small, elegant device. 2. biosensor which monitors eight physiological measurements continuously, in real time. vital signs:			TEL: (408) 963-4600 info@vitalconnect.com	Thesis 11	?	The Vista SolutionTM platform is only available
15	12	https://www.vitlsinc.com/vitls-technology	USA	2016	Vitls	Vitls wearable medical device	1. Is compatible with iOS, Android, any web browser, and many EHRs. 2. Small; Thin. Unobtrusive. Wireless. Flexible. Waterproof. Disposable. 6-Day Battery Life.			founders@vitlsinc.com Phone Number: 415-949-9963	Thesis 12	?	
16	13	https://www.usa.philips.com/healthcare/product/HC98980	Netherlands / USA	2016	Philips	Guardian: Wearable medical sensor - Wearable biosensor	0. FDA clearance; CE Mark certification 1. Patient-Wearable monitoring. (medical-grade wearable biosensor) 2. use wireless technology to			https://www.usa.philips.com/healthcare/product/HC98980319687 1/wearable-	Thesis 13	?	Phone US: 1-800-722-9377 Phone PT: (+351) 21423770
17	14	https://www.sentinelsensor.co.uk/	UK	2018	Sentinel Healthcare	Sentinel Sensor	1. FULL VITALS, EVERY 120 SECONDS 24/7 - NO WEB CONNECTION NEEDED 2. Medical Grade; Wearable; Vital Signs Monitor 3. continuous real-time			Email: contact@sentinel.healthcare Email (manager):	Thesis 14	?	

Products' comparison | Products' Comparison Detailed | Hospitals to be contacted | Medication adherence I ...

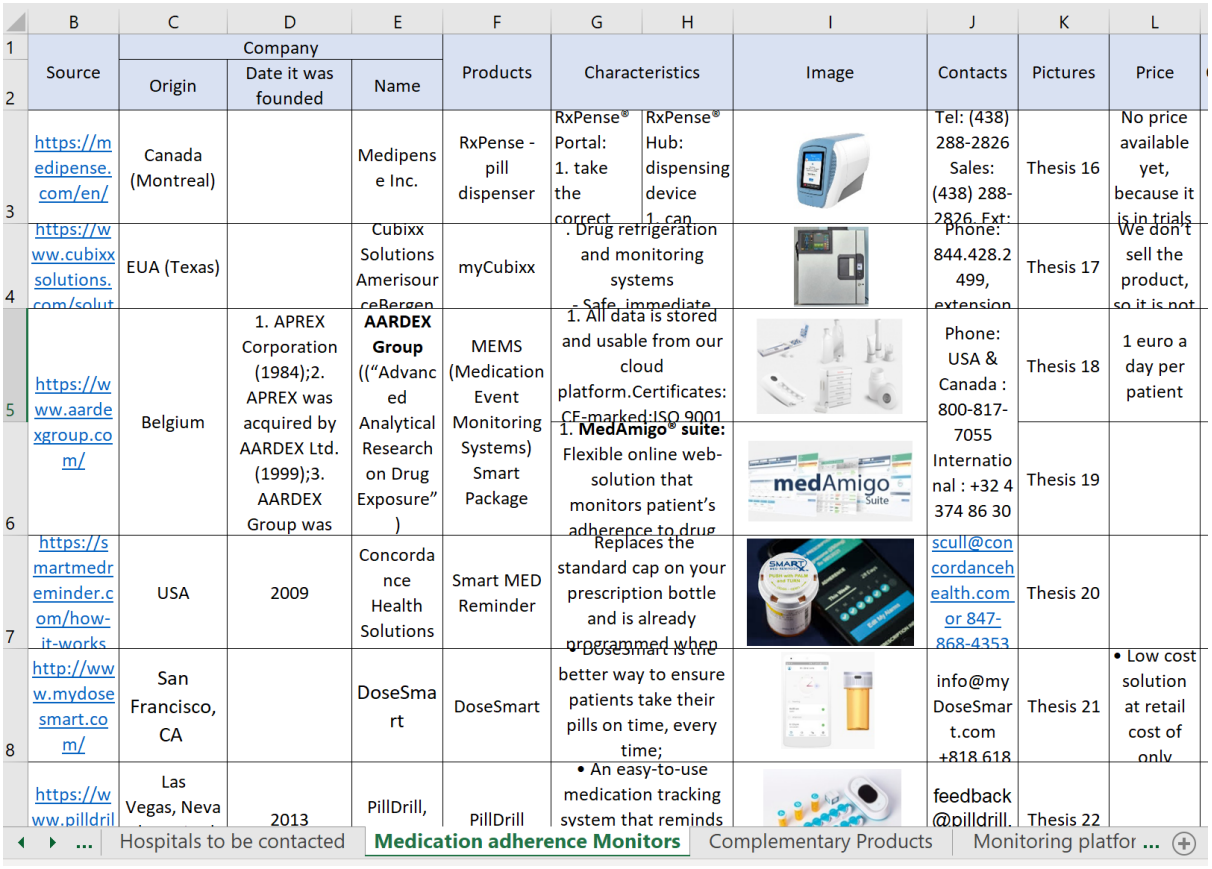
Figure 22: Product's kit



Characteristics	Master Caution	VitalJacket HOLTER: VitalJacket 1L	VitalJacket HOLTER: VitalJacket Motion 5L	Current	Health Tag	LifeVest	MySignals	FastFocus	WinPack	Caretaker	ApexPro	Vital Patch	Vitls	IntelliVue Guardian	Sentinel	QardioCore	ViSi Mobile - Sotera
	Products																
Easily identify at-risk patients				YES										YES	YES		
Instant notifications						YES		YES				YES	YES	YES			
Ability to add notes											YES		YES		YES		
Continuous 24/7 Monitoring	YES			YES	YES	most current information	YES	YES	YES			YES	YES	YES (or intervals)	YES		YES
Every 120 seconds													YES		YES		
Up to every 2 [illegible]				YES													
Real-time								YES	YES					YES			
Monitoring														YES (have own monitoring center)			
Fall detection	YES											YES		YES	YES	YES	
Motion & activity	YES			YES	YES			YES (Measured every 1 min)				YES	YES	YES	YES (GPS indoor and outdoor)		
Calories burned					YES												
Steps					YES									YES			
Distance					YES												
Active minutes					YES											YES	
State of mind					YES		YES							YES	YES(Patent Pending technology – Multi-sensory)		
Sleep Duration and Quality					YES		YES (can record 15 or 30 seconds of the data measured in detail mode)						YES	YES (You can add it)	YES (Through Respiration rate, 3 axis position and Accelerometer)		
Body Posture	YES			YES			YES	YES	YES	YES		YES		YES	YES (3 AXIS POSITION)		YES
Vital signs																	
Heart Rate	YES	YES	YES		YES	YES			YES	YES		YES		YES	YES	YES	YES

Products' comparison | **Products' Comparison Detailed** | Hospitals to be contacted | Medication adherence I ...

Figure 22: Product's kit



Source	Company: Origin	Company: Date it was founded	Company: Name	Products	Characteristics	Image	Contacts	Pictures	Price
https://medipense.com/en/	Canada (Montreal)		Medipense Inc.	RxPense - pill dispenser	RxPense® Portal: 1. take the correct / RxPense® Hub: dispensing device 1. can		Tel: (438) 288-2826 Sales: (438) 288-2826, Ext:	Thesis 16	No price available yet, because it is in trials
https://www.cubixxsolutions.com/solut	EUA (Texas)		Cubixx Solutions AmerisourceBergen	myCubixx	. Drug refrigeration and monitoring systems - Safe, immediate		Phone: 844.428.2499, extension	Thesis 17	We don't sell the product, so it is not
https://www.aardexgroup.com/	Belgium	1. APREX Corporation (1984);2. APREX was acquired by AARDEX Ltd. (1999);3. AARDEX Group was	**AARDEX Group** (("Advanced Analytical Research on Drug Exposure")	MEMS (Medication Event Monitoring Systems) Smart Package	1. All data is stored and usable from our cloud platform.Certificates: CE-marked;ISO 9001 / 1. **MedAmigo® suite:** Flexible online web-solution that monitors patient's adherence to drug		Phone: USA & Canada : 800-817-7055 International : +32 4 374 86 30	Thesis 18 / Thesis 19	1 euro a day per patient
https://smartmedreminder.com/how-it-works	USA	2009	Concordance Health Solutions	Smart MED Reminder	Replaces the standard cap on your prescription bottle and is already programmed when		scull@concordancehealth.com or 847-868-4353	Thesis 20	
http://www.mydosesmart.com/	San Francisco, CA		DoseSmart	DoseSmart	• DoseSmart is the better way to ensure patients take their pills on time, every time;		info@myDoseSmart.com +818 618	Thesis 21	• Low cost solution at retail cost of only
https://www.pilldril	Las Vegas, Neva	2013	PillDrill,	PillDrill	• An easy-to-use medication tracking system that reminds		feedback @pilldrill.	Thesis 22	

... | Hospitals to be contacted | **Medication adherence Monitors** | Complementary Products | Monitoring platfor ...

Figure 22: Product's kit

	B	C	D	E	F	G H	I	J	K	L	
1		Company									
2	Source	Origin	Date it was founded	Name	Products	Characteristics	Image	Contacts	Pictures	Price	Que
3	https://www.sensely.com/	San Francisco, California, United States	2013	Sensely	Chatbot platform	• Molly: Your virtual Assistant o Services: • Speech Recognition: Using a proprietary		info@sensely.com			
4	https://gyant.com/	United States	2016	Gyant	Chatbot platform	Health chatbot that asks patients to understand their symptoms and then sends the data to doctors who provide diagnoses and prescribe medicine in real time. A nurse or doctor will review your diagnosis, sign-off on a treatment, and get you the medicine that you need to feel better.				GYANT costs less than $10 per encounter — much less than your typical co-pay — and you don't even have to leave your	
5	https://infermedica.com/	Poland	2012	Infermedica	Chatbot platform	Infermedica leverages machine learning technology to power the symptom-checker chatbot, Symptomate. The platform runs online and on mobile phones as a chatbot or voice-based		office@infermedica.com		2 Models: Lite: Pay monthly: $750/mo; 20K API calls monthly; $0.04 for extra call; 2 languages	
6	http://www.lifecyclehealth.com	United States	2016	Lifecycle Health	Lifecycle Health platform	enables healthcare to provide patient and cost visibility to providers, enable deep collaboration		SUPPORT@LIFECYCLEHEALTH.COM			
7	https://doxy.me/pri	United States	2013	Doxy.me	Doxy.me (Telemedicine Platform)	• The simple, free, and secure telemedicine solution; • NO DOWNLOAD REQUIRED: With		support@doxy.mePhone Number +1 (800) 214-8509		• Price: Three models: Free, Professional and	

... | Hospitals to be contacted | Medication adherence Monitors | Complementary

Figure 22: Product's kit

	B	C	D	E	F	G H	I	J
1		Company						
2	Source	Origin	Date it was founded	Name	Products	Characteristics	Image	Contacts
9	https://www.smiths-medical.com/products/infusion/ambulatory-		1940	Smiths-Medical	CADD®-Solis Ambulatory Infusion	Wireless communication transforms the CADD®-Solis system from a standalone pump to an integrated system with PharmGuard®		info@smiths-medical.chPhone Number 651-628-7613
10	http://www.medicalexpo.com/prod/micrel-medical-devices/product-69404-505752.html#product-item_505756; http://www.micrelmed.com/index.aspx?produ	Athens, Greece	1980	Micrel medical devices	Infusion pump monitoring system / wireless Rythmic™ connect (2007)	• Rythmic™ Connect is a wireless real time technology using a GPRS device (IP Connect) that gets connected to the ambulatory Rythmic™pump and enables the pump to communicate with a web server and provide its infusion status online through the MicrelCare system. • Physicians, nurses and homecare service providers can access the status of		Tel: +30 210 6032333 | +30 210 6032334; E-mail: info@micrelmed.com
11	http://www.nipro-europegroupcompanies.com/product/surefuser/#post-298; www.nipr	Europe (Belgium)	1991	Nipro Group	SUREFUSER (Infusion systems)	The only infusion pump that combines quality, safety, accuracy and ease of use. Certificate: complies to the European norm (ISO-28620). Surefuser™+ is a disposable,		info@nipropurewater.comPhone Number 32 2 725 55 33; Tel: +32 (0)15 263 500(Belgi
	http://www.samtronic.com.br/PT_Br/b	BRAZIL	1987	Samtronic	Elastomeric pump ELASTOSA	• Maintenance-free, disposable, portable non-electric elastomeric infusion system designed to infuse a wide range		(+55 11) 2244-7750; contato.s

... Hospitals to be contacted | Medication adherence Monitors | Co

Figure 22: Product's kit

Appendix 5

The dependent variable chosen was the **HH_with_Kit_NV**, which respects to the likelihood of using the HH service with access to the products' kit. This variable's scale was initially: nothing likely, unlikely, likely, very likely, extremely likely. Then, in order to have a binary dependent variable, as mandatory in logistic regressions, one considered that the first two options were combined as unlikely taking, thus, the value of 0 and the last three options were combined as likely taking the value of 1.

Concerning the independent variables, similar transformations were computed. The health status was converted into a scale from 1 to 5, being 1 very bad health condition and 5 very good one. Then, all the satisfaction type of variables (Satisfaction_Traditional_Hospitalization and HH_Satisfaction) were transformed in a satisfaction scale from 1 to 6 (very bad = 1, bad = 2, regular = 3, good = 4, very good = 5 and great = 6). Next, the agreement type questions (Trust_Technology, Feel_Safer and Improve_Quality_Experience_Safety) were transformed into an agreement scale from 1 to 5 (where: strongly disagree = 1, disagree = 2, I do not agree or disagree = 3, agree = 4 and strongly agree = 5). All variables whose answers had only two options were transformed into 0 or 1. For instance, not only Yes / No questions (No_Room_Hospital, Home_Hospitalized, Easiness_Caregiver, Concerns_HH, Like_New_Technologies and Health_Insurance) are No = 0 and Yes = 1, but also Hospital_Type_Likelihood and Gender were transformed as Public Hospital = 0, Private Hospital = 1 and Female = 0, Male = 1, respectively. Additionally, some variables had multiple answers that once more were converted only to 0 or 1. For example, whether the inquired had stayed in the hospital more time than he / she wished was transformed into 1 if it had spent more time than wished and 0 otherwise (I am not sure; The necessary; Too short = 0). Regarding the Willingness_to_pay variable, now, it measures whether the inquired customer is willing to pay for the HH service with the product's kit at least the value of the TH service (less than traditional value = 0, more or equal to the traditional value = 1). Moreover, Level_Education now corresponds to 1 if the respondent has at least the bachelor's degree and 0 otherwise. As for age, the survey had 7 age intervals available, which were grouped into three main categories. The young adults (age until 24 years old), which took the value of 1. The adults (25 – 65) taking the value of 2 and the elderly people (over 65 years) taking the value of 3. Finally, in the Monthly_Net_Income, the average net income of each interval was computed so that one could substitute the interval for the respective mean (e.g. "From 651€ to 800€" was now substituted by 725,5€). All the remaining variables were already composed by intervals,

either 1 to 5 such as HW_Interest and TI_Interest or 1 to 10 as for Degree_of_Interest and Necessary_Integration_KIT.

	Original Variable Name	Variable Type	Transformed Variable Name	Variable description
Dependent Variable	HH_with_Kit	Nominal	**HH_with_Kit_NV**	Probability of choosing to use the Home Hospitalization service with access to the 5G-IoT remote monitoring products' kit.
	HW_Interest	Ordinal		Interest in topics related to Health and Well-being.
	TI_Interest	Ordinal		Interest in topics related to technology and innovation.
	Health_Status	Ordinal	**Health_Status_NV**	Consideration regarding individual health status.
	Hospital_Type_Likelihood	Nominal	**Hospital_Type_Likelihood_NV**	Most likely type of hospital chosen by the individual in case of need.
	No_Room_Hospital	Nominal	**No_Room_Hospital_NV**	Individual needed to be hospitalized but the hospital where he/she was at did not have room, having to be transferred to another hospital or to go home without healthcare treatment.
	Hospital_Stay	Nominal	**Hospital_Stay_NV**	If hospitalization period was considered larger than necessary, shorter than necessary or the right time.
	Home_Hospitalized	Nominal	**Home_Hospitalized_NV**	Individual has already been home hospitalized.
	Easiness_Caregiver	Nominal	**Easiness_Caregiver_NV**	Easiness to get a caregiver (family, friend, or health professional hired by you to play this role).
	Concerns_HH	Nominal	**Concerns_HH_NV**	If the individual has concerns about the Home Hospitalization service.
	Easy_Of_Use	Nominal		Apreciation regarding the products' kit easiness of use, not requiring action from the patient or caregiver to fully operate.
	Confortable_Discrete	Nominal		Apreciation regarding the products' kit being comfortable, discrete, light, small and wireless, with no cables to allow patients to continue with their day-to-day activities even when being hospitalized.
	Unique_Integrated_Platform	Nominal		Apreciation regarding the products' kit having a unique and integrated platform that allows the safe access of patients, health professionals and caregivers to all the information, coming from all products, regarding the state of health of the patient in real time.
	Notifying_HP_Time	Nominal		Apreciation regarding the products' kit allowing the early detection of the patient's health deterioration, anticipating the alert, notifying health professionals and caregivers in a timely manner.
	Battery life	Nominal		Apreciation regarding the products' kit longer battery life, thus reducing the number of times it is necessary to recharge the products during the time of home hospitalization.
	Cardiac_Resuscitation	Nominal		Apreciation regarding the products' kit ability to guarantee, when necessary, cardiac resuscitation autonomously and remotely.

Figure 23: Dependent and independents variables

Independent Variables	Trust_Technology	Ordinal	**Trust_Technology_NV**	Individual trusts on technology with medical quality certification to monitor my health status with hospital-grade accuracy.
	Feel_Safer	Ordinal	**Feel_Safer_NV**	Individual feels safer and more confident in enjoying the Home Hospitalization service if monitored continuously, in real time, autonomously and remotely by medical devices, than in person and from time to time by health professionals.
	Improve_Quality_Experience_Safety	Ordinal	**AK**	Individual believes that the products' kit will not only improve the service's quality, experience and safety, but also promote its efficiency and effectiveness.
	Innovation	Nominal		Opinion regarding the service as being innovative.
	Functionality	Nominal		Opinion regarding the service functionality.
	Utility	Nominal		Opinion regarding the service utility.
	Importance	Nominal		Opinion regarding the service importance.
	Degree_of_Interest	Nominal		Individual degree of interest in seeing this 5G-IoT remote monitoring products' kit integrated in the Home Hospitalization service.
	Necessary_Integration_KIT	Nominal		Individual considers necessary the integration of this 5G-IoT remote monitoring products' kit in the Home Hospitalization service, so that you would feel more relaxed, safe, confident and satisfied when using the service.
	Recommend_HH	Nominal		If the 5G-IoT remote monitoring products' kit was available today on the market, whether the individual would recommend the Home Hospitalization service to a family member or a friend who needed to be hospitalized.
	Prefer_FM_HH	Nominal		As a family member, how likely would the individual prefer to see its loved one hospitalized at home with acess to the 5G-IoT remote monitoring products' kit.
	Likelihood_HH	Nominal		If the the 5G-IoT remote monitoring products' kit was available in a hospital near the individual, the likelihood of it looking for the Home Hospitalization service at that hospital rather than the same service in another hospital without the products' kit.
	Willingness_to_pay	Nominal	**Willingness_to_pay_NV**	In case the service was used at a Private Hospital and, therefore, the costs of the service would be paid by the individual, how much it's the individual willingness to pay.
	HH_No_Kit	Nominal	**HH_No_Kit_NV**	Probability of choosing to use the Home Hospitalization service without access to the 5G-IoT remote monitoring products' kit.
	HH_regardless_Kit	Nominal	**HH_regardless_Kit_NV**	Probability of choosing to use the Home Hospitalization service regardless of whether or not the individual has access to the 5G-IoT remote monitoring products' kit.
	Traditional_Hospitalization	Nominal	**Traditional_Hospitalization_NV**	Probability of choosing to use the conventional Hospitalization service.
	Age	Ordinal	**Age_NV**	Individual's age.
	Gender	Nominal	**Gender_NV**	Individual's gender.
	Level_Education	Ordinal	**Level_Education_NV**	Individual's level of education.
	Monthly_Net_Income	Ordinal	**Monthly_Net_Income_NV**	Individual monthly household's income.
	Health_Insurance	Nominal	**Health_Insurance_NV**	Whether the individual has health insurance.

Figure 23: Dependent and independents variables

Appendix 6

Unrestricted Model

As explained before, for this model were chosen all the previous presented variables, which empirical evidence appeared to be relevant to explain the dependent variable.

$$
\begin{aligned}
HH\_with\_KIT\_NV \\
&= \beta o + \beta 1 * HW\_Interest + \beta 2 * TI\_Interest + \beta 3 * Health\_Status\_NV + \beta 4 \\
&* Hospital\_Type\_Likelihood\_NV + \beta 5 * Hospital\_Stay\_NV + \beta 6 \\
&* Home\_Hospitalized\_NV + \beta 7 * Easiness\_Caregiver\_NV + \beta 8 * Easy\_of\_Use \\
&+ \beta 9 * Confortable\_Discrete + \beta 10 * Notifying\_HP\_Time + \beta 11 \\
&* Battery\ life + \beta 12 * Cardic\_Resuscitation + \beta 13 * Trust\_Technology\_NV \\
&+ \beta 14 * Feel\_Safer\_NV + \beta 15 * AK + \beta 16 * Innovation + \beta 17 \\
&* Functionality + \beta 18 * Utility + \beta 19 * Importance + \beta 20 \\
&* Degree\_of\_Interest + \beta 21 * Necessary\_Integration\_KIT + \beta 22 \\
&* Recommend\_HH + \beta 23 * Prefer\_FM\_HH + \beta 24 * Likelihood\_HH + \beta 25 \\
&* Willingness\_to\_pay\_NV + \beta 26 * HH\_No\_KIT\_NV + \beta 27 \\
&* HH\_regardless\_KIT\_NV + \beta 28 * Traditional\_Hospitalization\_NV + \beta 29 \\
&* Age\_NV + \beta 30 * Gender\_NV + \beta 31\ Level\_of\_Education\_NV + \beta 32 \\
&* Monthly\_Net\_Income\_NV + \beta 33 * Health\_Insurance\_NV + \beta 34 \\
&* No\_Room\_Hospital\_NV + \beta 35 * Concerns\_HH\_NV \\
&+ \beta 36\ Unique\_Integrated\_Platform + \varepsilon
\end{aligned}
$$

After running the mentioned regression in Stata, each variable's *p-value* was analysed so that the statistically significant variables could be identified. A **confidence level** of 90% was used. If the *p-value* was equal or smaller than 10%, the null hypothesis was rejected and the coefficient was considered statistically significant, otherwise the null hypothesis was not reject and the opposite outcome was concluded.

$$Ho: \beta\, x = 0 \qquad H1: \beta\, x \neq 0 \qquad 1 \leq x \leq 36$$

(Null Hypothesis) *(Alternative Hypothesis)*

After carefully analysis, the following variables were considered **not** statistically significant: HW_Interest, Hospital_Type_Likelihood_NV, Hospital_Stay_NV, Easy_Of_Use, Comfortable_Discrete, Notifying_HP_Time, Battery life, Cardiac_Resuscitation, AK, Functionality, Utility, Importance, Degree_of_Interest, Necessary_Integration_KIT, Recommend_HH, Prefer_FM_HH, HH_regardless_Kit, Traditional_Hospitalization_NV, Age_NV, Gender_NV, Level_Education_NV, Monthly_Net_Income_NV,

Health_Insurance_NV, No_Room_Hospital_NV, Concerns_HH_NV and Unique_Integrated_Platform.

However, from this group of variables, still **5 were kept in the model** because one strongly believes in its importance not only to predict the likelihood of the dependent variable, but also because of its correlation to one or more explanatory variables. This is will avoid the **omitted variable bias**. Therefore, one assumed the following conclusions: Firstly, whether the patient spent more time than he / she wished in the hospital (**Hospital_Stay_NV**) is strongly expected to determine the likelihood of using the kit and it is also expected to be correlated to the willingness to pay for the service. If the respondent spent too much time in the hospital, it will be willing to pay more for the HH service with the kit. Secondly, the degree of interest in seeing the Kit integrated into the service (**Degree_of_Interest**) is highly believed to influence the dependent variable and is correlated to the interest in technology because the Kit is a brand-new innovation and tech based. Thirdly, the **Level_Education_NV** should affect the probability of Kit usage and is naturally expected to be correlated to the technology interest, as it is generally accepted that the higher the level of education, the higher tech savviness, on average, ceteris paribus. Additionally, if the respondent did not have an available room in the hospital (**No_Room_Hospital_NV**) then there is a high chance to accept the usage of the HH service with the kit. Also, this variable is certainly related to the degree of interest in seeing the product integrated in the service. Finally, the **Concerns_HH_NV** should impact the probability of Kit usage because and is naturally expected to be correlated to the interest of seeing the kit integrated into the service.

Logistic regression — Number of obs = 247; LR chi2(36) = 78.93; Prob > chi2 = 0.0000; Log likelihood = -51.881266; Pseudo R2 = 0.4320

HH_with_Kit_NV	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
HW_Interest	-.1336798	.3949369	-0.34	0.735	-.9077418	.6403823
TI_Interest	.8620439	.4167222	2.07	0.039	.0452834	1.678804
Health_Status_NV	-.9538951	.5065118	-1.88	0.060	-1.94664	.0388497
Hospital_Type_Likelihood_NV	.2115939	.6978414	0.30	0.762	-1.15615	1.579338
Hospital_Stay_NV	-1.282809	1.305592	-0.98	0.326	-3.841723	1.276106
Home_Hospitalized_NV	-4.356853	1.724301	-2.53	0.012	-7.736421	-.977286
Easiness_Caregiver_NV	1.431828	.6982742	2.05	0.040	.0632361	2.800421
Easy_Of_Use	-.4133514	.5619315	-0.74	0.462	-1.514717	.6880142
Comfortable_Discrete	-.5570564	.4029121	-1.38	0.167	-1.34675	.2326368
Notifying_HP_Time	-.5512194	.6634725	-0.83	0.406	-1.851602	.7491629
Batterylife	.2979386	.3655653	0.82	0.415	-.4185562	1.014433
Cardiac_Resuscitation	.1349359	.4117722	0.33	0.743	-.6721228	.9419945
Trust_Technology_NV	1.03111	.4376463	2.36	0.018	.1733391	1.888881
Feel_Safer_NV	.7125511	.3896856	1.83	0.067	-.0512186	1.476321
AK	.1907826	.4090927	0.47	0.641	-.6110243	.9925895
Innovation	.8146725	.490066	1.66	0.096	-.1458392	1.775184
Functionality	.3106074	.4893677	0.63	0.526	-.6485357	1.26975
Utility	-.6135208	.6155892	-1.00	0.319	-1.820053	.5930118
Importance	-.0626892	.4520345	-0.14	0.890	-.9486605	.8232822
Degree_of_Interest	.2937021	.1873297	1.57	0.117	-.0734573	.6608616
Necessary_Integration_KIT	-.0025136	.2351067	-0.01	0.991	-.4633142	.4582871
Recommend_HH	-.1403628	.2251202	-0.62	0.533	-.5815902	.3008646
Prefer_FM_HH	-.0696747	.1743257	-0.40	0.689	-.4113468	.2719974
Likelihood_HH	.7158437	.2478817	2.89	0.004	.2300045	1.201683
Willingness_to_pay_NV	1.098114	.6645917	1.65	0.098	-.2044614	2.40069
HH_No_Kit_NV	1.794691	.8483119	2.12	0.034	.1320303	3.457352
HH_regardless_Kit_NV	-.1538481	.7122804	-0.22	0.829	-1.549892	1.242196
Traditional_Hospitalization_NV	.7015441	.7752929	0.90	0.366	-.8180021	2.22109
Age_NV	.3708379	.6549737	0.57	0.571	-.9128869	1.654563
Gender_NV	-.5413317	.7721078	-0.70	0.483	-2.054635	.9719717
Level_Education_NV	1.014503	.7254962	1.40	0.162	-.4074434	2.43645
Monthly_Net_Income_NV	-.0000127	.0001167	-0.11	0.914	-.0002413	.000216
Health_Insurance_NV	-.0753287	.9932089	-0.08	0.940	-2.021982	1.871325
No_Room_Hospital_NV	-.5601564	1.28939	-0.43	0.664	-3.087315	1.967002
Concerns_HH_NV	.1243538	.6391069	0.19	0.846	-1.128273	1.37698
Unique_Integrated_Platform	-.195818	.4813204	-0.41	0.684	-1.139189	.7475526
_cons	-8.2818	5.333008	-1.55	0.120	-18.7343	2.170704

Table 12: Unrestricted Model (Initial model)

Logistic regression — Number of obs = 263; LR chi2(15) = 65.18; Prob > chi2 = 0.0000; Log likelihood = -68.665756; Pseudo R2 = 0.3219

HH_with_Kit_NV	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
TI_Interest	.4647564	.2619235	1.77	0.076	-.0486042	.9781169
Health_Status_NV	-.5368331	.349546	-1.54	0.125	-1.221931	.1482644
Hospital_Stay_NV	-.2402445	.9345886	-0.26	0.797	-2.072005	1.591515
Home_Hospitalized_NV	-2.943837	1.218539	-2.42	0.016	-5.33213	-.5555449
Easiness_Caregiver_NV	.6420417	.483371	1.33	0.184	-.3053479	1.589431
Trust_Technology_NV	.7931794	.3085954	2.57	0.010	.1883436	1.398015
Feel_Safer_NV	.4929544	.2457702	2.01	0.045	.0112537	.9746552
Innovation	.1216072	.3263352	0.37	0.709	-.5179981	.7612124
Degree_of_Interest	.1432928	.1176525	1.22	0.223	-.0873019	.3738875
Likelihood_HH	.2568613	.1385678	1.85	0.064	-.0147267	.5284492
Willingness_to_pay_NV	.7215645	.4824154	1.50	0.135	-.2239524	1.667081
HH_No_Kit_NV	.875527	.5320696	1.65	0.100	-.1673103	1.918364
Level_Education_NV	.9900966	.5523797	1.79	0.073	-.0925476	2.072741
No_Room_Hospital_NV	.0104192	1.054248	0.01	0.992	-2.055869	2.076707
Concerns_HH_NV	-.4816959	.4920198	-0.98	0.328	-1.446037	.4826452
_cons	-6.691066	2.898954	-2.31	0.021	-12.37291	-1.009222

Table 13: Restricted Model (final model)

Appendix 7

Since the number of appendix pages is limited, not having enough space to put the surveys completed, one has decided to display only the most important parts of each survey.

A. Health Professionals' Survey:

1. Age: From 24 to 30 years old; From 31 to 50 years old; From 51 to 65 years old; More than 65 years old
2. **Gender:** Male; Female
3. **Is:** Doctor; Nurse; Other: _____
4. This is inserted in: Public Sector; Private Sector
5. **What are the main barriers of this service?** ***(Select all the options that you think are convenient)***

- o Healthcare professional's mentality, behaviour and attitude, who believe in the Hospitalocentric idea that the treatment in the hospital is better.
- o Telemonitoring hardware is still very large, heavy and expensive.
- o Lack of communication technologies that allow the remote patient monitoring, in real time and in free mobility, as well as interoperability between the various patient monitoring equipment's.
- o Lack of Human Resources and the need to train them.
- o None of the above. Other: _____

6. **What are the most vital signs monitored in real time in most hospitalization cases, without being really sure about home hospitalization?**
   (Select all the options you consider necessary)
   - o Motion & activity ; Fall detection; Calories burned ;Steps ;Distance ;Active Minutes ;State of mind ;Sleep Duration and Quality ;Body Posture ;Heart Rate ; Heart Rate variability ;Weight ;Skin Temperature ;Blood oxygen saturation (SpO2) ;Blood oxygen level ;Blood glucose ;Pulse rate ; EMG (Electromyography) ;Blood Pressure ;Oxygen saturation ; Respiration rate ; Respiration variability ; Inhalation/exhalation time ;Respiration full waveform ; ECG (Electrocardiogram) ;Arrhythmias Detection ;Other: _____

7. **Which of the following products do you consider essential to have in the product kit?** ***(Select all that you consider convenient)***

Continuous and real-time monitoring product of patients' vital signs, which alerts and notifies healthcare professionals and caregivers whenever a value is out of normal.

Autonomous and remote cardiac resuscitation product

Chatbot - Artificial Intelligence platform that assists patients. It helps them to determine the best course of action by communicating and interacting through automated messages

Autonomous and programmed medication administration product (antibiotic): Ambulatory CADD infusion pump.

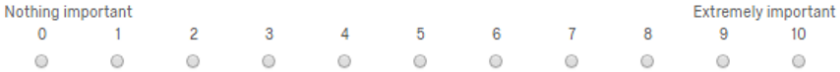
Product that stores medication in a temperature-controlled continuously monitored environment.

Telemedicine platform with videoconferencing functionality that allows virtual medical appointments

Oral medication adherence monitoring product.

Autonomous and programmed medication administration product: Elastomer pump for continuous infusion.

8. **From 0 to 10, what is this remote monitoring 5G-IoT Technology products' kit importance for the service of Home Hospitalization service?**



B. Hospital Managers' Survey:

1. **The Hospital is inserted in:** Public Sector; Private Sector

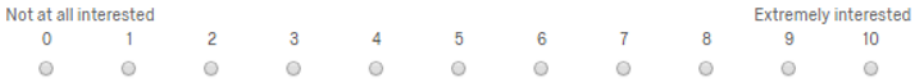
2. **Did you benefit from the "Programa de Incentivo à Integração de Cuidados e à Valorização dos Percursos (SNS)"?** Yes; No
3. **How many beds are available for the conventional hospitalization in your hospital?**
   - Number of beds available: _____
   - I'm not aware

4. **Why don't you provide the Home Hospitalization service? Which of the following constitute barriers to the service adoption?**

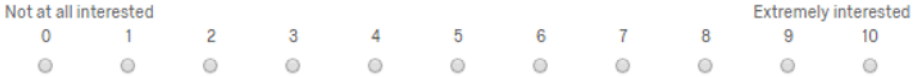
- Lack of communication technologies that allow the remote patient monitoring, in real time and in free mobility, as well as interoperability between the various patient monitoring equipment's.
- Complexity of creation a Home Hospitalization unit.
- Healthcare professionals mentality, behaviour and attitude, who believe in the Hospitalocentric idea that the treatment in the hospital is better.
- Telemonitoring hardware is still very large, heavy and expensive.
- Lack of Human Resources and the need to train them.
- Negative mentality and lack of patients confidence in relation to the Home Hospitalization service.
- Current conditions of the remote monitoring product market, which is in the development process, not allowing a flawless and secure service.
- Necessity for high investment in medical remote monitoring devices.
- Another aspect: _____

5. **Do you want to implement the Home Hospitalization service?**
   - Yes, short-term (less than 1 year).
   - Yes, long-term (more than 1 year).
   - No. It isn't in the Hospital strategic plan to implement a Home Hospitalization service.

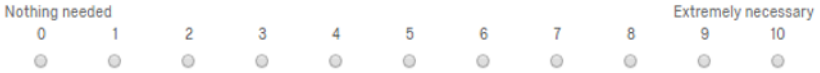
6. From 0-10, classify your **interest** degree in integrating into the Home Hospitalization service a remote patient monitoring products' kit?



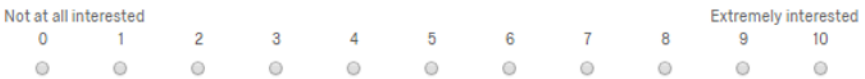
7. (If hospital already provides the HH service with the use of remote monitoring products) From 0-10, indicate your **satisfaction level** regarding the remote monitoring products used:



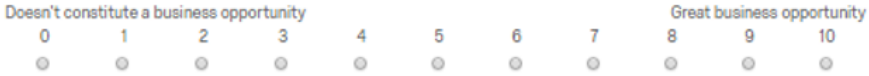
8. From 0 to 10, how much do you consider **necessary** to integrate 5G-IoT technology into remote monitoring products?



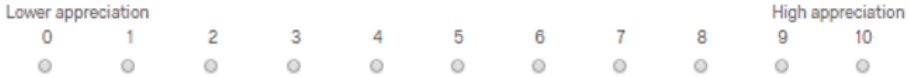
9. From 0-10, rate your **interest degree** in integrating 5G-IoT technology into remote monitoring products?



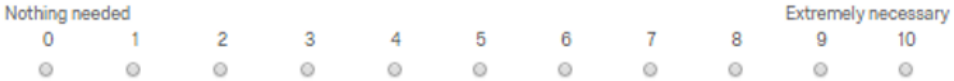
10. From 0-10, how do you classify the **business idea potential**?



11. From 0-10, classify the **appreciation degree** regarding the integrated way this unique solution is provided?

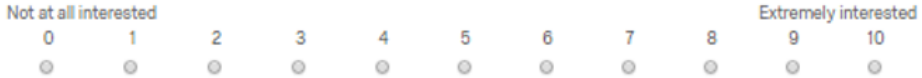


12. From 0 to 10, classify the **necessary degree** regarding the integration of this products' kit into the Home Hospitalization service in order to make it safe, effective and efficient?



13. From 0-10, classify your **interest degree** in acquiring this solution to integrate into the Home Hospitalization service?

14. What is the average amount per patient, per day, that you would be willing to pay for the products' kit?



- Average value per patient, per day: _____
- I' am not aware

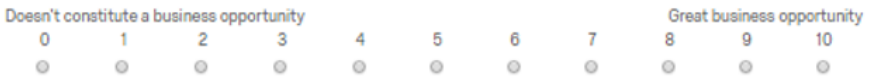
15. (If not aware) According to the following hypotheses, what is the average amount per patient, per day, that you would be willing to pay for the products' kit?

- less than 50€ (enter the value): _____
- From 50€ to 75€
- From 76€ to 100€
- From 101€ to 120€
- More than 120€ (enter the value): _____

16. What growth rate do you consider to be expected for the number of patients that could benefit from this products' kit in the first 5 years, and in the following 5 years (5-10)?

- First 5 years (%): _____
- Following 5 years (5-10) (%): _____
- I'm not aware

17. From 0-10, classify the degree regarding whether this products' kit integration into the HH service constitutes a business opportunity for your hospital?



C. Patients' Survey

1. **Age:** Less than 18 years old; From 18 to 21 years old; From 22 to 24 years old; From 25 to 30 years old; From 31 to 40 years old; From 41 to 65 years old; More than 65 years old

2. **Gender:** Male; Female

3. **What is the monthly net income of your household?** Less than 650€; From 651€ to 800€; From 801€ to 1 000€ ;From 1 001€ to 1 400€ ;;From 1 401€ to 2 000€ ; From 2 001€ to 2 700€; ;From 2 701€ to 3 000€ ; From 3 001€ to 3 700€ ; From 3 701€ to 4 000€; From 4 001€ to 4 700€ ;From 4 701€ to 5 000€; From 5 001€ to 5 700€ ; From 5 701€ to 6 000€ From 6 001€ to 6 700€ ; (From 6 701€ to 7 000€ ; From 7 001€ to 7 700€ ;From 7 701€ to 8 000€ ; From 8 001€ to 9 000€; From 9 001€ to 10 000€; More than 10

4. **Do you have health insurance?** Yes; No

5. **Have you ever been hospitalized**? Yes; No
6. **Have you ever been hospitalized at home?** Yes; No
7. (If hospitalized at home) **Were any technology telemonitoring products used?**
   - o Yes, a continuous and real-time monitoring of vital signs.
   - o Yes, a monitoring device for taking medication.
   - o Yes, a telemedicine platform for conducting virtual medical sessions.
   - o Yes, a product of autonomous and programmed administration of medication.
   - o Yes, other product: _____
   - o No, all the monitoring processes were done during procedure by health professionals.
   - o I do not remember.

8. (If hospitalized at home) **Overall, how do you rate you satisfaction level regarding the HH service?**
   - o Excellent
   - o Very Good
   - o Good
   - o Regular
   - o Bad
   - o Very Bad
   - o Poor
9. **Do you have any fears regarding to the HH service?** Yes; No
10. (If yes) **What are your main fears regarding the Home Hospitalization service? (Select at most 3 options)**
    - o Afraid of not having access to a healthcare professionals' team in case of emergency in a timely manner.
    - o Afraid that the medication storage conditions are not ideal.
    - o Afraid of not being properly monitored
    - o Afraid of increasing the occurrence of human error due to being outside the hospital environment.
    - o Fear of not having immediate assistance in case of cardiac arrest
    - o Fear of not complying with the medication plan and stipulated treatment.
    - o Another fear: _____

11. **Would you like to see the integration of new technologies in the Home Hospitalization service in Portugal**? Yes; No

12. Please classify your agreement level with the following statements:

	Strongly Disagree	Disagree	Agree	Strongly Agree	Neither agree or disagree
I trust on technology with medical quality certification to monitor my health status with hospital-grade accuracy.	○	○	○	○	○
I believe that the products' kit will not only improve the service's quality, experience and safety, but also promote its efficiency and effectiveness.	○	○	○	○	○
I believe that the product kit will not only improve the quality, experience and safety of the service, but also promote the effectiveness and efficiency of the service.	○	○	○	○	○
It is the Hospital responsibility to provide a service without failures, with communication technology (internet) incorporated in its products in order to allow the transfer of data concerning the patient's health status in a continuous way, in total mobility, without depending on the patient's home internet or the connection to other devices (tablet, mobile phone, outer).	○	○	○	○	○

13. **From 0-10, express your interest degree in seeing this 5G-IoT remote monitoring products' kit integrated in the Home Hospitalization service?**

Not Interested — Extremely Interested

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

14. **From 0-10, how much do you consider necessary the integration of this 5G-IoT remote monitoring products' kit in the Home Hospitalization service, so that you would feel more relaxed, safe, confident and satisfied when using the service?**

Not Relevant — Extremely Relevant

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

15. **If the 5G-IoT remote monitoring products' kit was available today on the market, would you recommend the Home Hospitalization service to a family member or a friend who needed to be hospitalized?**

Nothing likely — Extremely Likely

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

16. **As a family member, how likely are you to prefer to see your loved one hospitalized at home with access to the 5G-IoT remote monitoring products' kit?**

Nothing likely — Extremely Likely

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

17. **If the 5G-IoT remote monitoring products' kit that I intend to create was available in a hospital near you, what is the likelihood of you looking for the Home Hospitalization service at that hospital in rather than the same service in another hospital without the products' kit?**

Nothing likely — Extremely Likely

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

If you had to be hospitalized and were given the opportunity to choose which service to use, what is the probability of:

	Nothing Likely	Unlikely	Neither likely nor unlikely	Likely	Extremely Likely
Choose to use the Home Hospitalization service with access to the 5G-IoT remote monitoring products' kit.	○	○	○	○	○
Choose to use the Home Hospitalization service without access to the 5G-IoT remote monitoring products' kit.	○	○	○	○	○
Choose to use the Home Hospitalization service regardless of whether or not you have access to the 5G-IoT remote monitoring products' kit.	○	○	○	○	○
If you had to be hospitalized and given the opportunity to choose which service to use, what is the probability of: - Choose to use the conventional Hospitalization service.	○	○	○	○	○