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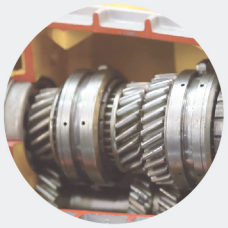


ANALYSIS OF THE SUPPLY CHAIN MANAGEMENT IN A PORTUGUESE PUBLIC HOSPITAL: A CASE STUDY

JOSÉ AUGUSTO SANTOS SEQUEIROS
outubro de 2020

POLITÉCNICO
DO PORTO

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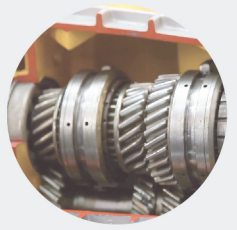


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TESE DE MESTRADO

MESTRADO EM ENGENHARIA E GESTÃO INDUSTRIAL

José Augusto Santos Sequeiros

Estudante n.º 1180162

Dissertation presented to Instituto Superior de Engenharia do Porto to fulfil the requirements for obtaining a Master's degree in Engineering and Industrial Management, carried out under the guidance of Maria Teresa Ribeiro Pereira, PhD

2020

Instituto Superior de Engenharia do Porto

Department of Mechanical Engineering

P.PORTO

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This thesis marks the end of a re-entry into Higher Education, in an area that, in some way, was unknown to me, with different ways of acting and knowledge than I had previously experienced.

I begin by thanking the Centro Hospitalar da Póvoa do Varzim e Vila do Conde, its Board of Directors and Pharmaceutical Services for allowing me to develop this work in its facilities, always being helpful and welcoming. I would like to thank Dr. Rosa Armandina, Service Director, and Dr. Irene Gonçalves, Pharmacist, for being totally available to answer questions and follow up on local visits.

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"If somehow the Lord gave me a second chance at that moment, I would do it all over again."

Joel Miller - The Last of Us Part II (2020)

RESUMO

A situação atual das unidades de saúde é caracterizada pelo custo crescente da prestação dos cuidados, pelo consequente agravamento da situação financeira e pelos processos complicados e morosos. Aliados à procura crescente, podem tornar-se fatores que tornam a resposta do serviço deficiente. Devido a esta situação, uma gestão mais eficiente e eficaz da logística e da cadeia de abastecimento é reconhecida transversalmente como uma das principais áreas de melhoria. A fim de dar a conhecer quais as áreas a melhorar, vários objetivos foram contemplados neste trabalho, como a análise dos métodos e critérios de seleção de medicamentos em farmácias hospitalares, a definição de obstáculos à gestão racional de stocks e a análise de dados históricos para previsão da procura futura num hospital público português. O estudo revelou que alguns dos 1.346 produtos presentes no ERP da farmácia não têm dados históricos suficientes para criar uma previsão precisa. Neste contexto, e considerando um nível de serviço de 99%, 41% dos produtos têm stock superior ao que deveria ser o stock máximo, cerca de € 147.908,87 de imobilizado e 11% dos produtos estavam, à data, em risco de esgotar *stock*.

A evolução dos sistemas de informação nos Hospitais deve garantir a sustentabilidade tecnológica da transformação digital, o alinhamento com as medidas de racionalização das TIC, a melhoria do serviço ao cliente e a melhoria da qualidade da informação disponibilizada ao utilizador.

Por outro lado, considerando o atual evento de pandemia, foi analisado o seu impacto na cadeia de abastecimento hospitalar. A mudança de comportamento dos pacientes hospitalizados levou a duas quebras nítidas em dois indicadores relevantes, o número de consultas hospitalares e os gastos com medicamentos. Estes indicadores mostram que existe menos procura de serviços hospitalares regulares programados, com menos 1,9M de consultas realizadas nos Hospitais Públicos portugueses. No que concerne o consumo de medicamentos a nível nacional, previu-se um custo adicional de 103M € até ao final do ano, mais elevado do que nos anos anteriores.

Palavras-chave: Cadeia de Abastecimento, Cuidados de Saúde, Métodos de Previsão de Consumo, Sistemas de Apoio à Decisão, COVID-19

ABSTRACT

The current situation of healthcare units is characterized by the increasing cost of providing the respective care, the consequent deterioration of the financial situation and the complicated and time-consuming processes. Allied to the growing demand, they could become factors that make the service demand deficient. Due to this situation, more efficient and effective logistics and supply chain management is transversally recognized as one of the main areas for improvement. In order to provide insight on which areas to improve, several objectives where looked after in this work, as the analysis of the methods and criteria for the selection of medicines in hospital pharmacies, the definition of obstacles to the rational management of stocks and analysis of historical data to forecast future demand of a Portuguese public hospital. The study revealed that some of the 1346 products present on the pharmacy's ERP do not have sufficient historical data to create an accurate forecast. With this context, and considering a service level of 99%, 41% of products have a stock higher than what should be the maximum stock, approximately € 147.908,87 of fixed assets and 11% of the products were, at the time, at risk of going out of stock.

The importance of the evolution of core information system of Hospitals was at stake, ensuring the technological sustainability of the ongoing digital transformation, alignment with ICT rationalization measures, improvement of customer service and improvement of the quality of information available to the user.

On a side note, considering the current event of pandemics, it was analyzed its impact on hospital supply chain. The change in the behavior of hospital patients led to two clear breaks in two relevant indicators, the number of hospital visits and spending on medication. These indicators show that there is less demand for scheduled hospital services, 1,9M less consultations carried out in Portuguese Public Hospitals. In these times, the capacity for hospital care and intensive care is exceeded, creating a significant challenge. In Portugal, as the impact of the pandemic on medication consumption nationwide, it was predicted an additional cost of € 103M by the end of the year, higher than in previous years.

Keywords: Supply Chain, Hospital Pharmacy, Forecasting Methods, Decision Support Systems, COVID-19

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LIST OF ABBREVIATIONS

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ACSS	Administração Central do Sistema de Saúde
CHPVVC	Centro Hospitalar da Póvoa do Varzim e Vila do Conde
DGS	Direção-Geral da Saúde
E.P.E.	Entidade Pública Empresarial
EOQ	Economic Order Quantity
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
ICU	Intensive Care Unit
ISEP	Instituto Superior de Engenharia do Porto
IT/ICT	Information and communications technology
MERS	Middle East Respiratory Syndrome
MSE	Minimum Squared Error
NHS	National Health Service
OP	Order Point
OPB	Optimal probability of breakage
P. PORTO	Instituto Politécnico do Porto
PCC	Public Contracts Code
PCC	Public Contracts Code
PDF	Portable Document Format
SARS	Severe Acute Respiratory Syndrome
SPMS	Serviços Partilhados do Ministério da Saúde
SR	Shortage Rate
SS	Security Stock
WHO	World Health Organization

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1. INTRODUCTION

As this is a master's degree work, and having a strong connection to Biomedical Engineering, it became clear that this work should be developed in a Healthcare Unit with a strong component of practical work. Thus, and given the interest in analytics, it was set out to conduct a study on the hospital pharmacy of the Centro Hospitalar da Póvoa do Varzim and Vila do Conde, E.P.E. (CHPVVC). The proposed study goes through the analysis of the consumption of medicines or medicines and other pharmaceutical materials, from a perspective, primarily, of demand and stock management, with a view to optimizing and reducing ownership costs, but also to look critically at the legislation associated with public purchases, the rational management associated with the healthcare sector and the impacts they have on logistics management. Additionally, and considering that there are no tools in the Enterprise Resource Planning (ERP) used in the hospital pharmacy - Glintt's software, the urgent need to create tools to accurately and scientifically calculate data regarding expected demand (with the appropriate calculation method), security stock, order point, economic order quantity, shortage and rupture are on point.

The complexity of this work is mainly related to four points, the volume of data existing in the ERP and the fact that these are not treated at all, that there are no direct and accurate data on the delivery lead time of the different suppliers which was told has being defined as one or two days, and the complexity of the impacts of the legislation associated with public purchases in these data. As for the originality, at the present, as far was searched, no academic study has being found any that relates these four points, with a view to create a decision support tool. Additionally, and making the best of a situation with significant impacts on society as a whole, it was proposed to carry out a study on the impact of the pandemic on demand and lead times in the first half of 2020, comparing actual consumption data with forecasts calculated by the model. Figure 1 is a schematic representation of the thesis' organization.

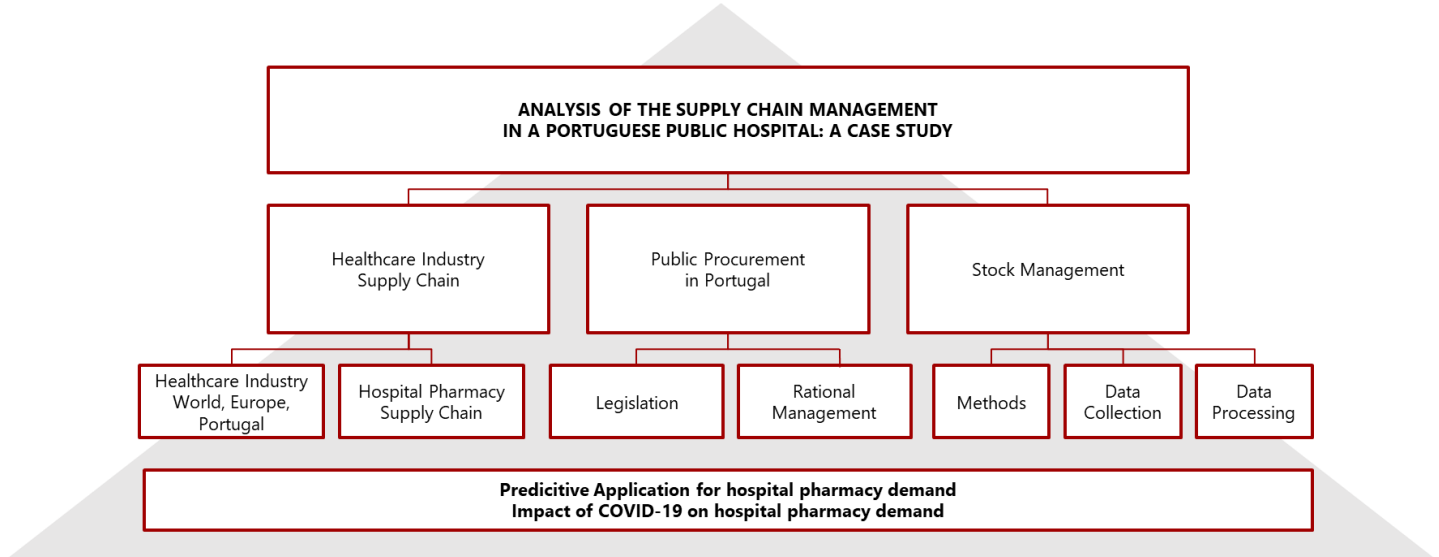

Figure 1 – Thesis organization (adapted from The Pyramid Principle, Minto)

1.1. Motivation and Objectives

The main objective of this work is to increase efficiency within the hospital pharmacy in question. In this sense, different steps will be taken. In a first phase, describe the main methodologies applicable to the management of stocks of medicines and other pharmaceutical products in the context of hospital pharmacy. Subsequently, analyze historical consumption data at the institution and scientifically forecast future consumption. This work distinguishes from the others by the inclusion of restrictions associated with public purchase, legislation, marketing, and distribution methods used by pharmaceutical companies.

Each of the general objectives may be subdivided into several points such as:

- the analysis of the methods and criteria for the selection of medicines in hospital pharmacies,
- the definition of obstacles to the rational management of stocks,
- the definition of the specificities of the purchase of medicines, identification of characteristics, specificities, and legal processing of the types of procedures provided for in the public procurement code,
- analysis of historical data to forecast future demand, with a breakdown into rational stock management data such as the order point, order quantity and rate shortages, definition, analysis and
- characterization of consumables according to the ABC technique.

Thus, the question to be raised will be how, with what means and by how much the efficiency of the pharmacy can be increased considering the cultural, legal, and scientific environment.

1.2. Institution overview

CHPVVC consists of two Hospital Units, one located in Póvoa de Varzim and the other in Vila do Conde, in the center of the respective cities, which are about three kilometers apart. These units belonged to the old hospitals that gave rise to them. The area of influence of the Hospital Center covers the municipalities of Póvoa de Varzim and Vila do Conde and some neighboring parishes of other municipalities, namely Esposende, Barcelos and Famalicão, covering an estimated population of around 150 000 inhabitants. Pharmaceutical Services are located on the ground floor of the Póvoa de Varzim unit.

It is, since 2008, and according to the XVII Constitutional Government Program and the Stability and Growth Program, a public business entity. This model is more suitable for managing differentiated healthcare units, once that combines the advantages of management autonomy with government protection. Thus, with a view to modernizing and revitalizing the National Health Service, through an innovative management with a business character oriented towards satisfying the user's needs, creating a network of these entities.

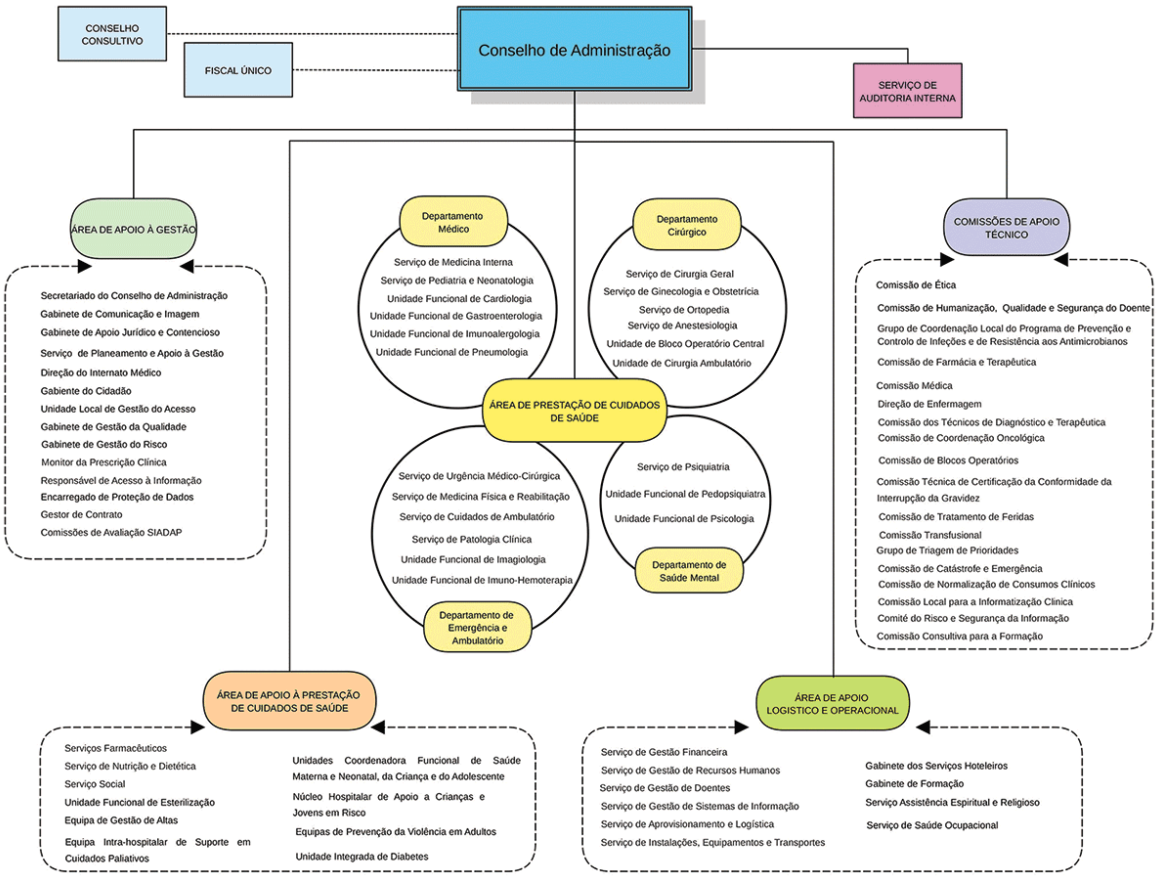

Figure 2 - CHPVVC Organization Chart

The institution provides excellent healthcare, fostering competence, rigor, and humanization in the respective care practice. The CHPVVC's mission bases on a continuous perspective of sustainable growth, a commitment to change and the creation of sustained value.

The Pharmaceutical Services is a department that ensures drug therapy for patients as well as guarantees the quality, efficacy, and safety of medicines. The multi-professional team of Pharmaceutical Services consists of pharmacists, diagnostic and therapeutic technicians, technical assistants, and operational assistants. In the Figure 3, it is possible to see the spatial distribution of the different service areas of the service. This service has a total area of 152 m^2, 20,5m^2 being reserved for storage. There are also two warehouses outside this location to store flammable products (6,84m^3) and large volumes (47,5m^3).

1. Prescription validation zone
2. Service manager's office
3. Technical Assistants Office
4. Farming area
5. Receiving orders
6. Storage
7. General Service
8. Unit dose distribution zone
9. Classic distribution zone

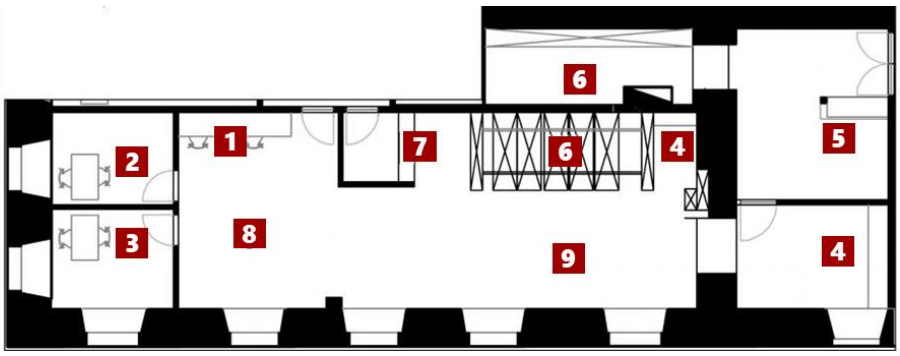

Figure 3 - Plant and description of the areas of pharmaceutical services

1.3. Context and relevance

The current situation of healthcare units is characterized by the increasing cost of providing the respective care, the consequent deterioration of the financial situation and the complicated and time-consuming processes [1]. Allied to the growing demand, they could become factors that make the service demand deficient. Due to this situation, more efficient and effective logistics and supply chain management is transversally recognized as one of the main areas for improvement.

The Summary Report on the Healthcare Sector: From Rationalization to Excellence, from Porto Business School [2], points to a turnover of companies classified as belonging to the healthcare sector in the order of 26 billion euros (data from 2010), corresponding to 15% of Portuguese GDP, generating an added value equivalent to 4.8% of GDP. The sector's successes have resulted in a great increase in the life expectancy of the Portuguese in the last forty years. When they live longer, they use more - especially after the age of 65 - the healthcare system, which made the burden of the NHS soar. As such, restrictive measures, and rationalization in the use of resources have emerged during successive governments. In addition, the economic and financial crisis experienced in the 10 years of the 21st century has prompted the implementation of several measures in terms of medicine policy to promote its rational use and control of drug expenditure [1], [3], [4]. They can refer as main measures adopted, the promotion of the use of generic medicines, the introduction of the reference price system, the establishment of maximum limits of expenditure growth, the alteration of the participation levels and the general reduction of prices of medicines. Representing the costs of materials and services as the second largest group of costs in a hospital, it is recognized that supply chain management is one of the main areas of improvement, where we achieve important impacts on the organization's performance [5].

The adequate acquisition and management of medicines and other pharmaceutical products is closely related to the ability of a given healthcare institution to provide care inherent to its mission and functions. Thus, medicines and other pharmaceutical products are considered essential goods for the proper functioning of healthcare institutions [6]. Pharmaceutical stock management emerges, which encompasses the set of activities that aim to guarantee the stock of medicines and other pharmaceutical products, in order to meet the therapeutic needs of patients, but also the interests of the health institution [7], [8]. In Portugal, the primary objective of pharmaceutical activity is the effective and efficient care of the patient, regarding the timely availability of the medicine necessary for its treatment. In this perspective, the pharmacist, as a health agent, is responsible for carrying out all the tasks inherent to the medication, being at the heart of all issues related to its acquisition and maintenance considering the medicines expired data too. According to the Hospital Pharmacy Manual [9], made available by the Ministry of Health, the functions of the Hospital Pharmaceutical Services are listed, among others, in the selection and acquisition of medicines, pharmaceutical products and medical devices; the provision, storage and distribution of experimental medicines and the devices used for their administration, as well as other medicines already authorized, which may be necessary or complementary to the conduct of clinical trials. This complexity of processes and data analysis coupled with the current activity of the pharmacy may be an obstacle to more efficient resource management [10].

Thus, the management of hospital material is identified as a central point in containing the constant increase in health costs in industrialized countries[6].

1.4. Thesis Organization

The thesis divides into five chapters. The first, “INTRODUCTION”, has the objective to introduce the work and to define its main objectives. “LITERATURE REVIEW” aims to give an overview of the field of the study, how it was studied and what has been done during the years and its future perspectives. “METHODS” explains how experimental work had been performed, which data and techniques were chosen to achieve the objectives. The next chapters are related with the presentation and discussion of results, “RESULTS AND DISCUSSION”. The conclusions and proposals for future work are in CONCLUSIONS.

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2. LITERATURE REVIEW

2.1. Logistics and Supply Chain Management

Logistics has, for a long time, its origins and development linked to the military area. This connection is present, according to Carvalho [3], through five major logistics components: supply, transport, maintenance; evacuation and hospitalization of the wounded and complementary services.

The first logistical component referred to, supply, includes issues such as the need to deliver vehicles, weapons, protections, ammunition, food, medicines and fuels at the front of the war, as well as the troops themselves, that is, it has the great purpose of creating physical flows. However, this supply cannot be carried out without using the means of adequate transport, hence also the importance of the second logistics component, the transport, where they are approached and analyzed how the troops, supplies, weapons and all the materials necessary for the establishment of war. That is, the logistics associated with the speed and capacities of transport that are susceptible to be offered to meet the needs. Also the know-how related to the maintenance of products, weapons, machines, vehicles, food and medicines is essential not only so that, when used and administration, are in the best conditions, but also so that there are no breaches of stock. With this brief history overview, it is possible to understand the wide range of activities that logistics can support, as well as its criticality, in this specific case, to gain competitive advantage in combat. This competitive advantage associated with these logistical components, is susceptible to achieve not only in the military field, but also in a wide range of areas and industries.

Logistics is not limited to these contributions, a greater contribution of the logistics area can be offered to the healthcare sector, through a wide range of activities. The hospital supply chain does not differ when compared to the supply chain of any other organization [11].

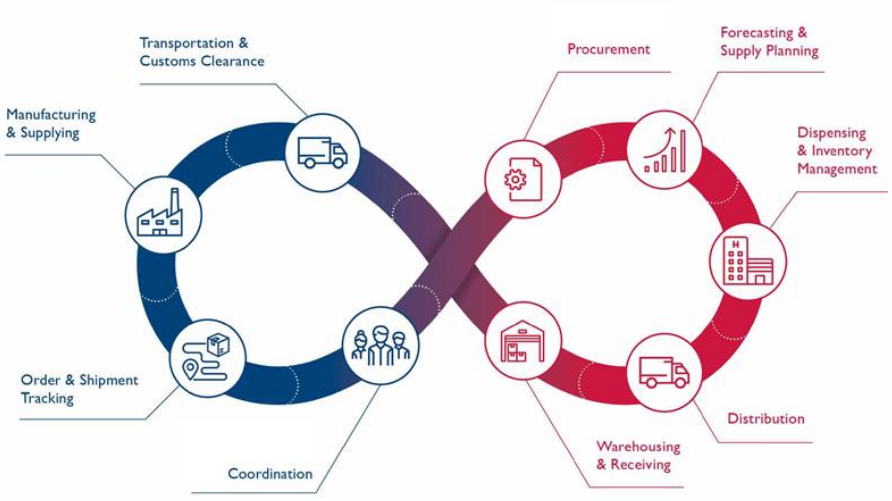


Figure 4 - The various processes in the supply chain - Adapted from [12]

Figure 4 is an end-to-end representation of what a supply chain can ultimately be. Supply chain management organizes the vast network of supply chain players—procurers, manufacturers, shippers, distributors, warehouse agents, facility managers, and service providers [12].

Considering any healthcare provider, the stock management must be balanced, since the excess of material or the lack of it can cause problems to the organization, and most importantly, the patient [7], [13]. Excess stock increases ownership costs and might outdate or obsolete products, but on the other hand the lack of it can delay treatments, worsening health status or death [14], [15]. So, the management of materials that includes the acquisition, reception and internal distribution is fundamental [16].

As Carvalho puts it, the central dimensions of Logistics are time, cost, and quality of service. This means that logistics management is done through a management instrument that includes these dimensions and that promotes reasoning and decisions, essentially through balances and exchanges, among them [3]. Additionally, one of the most important steps in the purchasing process is the selection of suppliers, which integrates and influences these central dimensions [17], [18]. Generally, a buyer selects suppliers that meet requirements for delivery times, quality as specified in the requested project and satisfactory payment terms. In the hospital context, according to Paterno, procurement is the most important function of logistics and can be defined as a service that aims to provide the materials needed by the hospital, plan the correct quantities and satisfy them at the right time, in the best quality and at the lowest cost[19], [20].

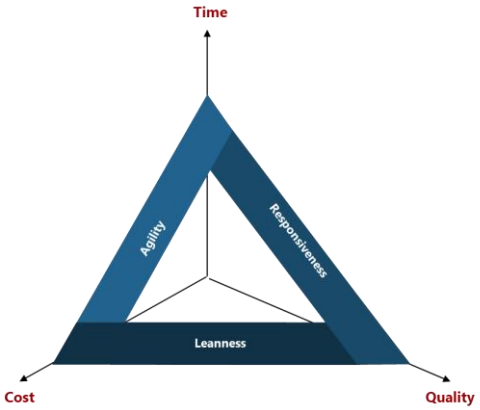


Figure 5 - Trinomial of the dimensions of logistics [3]

The combination of two dimensions develops some arguments that may be important for the way in which the logistic system is intended to be grow, given the manifest difficulty of achieving improvements in the trilogy as a whole [3], [21], [22]. A good combination of time and cost develops the system's agility (in the face of any external stimulus, to be able to respond by moving and changing positions, to a new stable state), a good combination of cost and quality develops leanness (ability to manage the system without surplus, maintaining a high quality of customer service and being able to make the system so efficient that , gradually, costs can be lowered) and, finally, a good combination of time and quality develops responsiveness (the speed of response of system to a stimulus, maintaining the service quality standards) [3], [23]–[25].

Simchi-Levi, et al. define Supply Chain Management as "a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements" [26]. Those responsible for the logistics of a hospital should ensure the correct distribution of products, where and when they are delivered, with the intended quality and quantity for the provision of healthcare, avoiding the stock rupture and guarantee that this whole process is carried out in the most effective and efficient [16],

[27]. Consequently, increasing the effectiveness and efficiency of the supply chain becomes a critical factor for any organization to remain competitive in a market that is increasingly global and where the competition is increasing [11], [15], [22].

This work will mainly focus on three points from Figure 4, namely Dispensing and Inventory Management, Forecasting and Supply Planning and Procurement.

2.2. Healthcare Industry and Supply Chain

2.2.1. Healthcare Industry – World, Europe, Portugal

In the healthcare sector, the value can be largely based on the ability to efficiently coordinate the activities of the pharmacy supply chain with that of the hospital. Awareness of logistics is becoming more widespread, with many initiatives and studies on the integration of the supply chain, such as the provision of outsourcing strategies [15]. However, the internal supply chain, unlike the external one, remains the weakness of many organizations. This happens mainly due to the lack of a systemic approach in the management of these chains, which reflects in enormous costs in materials and a reduced quality of service delivered to users. The management of hospital logistics will ultimately affect the institution's clinical performance [5]. Errors associated with the prescription and administration of medicines can be described as possible examples of procedural errors associated with deficient logistics management [28].

Regarding the optimization of the use of resources, the difficulties in transposing the industry's best practices to the hospital environment are evident. One of the biggest causes of inefficiency is due to the existence of hidden stocks to avoid stock outs, which are based on procedures that are more focused on policies and user experience than on the institution's data analysis [1], [29]. Recently, the Lean approach has gained increasing popularity in and for process improvement [15]. Lean focuses on the value desired by the end customer, eliminating waste, identifying the value flows of the organization's processes, maintaining a continuous flow between the stages of the process and, finally, continuously improving [30]. A recent review of the literature on the application of Lean methodologies in the health field revealed that the most common areas of improvement include the punctuality of the service, cost reductions, increases in productivity and various aspects of quality that involve reducing errors, in addition to greater team and patient satisfaction [31].

As previously mentioned, the adoption of stock management, supply, and distribution policies, due to the high investment associated with stocks, is essential. Studies carried out in recent years suggest that the costs associated with stock management in the health sector are between 10% and 18% of healthcare organizations' net revenue [14].

The traditional management of public hospitals in Portugal was based on a model created in the 1980s, which was never revised or updated according to the changes that took place in society and in Public Administration [32]. This model was challenged by the inefficiency of management and the negative effects it had for citizens, professionals and the health system [33]. Some studies were carried out, and some flaws were pointed out, as lack of autonomy, non-attribution of responsibilities, absence of competition between the units, underfunding and historical-based allocation of funds, lack of incentives, difficulty in hiring professionals and poor quality of care [32]–[34]. A study carried out in 2011 by INFARMED, to analyze the levels utilization and expenditure of

pharmacotherapeutic groups and active substances aimed to conclude which contributed most to the changes in usage and expenditure levels. The growth rate of expenditure at the selling price to the public of the total market (includes the NHS market, non-prescription medicines market and the rest of the market, which includes sub-systems and private insurance) increased 18.5%, between 2003 and 2011. The pharmacotherapeutic groups that are the main source of expenditure are concentrated on the Cardiovascular System and the Nervous System Central, which in 2010, had a market share of 27.4% and 21.9%, respectively [35].

The reforms in hospital management followed a European trend influenced by the perspective of New Public Management that favored management practices with greater autonomy for managers and greater accountability for their actions, accountability in a clear and public manner, the introduction of incentive mechanisms performance and the application of management tools. However, it is important to note that this reform does not mean privatizing hospitals, as public ownership and funding are maintained, with no transfer to the private sector [32], [36]. The creation of hospital centers increased efficiency in resource management, avoiding waste, which generated signs of greater profitability, which makes the health system fairer and with higher quality [32]. With these measures, the contracting of the activity with Hospitals, Hospital Centers and Local Health Units started to consider efficiency and productivity, among which the following stand out:

- The implementation of free access and circulation between units of the NHS.
- Respect for the principles of good accounts.
- The shared management of resources between the different hospitals, to use all the installed capacity in each hospital, fulfilling minimum waiting times.
- Reinforcement of transparency and accountability.
- Improve user access through the Integrated Access Management System.
- Articulate the relationship between hospitals and primary care.

The future of health is to rigorously promote all management practices that promote the best results in terms of access, efficiency, and quality [32], [37].

Through entrepreneurship, hospitals have taken a significant step towards excellence in care delivery, but there is still much to do to be able to do more and better in the pursuit of maximizing efficiency and capacity [14], [25], [29].

2.2.2. Hospital Supply Chain

Logistics, nowadays, must be a process of creating value for business [38], [39]. The performance of companies in competitive markets means that it is necessary to optimize the chain of activities with a strategic dimension and centralize them. Plowman says that the “five rights” must be followed, that is, ensuring the availability of the right product, in the right place, at the right time, under the right conditions, at the right price [40]. In this sense, activities such as demand forecasting and stock management are fundamental for reaching the premise highlighted by Plowman. Along with this trend, companies have become aware that they no longer compete alone, but as entities in supply chains, having to consider the interconnection of business processes along the chain [39].

Thus, the management and optimization of the supply chain appears as a key element for companies, contributing to their competitiveness through the efficient integration of processes and the satisfaction of the service levels required by customers [25].

The provision of healthcare services has been the central concern of healthcare organizations for several years. The increase in demand for health services, together with economic realities, highlights concerns about the sustainability of the public health system [32], making it necessary to seek maximum efficiency in its management [1]. Patient care is supported by a wide range of activities, including inventory management, purchasing and distribution of supplies to the point of care. These activities, known to many as healthcare logistics or supply chain management, aim to ensure the delivery of the right products, where and when needed, with the quality and quantity necessary to provide services, avoiding interruptions in supply [41]. Figure 4 shows an end-to-end representation of the supply chain. Although, Neves in his work from 2009, Figure 6, set up another representation, which gives additional detail to dispensing and, most importantly, to patient administration [6].

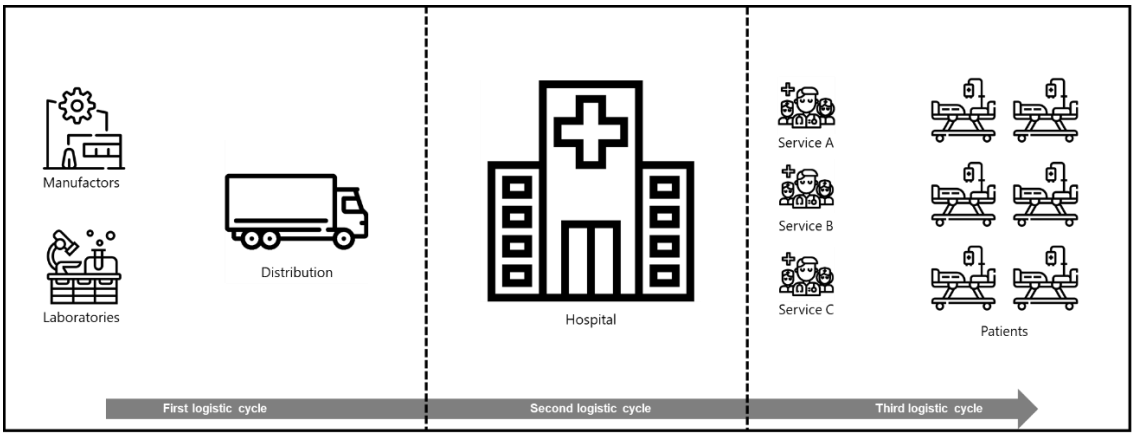


Figure 6 – Hospital Supply Chain [6]

The first cycle includes the route of the articles from leaving the supplier until they arrive at the hospital and are stored. The second cycle occurs when the product leaves from the main warehouse until it reaches the warehouses of specific healthcare services. The third cycle corresponds to the transition from service's warehouse to the patient's place of treatment, where product is consumed [6], [15]. As is, logistics management includes the following integration processes: transport, supply, storage, maintenance, purchasing, contracting and information management in accordance with the sub-optimization of any activity singular [4]. Logistics brings together a set of design activities, planning and execution allowing the purchase, inventory management and replenishment of goods and services surrounding the provision of medical services to patients. More specifically, Figure 7 makes it possible to see the different ramifications of hospital logistics. The often-unsuspected weight of these many ramifications results in significant costs. In fact, the logistics costs represent a substantial part of a healthcare facility costs, i.e. between 35% to 45% [4]. Additionally, up to 10% of the time of healthcare staff is devoted to logistical tasks. These activities are often considered areas for improvement. Therefore, logistics becomes not only a source of savings in terms of support services, but can also make clinical professionals more productive, as they can increase dedication to daily work [1].

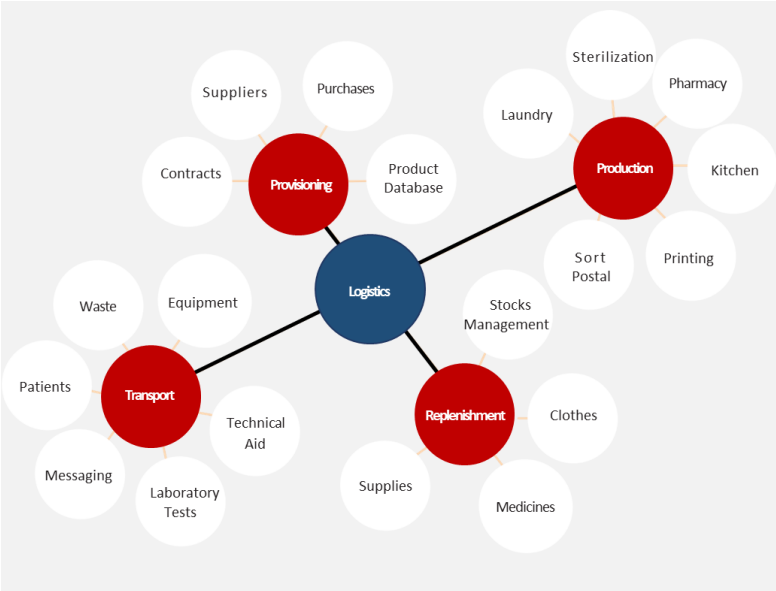


Figure 7 -Ramifications of hospital logistics (Adapted from Chow and Heaver and Beaulieu and Roy [42]*)*

Carvalho added in his book [3] a series of macro-processes for the health supply chain. The development of more rationalized and integrated products is strongly dependent on the emergence of a European pharmaceutical market. The opportunities to rationalize stocks and integrate distribution activities European scale are very limited, especially in pharmaceutical products, given that there is a proliferation of similar but not identical products due to the need to respect the regulations of each country [23]. Figure 8 indicates the main trends, difficulties and expected improvements for the macro processes identified, within the hospital logistics network

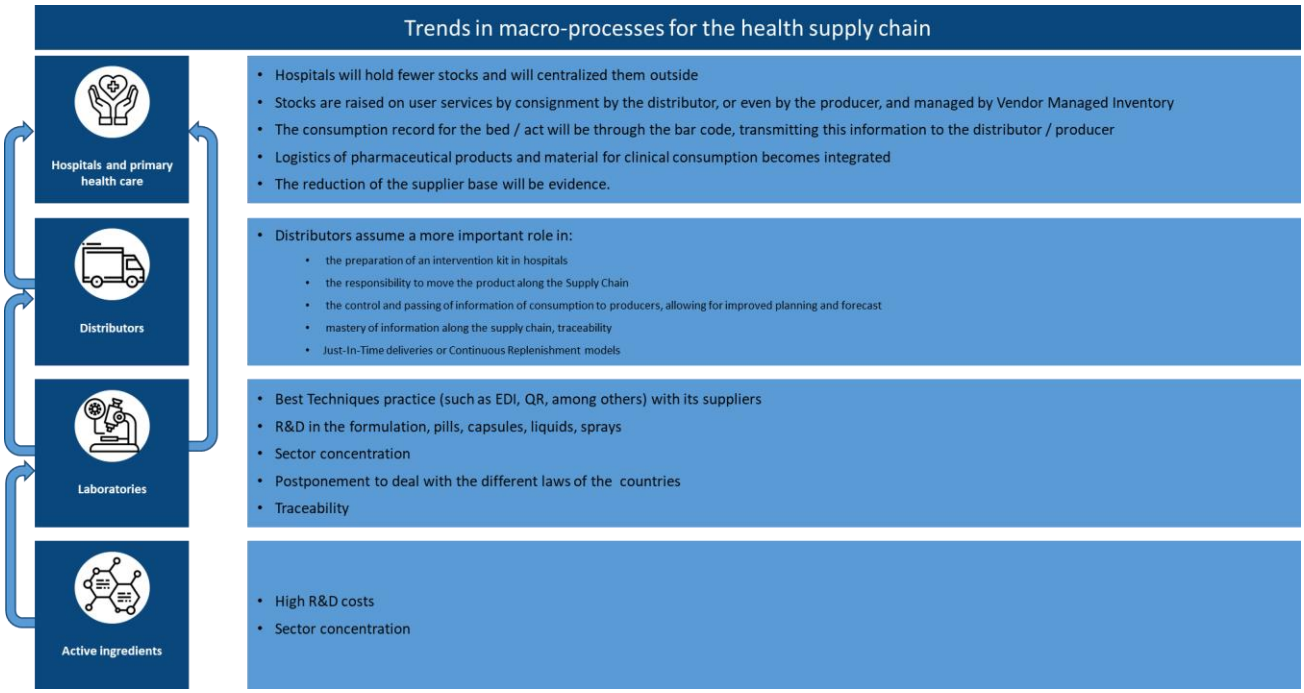


Figure 8 – Trends for the healthcare supply chain (Adapted from [3]*)*

2.2.3. Hospital Pharmacy

This subchapter will focus on the activities inherent to the Hospital Pharmacy, focusing on its legal and technical framework, analyzing the legislation and relevant technical manuals in the sector.

The hospital pharmacy can be defined as a clinical support department, endowed with technical and scientific autonomy. The primary objective is to guarantee the safe and rational use of medicines and other pharmaceutical products, meeting the therapeutic or diagnostic needs of patients [2], [10]. It can also be highlighted some hospital pharmacy objectives, focused on the medicine, and that allow reaching its primary objective, such as: participating in the selection of medicines and other pharmaceutical products; develop management, acquisition, storage, distribution and control activities; develop and implement an effective, efficient and safe drug distribution system; implement a pharmacovigilance system, among others [4]. Drug management encompasses several phases, developing in the following order: selection, acquisition, storage, distribution and finalized with the respective drug administration to the patient [43]. As already mentioned, the responsibility of all pharmaceutical products, medicines, and material for clinical consumption in a hospital pharmacy is the responsibility of its Technical Director, who is the Hospital Pharmacist [9].

According to Decree-Law no. 44/204, of February 2 of 1962, General Regulation of Hospital Pharmacy [44], a hospital pharmacy is the set of pharmaceutical activities performed in hospital bodies or services connected to them to collaborate in the assistance functions that belong to these bodies and services and promote the action of scientific research and teaching that they have.

In terms of responsibility, and according to what is legally established, a pharmacist must be responsible for the hospital pharmacy. It is responsible for not only ensuring the correct therapy for patients, the quality, efficiency and safety of medicines, but also promoting the integration of its team in healthcare, scientific research and teaching actions and the efficient management of the service's stocks [9]. The Hospital Pharmacy Manual brings together a set of rules and procedures related to the construction, installation, and operation of Hospital Pharmaceutical Services. It is there that the management of medicines is defined as the set of procedures performed that guarantee their good use and dispensing them in perfect conditions. This includes several stages, such as selection, acquisition, and storage, followed by the distribution of medication and other pharmaceutical products, and their administration [1], [29], [45]. Figure 9 is an adaption of this circuit as in the referred manual.

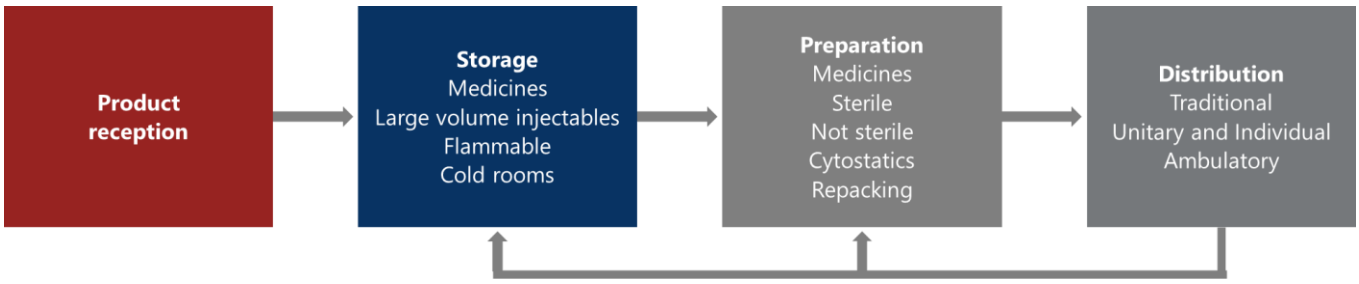


Figure 9 - Circuit of medicines, pharmaceuticals and medical devices (adapted from [9])

In this perspective, the pharmaceutical management of medicines and other pharmaceutical products assumes a central role in fulfilling its objectives. This plays a relevant and strategic role, mainly due to the high economic burden it entails [14], [17], keeping stocks of medicines in the

same proportion of their consumption, avoiding excessive stocks or stockouts, is one of the greatest challenges for hospital pharmacists [38], [40]. This challenge is mainly due to the significant fluctuations and high degrees of uncertainty inherent in stock management [46], but also with the aim of reducing costs, including storage costs. In this process, in addition to the financial aspect, quality assurance should also not be discouraged, to ensure the pharmacotherapeutic needs of patients [10].

2.3. Public Procurement

In this sub-chapter it will be discussed what is public procurement, associated legislation, government model and strategy. In addition, reference will also be made to the advantages and disadvantages of joint purchases within the healthcare sector.

2.3.1. Overview

Since 2002, Portuguese hospitals thus started to be managed as companies to promote more efficient use resources and provide the provision with greater responsiveness through greater autonomy of management teams in hiring resources and the acquisition of goods and services [47]. This model identifies a double line of authority: the managerial one, centered on the administration (team that makes up the board administrators, managers and intermediate administrators) and another more technical centered in the intermediate level professionals (represented by doctors and nurses). The later one is where a decentralized management model known as Integrated Responsibility Centers that in central dependency of hospital administration is managed by a responsible service director costs, planning and delivery of your department's clinical activities [1], [4], [29]. In the search for efficiency and the best performance and quality of services, there are some internal conflicts and problems in the organization of hospitals, which are often related with this dual authority [3]. This plays a relevant and strategic role, mainly due to the high economic burden it entails. From a general perspective, stock management consists of maintaining a stock level for a given item in the same proportion as its consumption, with the aim of reducing costs, including storage costs [3], [9]. In this process, in addition to the financial aspect, quality assurance should also not be discouraged, to ensure the pharmacotherapeutic needs of patients [10].

The publication of Decree-Law no. 93/2005, transformed the legal status of several institutions that became a Public Business Entity [48], replacing the previous statute that gave it nature limited liability company. In Portugal, the Public Contracts Code (PCC) regulated by Decree-Law no. 18/2008 of January 29 [49], which transposed the European directives 2004/18/EC and 2004/17/EC of the European Parliament and of the Council, relating to the conclusion of public contracts for public works contracts, leasing or acquisition of movable goods and services. The PCC, in addition to systematizing a set of rules scattered in this area, now mostly revoked, intends to apply to all public contracts entered. Figure 10 shows the main principles in public procurement and why they are important to CCP. The centralization of the acquisition of goods and specific health services, for all services and institutions of the NHS and bodies and services of the Ministry of Health, is provided by SPMS - Shared Services of the Ministry of Health.

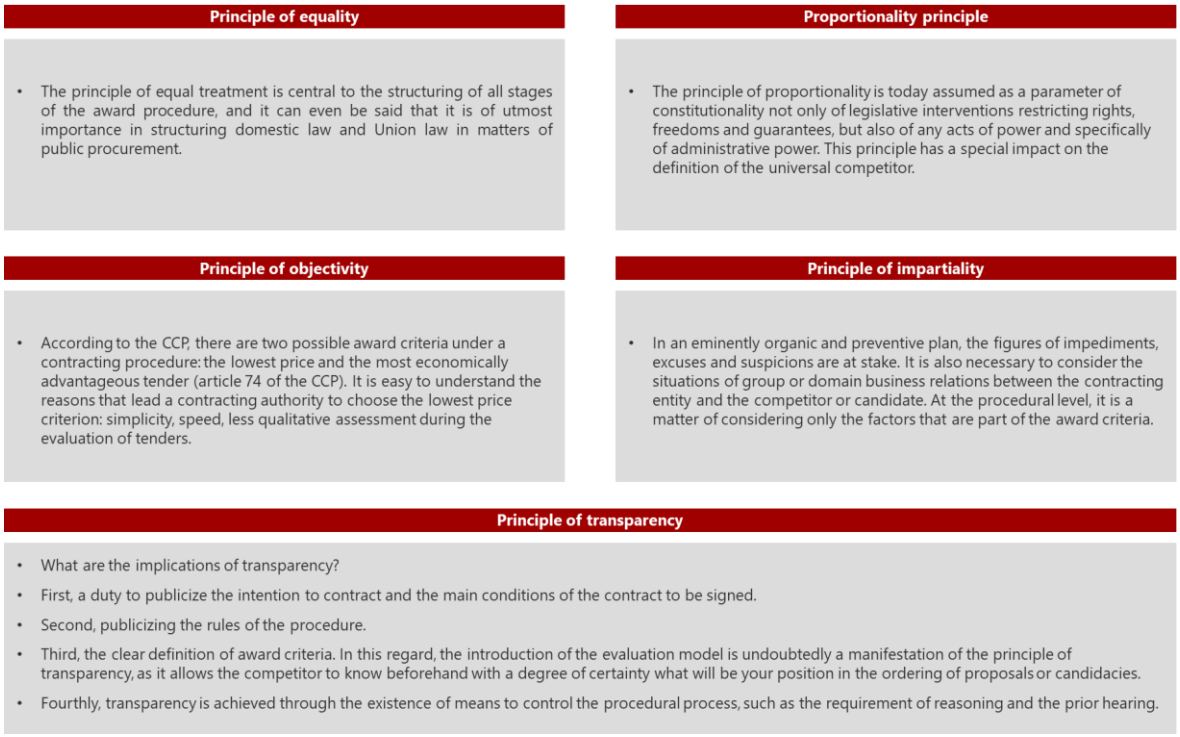


Figure 10 - The five main principles for public procurement (Adapted from [45], [50]*)*

The Portuguese National Health System is made of numerous entities, under the responsibility of the Ministry of Health. This authority may have a Direct Administration, Indirect Administration or belong to the public-business sector. As it is constantly changing, the most up-to-date version of the organization chart can be consulted on the NHS website [51].

In this way, it is intended that national legislation goes in favor of five fundamental points [2], [10],

1. Rationalization of expenditure
2. Savings generation
3. Operational efficiency
4. Promotion of competitiveness and quality
5. Generation of management information

In Portugal, the National Strategy for Quality in Health 2015 -2020 aims to improve the quality and safety of the care provided by the National Health Service. All available resources are essential, especially in a context of scarcity, and they should be used, by citizens and health professionals, in a logic of complementarity, so that you can do better and get better results at a lower cost. Thus imposes a positive differentiation on all who use or work for the health system, forcing the full commitment of the Clinical Directors and the strong commitment of the Quality and Safety Committees in the implementation of this Strategy, namely in the reduction of costs that do not add value, in the reduction of waste and redundancy, in the standardization of procedures, efficiency gains and obtaining better results [29], [52], [53].

2.3.2. Rational Management

Cost management and control are central to any institution, including in hospital institutions, where costly medical treatments can make the exercise of medicine unfeasible and put health, or even the survival of patients, at risk. In this context, the management of stocks of medicines and other pharmaceutical products due to their high economic impact (which represents the second largest item of expenditure in the hospital budget), acquires extreme importance [7], [54].

Regarding shared healthcare-specific services in the area of procurement and logistics, the SPMS's mission is to centralize, optimize and rationalize the acquisition of goods and services and provide logistics services, with attributions in terms of purchasing strategy, pre-contractual procedures, public procurement, internal logistics, payments and performance monitoring [50], [55]. Table 1 shows the strategic guidelines and the main objectives of what are centralized purchases in Portugal.

Table 1 - Strategic guidelines for the five fundamental points [56]

Rationalization of expenditure	• Agreements for the largest expense items corresponding to the needs of the NHS; • Standardization of products and services. • Reduction and rationalization of public expenditure and consumption.
Savings generation	• Qualification and selection of supplier entities with the best prices; • Simplification of purchasing processes. • Contribution to the rebalancing of public accounts; • Reduction in public expenditure on medicines and other goods.
Operational efficiency	• Explication of the consultation, negotiation and award rules under the Acquisition Framework; • Definition of service levels to be guaranteed by suppliers; • Introduction of technological means to support the acquisition process; • Reduction of the number of qualified / selected suppliers.
Promotion of competitiveness and quality	• Selection of suppliers based on best prices at the time of celebration the framework agreement and at the time of award; • Qualification of suppliers according to economic, financial, technical, environmental, quality and service levels. • Promote business development and competitiveness by encouraging competition; • Allow the NHS to benefit from the best market conditions.
Generation of management information	• Introduction of the obligation for suppliers to send management information to the SNS, SPMS and purchasing entities. • Performance evaluation of framework agreements and continuous improvement of purchasing processes.

Additionally, several strategic measures are being implemented to increase sustainability of the healthcare sector. The introduction of monitoring and control mechanisms with the aim of improving levels of overall system efficiency, with a view to eliminating productivity differentials between the NHS units. Additionally, the creation of autonomous management units (Integrated Responsibility Centers) of high performance, shared management of resources between units that integrate the NHS, through mechanisms of affiliation. In view of the progressive internalization of the activity and the consequent gains in efficiency due to greater profitability of installed capacity, centralization in the ACSS and SPMS of the processes of negotiation, acquisition of goods and services and integrated management of contracts with entities external to the NHS and a systematic review of agreements, subcontracts and conventions, with a view to reviewing the its utility and market conditions [52], [56].

2.3.3. Joint Purchases

The purchasing process of a company or organization can be defined as obtaining all goods or services, skills, and knowledge, from external sources, provided for the execution, management, or support of all the activities of that same organization [18]. The purchasing process is a core responsibility for an organization, as it involves the ability, through a series of decisions and guidelines, to "buy products in the right quality, in the right quantity, at the right time, at the right price and at the source right"[16]. For this reason, many institutions have come to recognize that the procurement process is an essential element of supply chain management.

The centralization of purchases, which can be defined as a strategy to facilitate and consolidate the practice of purchasing goods for different associations, appears as a new approach to the growing importance of purchases in the business environment [14], [18]. Thus, consolidating this practice means transferring to a single central entity as different activities that make up the purchase process.

In Portugal, Centralized Purchases for the Public Healthcare sector the main vectors are efficiency, transparency, equality and promoting competition. Principles such as equity, access and equality will be the focus of purchases centralized, since the aggregation of national needs allows to equip all entities quality goods and services at the same prices, resulting from economies of scale [55]. At the same time, centralized purchases also allow to obtain savings from reduction of procedural and operating costs.

Rozemeijer [18] states that synergies can develop in six ways:

- Power of negotiation: by combining your purchases, different units can gain strength with suppliers, reduce costs, or even increase the quality of purchased products. Similarly, companies can benefit from other partners such as universities, customers, government or even competitors.
- Sharing intangible resources such as knowledge and information: organizations can improve their results by perceiving processes other companies, many companies place a lot of emphasis on improving processes and this reflects the importance that this sharing can have.
- Tangible resource sharing: Business units can gain savings from scale and avoid duplication of efforts by pooling human resources
- Vertical integration: The coordination of product and service flows between units can reduce inventories, product development expenses or even the increase in available capacity.
- Strategic coordination: Align strategies of two or more business units it can be an important source of synergy, but difficult to achieve.
- Creation of combined businesses: The combination of knowledge from different units may give rise to a new unit or articulation with internal companies.

Despite the numerous advantages, some authors refer that the aggregation of purchases can lead to an oligopoly situation on the part of providers [55]. Over time and with the high bargaining power of the group of purchases, some suppliers are forced to withdraw their products from the market

or to merge with other suppliers. In this situation, in the medium / long term, with the competition, prices may become higher. The authors still question whether purchasing groups really add value to their members and whether the responsiveness of purchases is the same as that of a decentralization [14]. On the other hand, for Karjalainen [57], the disadvantages of centralization result largely from behavioral problems and the difficulty in controlling fully effective at a distance. As a disadvantage of centralization the author refers the associated indirect costs, the longer responses to the units decentralized and the possibility of lack of information or misrepresented knowledge on decentralized needs. [14], [18], [55]

Table 2 - Advantages and disadvantages of joint purchases [55]

Advantages	Disadvantages
Optimization of the purchases by reducing overlapping activities	Possibility of oligopoly on the part of suppliers, generated by imperfect competition
Creating economies of scale (decrease in unit costs of the product, thanks to the negotiating power through volume increase)	Decreased responsiveness of suppliers
Efficiency in acquisition standardization of purchases	In the medium or long term, it can lead to a decrease in competition and a possible increase in prices
Creating synergies and increasing productivity	Difficulties in controlling the purchasing process, which may compromise its effectiveness
Quality and speed of management information produced	Longer response to decentralized units
Increased quality of service rendered	Lack of information about the local needs of each institution or a misperception about those same needs

2.4. Stock Management

The management and control of costs are central to any organization, including hospital institutions, where costly medical treatments can make the exercise of medicine unfeasible and put health, or even the care of patients, at risk. In this context, the management of stocks of medicines and other pharmaceutical products due to their high economic impact (which represents the second largest item of expenditure in the hospital budget), is extremely important [7], [54].

The management of actions is one of the main activities of the hospital pharmacist. This plays a relevant and strategic role, mainly due to the economic costs it entails. From a general perspective, stock management consists of maintaining a stock level for a given item in the same proportion as its consumption, with the aim of reducing costs, including storage costs. In this process, in addition to the financial aspect, quality assurance should also not be discouraged, to ensure the pharmacotherapeutic needs of patients [13], [55].

Stock management consists of an uninterrupted analysis of changes in consumption suffered in each period, as well as their probable causes. In this way, it is possible to detect a future trend and predict its likely performance, with a certain degree of confidence [58]. Maintaining stocks represents, on the one hand, a great risk, but on the other hand they provide a certain level of security due to the high degree of associated uncertainty. The stock is useful insofar as it defends against scarcity, in providing the satisfaction of the needs resulting from the different rhythms of

consumption [59]. The maintenance of stocks also allows to reduce the frequency of purchases of small quantities, which in addition to being a nuisance leads to an increase in associated costs. In addition, the acquisition of large quantities can provide price reductions that exceed the costs inherent in their storage. The periodicity of the purchases and their quantity must reflect the availability and capacity of the supplier, the definition of stock levels, the storage capacity, as well as the financial resources available at the institution [3], [23].

Currently, most hospital pharmacies use historical consumption data and / or subjective criteria as a technical criterion in the decision to purchase medicines and other pharmaceutical products. However, there are advantages and disadvantages in its use, so it is recommended to use joint methods to gather more appropriate and accurate information that allows efficient management [1], [47].

An efficient stock management implies that some essential requirements are adopted, such as [13], [15], [60], [61]:

- Establish your order point for each item based on safety stock, minimum stock, and maximum stock;
- Permanent control of stocks to quickly overturn supply shortage;
- Reduce acquisition costs;
- Reduce or avoid the stock of medicines in disuse or obsolete;
- Reduce storage costs;
- Conduct periodic physical inventories, to keep physical stocks updated with those of the computer support;
- Good relationship with suppliers.

In the management process, there are also some factors that may be responsible for the increase in spending on the purchase of medicines, of which the following stand out:

- The absence of organization and structuring of the hospital pharmacy, namely, qualified personnel and adequate minimum structure [3];
- The delay in opening the procurement procedure, which can be complex and involve a set of legal and administrative requirements that need to be met. In situations of urgency in the purchase of drugs or other pharmaceutical products, the pressure in decision making can increase, which proportionally increases the risk of not buying correctly [14];
- The increase in the frequency of acquisitions and in small, segmented quantities on an urgent basis, due to lack of management, can lead to irregularities in their supply and increase the risk of wasting resources [25];
- The constant ruptures of medicines and other pharmaceutical products, when causing the frequent interruption of treatments, can compromise or worsen the patients' health situation, resulting in avoidable expenses [62];
- The absence of a computer support that allows a control of the orders generated and their current state of supply or, even, that makes it possible to quickly gather therapeutic information from patients in order to allow correct decision making [63].

Hospital pharmacies, in their therapeutic arsenal, have an increasing diversity of medicines and other pharmaceutical products, which makes it difficult to manage stocks, especially when each item has its own particularities such as random consumption, price, delivery time suppliers, among others [25], [30].

In this context, the standardization of medicines appears to be a viable alternative for more efficient management, since it allows classification in groups with similar management characteristics. This saves time by applying the same management methodologies to all articles in the same group. In this way, it allows you to direct the remaining time for the treatment of articles or other tasks considered to be a priority [64]. Figure 11 represents the main intrinsic and extrinsic factors that influence the consumption of medicines and other pharmaceutical products at the hospital level. It is important to note the points related to epidemics and pandemics, a current factor and with media impact.

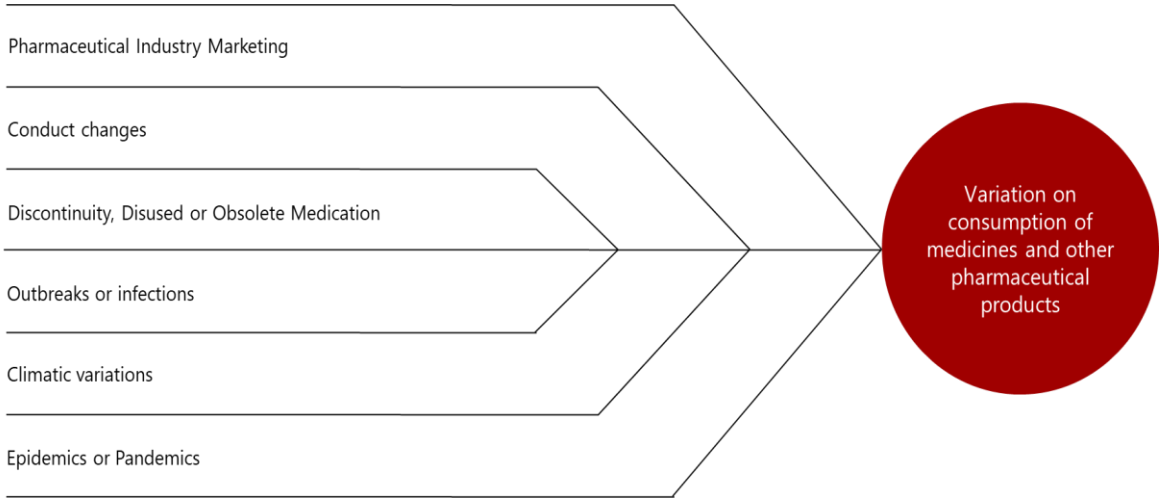


Figure 11 - Intrinsic and extrinsic factors that influence the consumption of medicines and pharmaceutical products [10]

The importance of forecasting for operations management cannot be overstated. Over the last years, demand/supply planning processes for planning horizons in the intermediate range have been receiving increasing attention, especially as the information technology originally intended to facilitate this planning has achieved limited success [65].

Quantitative methods can be used when:

(1) information passed on the variable you want predict is available,

(2) the information can be quantified, and

(3) if it is assumed that the pattern of the past will continue in the future.

In some cases, a prediction can be made using the time series methods or a causal method. If historical data are restricted to values past the variable we want to predict, the forecasting methods are called series data. The purpose of this method is to discover a pattern in the historical data and then explore this default in the future. This forecast is based only on past values and/or forecast errors [66]. Causal forecasting methods are used when establishing relationships between the variable for which it is intended to draw up forecasts and one or more that act as ”explanations of the variation of the first In this context, it is assumed that the existence of cause/effect relationships

between the explanatory variable and the dependent variable, which must be substantiated solid arguments (physical, logical or otherwise) resulting from an understanding of the phenomena under analysis and not from the conclusions drawn from the model [67].

The pattern or behavior of the data in a time series can several components that might exist simultaneously. Usually, it has four main components:

Trend [3], [68]

In the analysis of time series, measurements can be made all hours, days, weeks, months or years or any other regular interval. The time series data generally fluctuates, time series can gradually show movements relatively high or low values over a long period of time. At gradual changes in the series are called trends these changes or trends are usually the result of long-term factors such as changes in the population demographic characteristics of the population, technology, and preference of consumers.

Cyclicality [3], [69]

Although time series may exhibit a trend for several periods of time, this does not mean that all future time series values will fall exactly on the trend line. In fact, the series times often show alternative sequences of points below and above the trend line the any repetitive sequence of points above or below the trend line, which has a duration over one year, can be referred to with the component cyclical time series.

Seasonality [3]

Considering that the trend and cyclicality of the series temporal data were identified by analyzing movements of historical data from several years, many series show a regular pattern over a period of one year. Per example, a pool manufacturer expects sales during the autumn and winter months and peaks of sales during the spring and summer months but, manufacturers of equipment for snow and thick clothing, expect peak sales in the autumn and winter months and low sales in spring and summer.

Irregularity [3], [22]

The irregular component of a time series is the factor reminder that considers deviations from the values of current series from the expected effects of trends, cyclicality, and seasonality. The irregular component is caused by the fact that non-anticipation of the factors affecting the time series due to this component consider the random variety in the time series, this is unpredictable, we cannot predict its impact on time series what when combined give rise to values specific for time series.

2.4.1. Stock Management Methods

In hospital logistics there are different methods that help in an effective and efficient stock management as the traditional method, the alternative method, the double box, the car exchange system, the tier replacement method and the computerized and robotized [13], [45].

The traditional method is the most used in health services and therefore the best accepted by them, in addition to being the one that requires less investment. In this method, the request is made by

the consumer service, which is also responsible for your stock management. In the alternative method, the quantities required are fixed, based on the average consumption of each service, thus saving time for medical service personnel. The double box method is a simple Kanban system that starts with placing of two equal boxes and with the same stock in the place where it will be consumed. When the products from the first box are all consumed, before starting to remove the material second box, the user must act in such a way that the need for replacement. In the car exchange system, all consumer service material is tidy in cars. You start by determining maximum stocks, then the configuration of each car, making it necessary to prepare twice as many cars so that exchange is possible. In the tier replacement method, firstly, provisioning and service consumers act together to determine minimum and maximum stocks. Finally, the computerized and robotized enables control by electronic cabinets, which through computer system controls consumption and quantities consumed and needed [4], [70], [71].

2.4.2. The importance of decision support software

Due to the growing volume of data and information, it is almost mandatory to use information systems (IS) to manage and transform the data into useful information for the organization [72]. An IS is a system used to transform data into information, regardless of the use that will be made of that information. ERP are a type of IS, the resource planning systems of the company, and encompasses several systems from one company [73]. These systems are characterized by a modular software package that aims to assist the integrated management of processes underlying the various departments and functional areas of the company and also with its partners (customers, suppliers, service providers, among others). The main objective of this software package consists of eliminating the redundancy of operations, administrative burdens and bureaucratic, through the automation of processes, allowing greater consistency of information, and enabling, in real time, to develop and manage the business in an integrated manner [73], [74]. As such, one can affirm that an ERP system has as main characteristics to be: modular, configurable, integrated, flexible and shareable [7], [75].

Health Information Systems allow cooperation, knowledge, and information sharing, as well as the development of service provision activities in the areas of systems and technologies information and communication [53]. They play an important role in the reform of the health system, having as main objectives the improvement of accessibility, efficiency, quality and continuity of care and increased satisfaction of professionals and citizens [53]. Additionally, technology can be a facilitator of information sharing, promoting a culture of common knowledge and information sharing, allowing the collection of information to be facilitated and treated at source (data validation), facilitating its future treatment. It allows the development of remote work, it can lead to a reduction in personnel costs with the automation of certain tasks and it allows the information provided to be higher quality, translating into more accurate decision-making and in accordance with the real scenario [76]. The successful implementation of Supply Chain management does not come from the purchase of any system or technology, for example through organizational culture, recognizing the importance of integrated tactical planning and by analyzing the indicators for assessing performance and give visibility and greater weight to the established objectives. Martins [75] mentioned in his work that what is often at stake is the delivery processes or the fine-tuning of critical aspects of those same processes. The behavioral dimensions are of paramount importance and may not follow identical rhythms. In addition, most hospitals around the world have a very

diverse ecology of information systems with different data, clinical and non-clinical data, often poorly integrated. This fact, associated with the plethora of databases, registration habits, and multiple legacy and departmental applications, means that the integration strategy has to be thought of simultaneously software and behavioral aspects [77].

2.5. How a global pandemic affects hospital logistics

The SARS-CoV-2 infection, known as COVID-19, was declared a pandemic by the World Health Organization (WHO) on March 11, 2020, 3 months after the first cases in Wuhan, China. In May 2020, the disease had already affected more than 5 million people, causing more than 330,000 deaths worldwide [78]. Estimations indicate that a severe global pandemic or a temporary change can lead to an average GDP loss of 6.7%, with a loss of 8.4%, both for the USA as for the euro area. According to the Organization for Cooperation and Development Economic Development, global economic growth may fall by half in 2020, in the worst scenario for the Covid-19 outbreak [79].

Concerning supply chain, epidemic outbreaks represent a special case of risk which is distinctively characterized by three components. These components are [46]:

(i) long-term disruption existence and its unpredictable scaling,

(ii) simultaneous disruption propagation in the supply chain, and

(iii) simultaneous disruptions in supply, demand, and logistics infrastructure.

In a pandemic, competing demands for resources, long-term impact, and risk of contagious and illness of the health team lead to limitations regarding the transfer resources or patient care. Distinct from other risks, the epidemic outbreaks start small but scale fast and disperse. Recent examples include SARS, MERS, Ebola, and Swine flu [80].

In the event of pandemics, the capacity for hospital care and intensive care is exceeded, creating a significant challenge, a more collaborative governance, integrating governments at different levels, hospitals and non-government agencies/organizations government [78], [81]. In this way, there is an opportunity to create a technical-political space for planning supported by important stakeholders and that can benefit from the use of planning and forecasting tools.

2.5.1. Global and local impacts

In a context where severe disruptions, as closed or partially closed manufacturers or shortages of medical equipment and supplies a good number of industries also experience ripple effects [46], [82]. The pandemic's disruptions o supply chains around the world started in China before anywhere else [80]. The ripple effects from this challenge requires different strategies and actions mainly regarding the interruptions and resilience of companies, individuals and governments [83]. In recent times, a term associated with rare and unpredictable events has emerged, the black swan. The global economy was badly shaken by a black swan event with a very strong impact that caused a halt in numerous global value chains [83]. In addition, social isolation policies have caused a decrease in demand for goods and services. Several papers reported some redesigned of supply chain crucial points as:

- Hospitals were able to buy goods and services in emergency call from other suppliers without the need for lengthy bidding contracts [81];
- Resources were created and changed, such as, for example, the adaptation of the laboratory and its professionals, and the preparation of human resources to deal with situation [78];
- There was prioritization of resources, with ICU beds from different departments directed to the infectious diseases [83];
- Idle resources, even to a small degree, helped the hospital to cope with the pandemic.
- The possibility of eliminating existing processes was also presented to create flexibility.

In Portugal, the increase in the number of infected, hospital admissions and deaths directly and indirectly related to the disease in question, quickly changed the context of health care provision. The exceptional situation created by the SARS-CoV-2 epidemic and the epidemiological infection by COVID-19 changed significantly the health system, either because of the disease itself, which implied a specific and immediate response by health services; either by virtue of the measures adopted by the competent entities (President of the Republic, Assembly of the Republic, Government and General Directorate of Health - DGS), with the purpose of preventing transmission of the virus and combat the potential public calamity resulting from the disease in concerned by restricting rights and freedoms. Furthermore, the expression of the pandemic continues to be characterized by a high territorial heterogeneity. Some of the results obtained were as follows [84], [85]:

- Since the beginning of March, the preliminary number of deaths in 2020 for the total of the country has remained higher than that recorded in the same reference period.
- In the first half of July, 99% of companies were in operation. Also, companies reported a reduction in turnover and a reduction in the number of employees working in the face of the expected situation without a pandemic.
- The increase in prices was immediately noticed in essential and most demanded products, among them personal hygiene products and medications, with alcohol in gel and liquid being products that were lacking in the national trade.

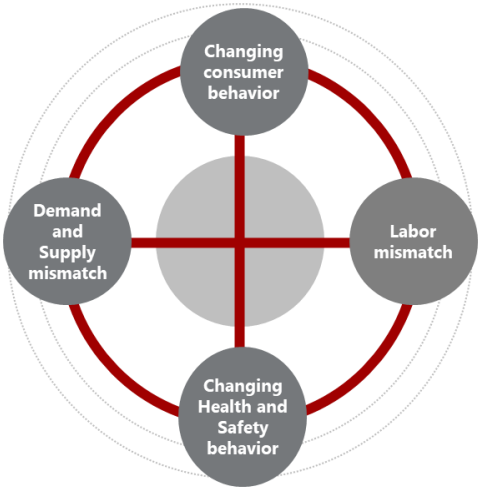
2.5.2. Challenges and long-term changes in supply chain

Based on the available reports and evolving real-time experience, the pandemic effects on supply chains are profound, potentially long-lasting, and extensive. In this context, it is important to rethink supply chain for medicines and supplies, creating a more resilient and innovative management. The use of simulation, risk analysis, and optimization should become regular, being able to be lean and agile [22], [79], [80]. Table 3 is a brief description of the most important operations and decisions to be performed during an outbreak.

Table 3 - Logistics operations and decisions during an outbreak (adapted [82]*)*

Phase	Logistic Operation
Preparedness	Identification of sources
	Contract management
	Inventory management
	Periodical review and updating of medical supplies
	Facility location of stockpiling centers
	Network design transportation/distribution
	Selection of facilities/health
Outbreak	Provision of appropriate materials
	Training of clinical workers
	Provision of commodities and resources to the outbreak response
Response	Review and updating of supplies
	Transportation/distribution of supplies
	Dispensing of medical supplies, supplementary materials
	Management of human resources
	Adjustments to the capacity of healthcare facilities to hospitalize infected people
Evaluation	Development of indicators to evaluate the performance of logistics control operations
	Assessment coordination issues
	Establish and operate procedures

Another change observed is related to social isolation and the behaviors of consumers and patients. This change directly impacts the demand of families in all activities where there are direct interactions between people and a large part of the service sector. Their reflections on supply will also depend on levels of automation and digitization or greater human-machine interaction, which are prominent in the industrial and agribusiness sectors and of less relevance, especially in developing economies in the service sector. Figure 12 outlines the interconnection of all the variables mentioned so far, that is, how the change in consumption habits, impacts in the supply chain, labor create the effects that will change the way certain services are provided, namely, health services.



Demand and Supply mismatch	Changing consumer behavior	Labor mismatch
Changing consumer behavior	**Labor mismatch**	**Changing Health and Safety behavior**
• Patients avoid going to hospitals which leads to an accumulation of drugs • Producers stockouts more frequent • Characteristics of inpatients changed with greater need for the same type of medication	• Hospital overcrowding combined with few human resources and absenteeism will lead to an insufficient response capacity	• Increased attention to safety and health in the workplace with their care and safety equipment
Changing Health and Safety behavior	**Demand and Supply mismatch**	**Changing consumer behavior**
Demand and Supply mismatch	**Labor mismatch**	**Changing Health and Safety behavior**
• Telemedicine leads to the non-displacement of the patient, who in turn fills the prescription locally	• Patients avoid intrahospital dislocations • Dehumanization in contact with the patient	• Inefficiencies may occur due to lack of resources and new safety rules introduced

Figure 12 - Interrelated hospital supply chain themes identified during the coronavirus disease of 2019 pandemic (Adapted from[80]*)*

3. METHODS

In this chapter we intend to address the chosen methodology, reasons, and limitations, in order to create the adequate conjecture to the presentation of the results obtained. It is also intended to create the context for presenting the stock management support tool. This chapter is divided into four sub-chapters, namely data collection, consumption forecasting methods used, stock management using a stochastic model in a periodic review system and Pareto Analysis (ABC). At the end of this chapter, it is intended that the bases for the presentation of results and discussion of them are designed, considering these four revealing points in the study:

1. **A recap of research question**
    - Compared to the current state, what would the stock management of medicines look like if a scientific method were used to forecast consumption?
    - The importance of Information Systems on the supply chain management.
2. **A description of the used methods**
3. **The background and rationale for the design choice**
    - The health market has a huge impact on world GDP, where savings must be essential. On the other hand, the quality of service provision cannot and should not be compromised.
    - There have been several legislative changes in recent years that have led to changes in the way hospitals are managed
    - Need for stock management optimization due to several factors:
        - Reduction in the number of stockouts
        - Optimization of financial resources
        - Space optimization due to physical limitations
4. **An evaluation of the method, and a statement of its limitations.**

It is important to mention that the methodology of the study is loosely based on the chapter "A Review of Stockholding Policy", Global cases in logistics and supply chain management, by Ian Black [86].

In this way, the study that we intend to show will focus on the information about available supply chain management, its analysis and curation of a tool that supports the decision of those who work in their daily lives in this sector.

3.1. Data collection

In scientific research, there is always start from a problem whose statement has already the perspective in which the writer stands theoretically and epistemologically. It translates the way of seeing the question to be examined; that is, the enunciation of the problem to be investigated already shows the theoretical view on the theme under examination and it is this look that will direct our investigation and ways of approximation of the survey and analysis of the data obtained. So, it is not the use of quantitative or qualitative data that differentiates forms of approach questions in investigation, but rather the perspective that guides the investigation [87]. In order to reduce this subjective variability, an almost entirely quantitative approach was chosen, except for the use of quantitative methods, such as interview and observation, to frame the data collected in what is the reality of the pharmacy itself, limitations and staff operating modes.

Regarding qualitative data, interviews were conducted with the Director of Pharmacy Service, Pharmacists, Pharmacy Technicians and Administrative Technicians. In these interviews, topics such as information circuits in order forms, order control methods, methodologies used in forecasting needs and the use of the pharmacy ERP as a support tool were addressed. Additionally, the observation of these same circuits took place throughout the administrative circuit.

Concerning the quantitative data, it was obtained directly from the ERP, and was subsequently treated. Glintt's Software is the one used, and, accordingly to their website, it is a solution that covers areas as relevant as complementary means of diagnosis and therapy, pharmacy and logistics that optimizes pharmaceutical and supply services, ensuring response to the area clinic and a correct work base [88]. Data such as monthly consumption history, supplier list, product list, order history, price evolution and ABC analysis were obtained. It should be noted that much of this information was found in an unstructured way, including the history of orders and receipts not intelligible for statistical treatment.

This collection was the starting point for the analysis and chosen methods that will be analyzed in the following subchapters.

For the hospital's consumption analysis, data were collected for the last five years. These data are grouped by month to facilitate comparison. 1346 different compounds were collected, resulting in 40692 consumption data for all medicines in the pharmaceutical warehouse were collected. In addition, other data were collected, which are currently not intelligible for processing. Thus, the work is at this point, processing non-numerical data to complete the information necessary for the analysis proposed previously. For example, the date of arrival of a specific order. There is no direct variable of this value in ERP, having to be transformed from the receipt note of the same. In Table 4 it is shown a brief list of retrieved variables from the ERP.

Table 4 – Data collected from the ERP, description and data type

Variable	Description	Data type
Medicine	ID and description of medical compounds	Number and string
Quantity Consumed	Registered value in ERP in each time	Number
Period	Study time interval	Number

Medium price	Ratio between cost and consumption in each time interval	Number (not available in ERP)
Order Date	Date for the request	Date
Order Received	Date of the request arrival	Date (not available to compute)
Supplier	ID and description of the supplier	Number and string
Economic Order Quantity (EOQ)	The ideal order quantity that a company should make for its inventory	Number (calculated by the ERP)

This phase will involve an iterative and recursive work of data processing. Figure 13 is an adaption for the model proposed by Sun et. al in their work Data Processing and Text Mining Technologies on Electronic Medical Records: A Review [89].

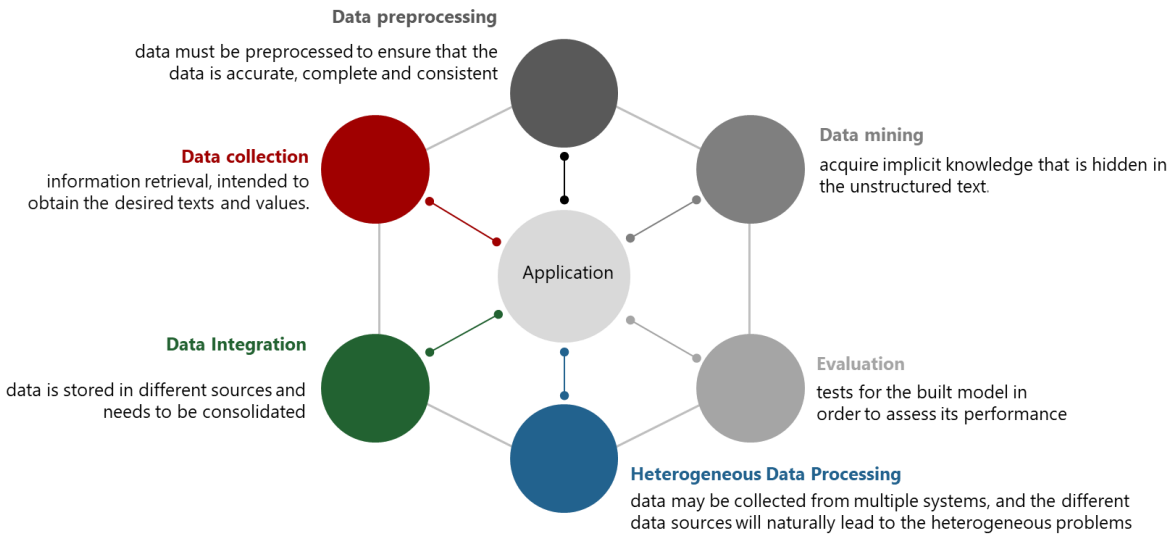


Figure 13 - Data processing flow (adapted [89]*)*

3.2. Current management situation

Drug management is the set of procedures performed by the Pharmaceutical Hospital Services, which guarantee the good use and dispense medicines in perfect condition to hospital patients. The management of stocks of pharmaceutical products, namely medicines, should be carried out by computer, with updated information automatic stocks. When the IT solution is not available, you will have to resort to the manual model on paper support, with records of the movement of medications (inputs and outputs).

The control of the stocks of medicines existing in the services pharmacists must be carried out at least once a year and be subject to extraordinary counts when applicable, namely in the Medicines for Conditioned Use. Drug management has several phases, starting with its selection, acquisition, and storage, passing through distribution, and ending in administration of the drug to the patient.

The hospital pharmacist is responsible for ensuring that patients have the best medicines, pharmaceuticals and medical devices quality and the lowest costs. This is the responsibility of the hospital pharmacist and must be carried out by the Pharmaceutical Services in conjunction with the Provisioning. Documentary support for acquisitions must be properly filled, during the period required by law.

Additionally, reception of medicines and health products implies several activities as: qualitative and quantitative conference on medicines, products pharmacists and medical devices received, conference of the delivery note with the purchase order, signature of the delivery note and delivery of a duplicate to the carrier, conference, registration and archiving of technical documentation, check-in of the product, sending the original delivery note to the Procurement Service, sending products for storage, taking into account the criteria technical requirements (special storage conditions, safety medication). As it can be easily understood, these activities involve a lot of repetitive work that could be automated. In addition, the repackaging and labeling of single-dose medicines must be carried out to ensure the safety and quality of the medicine. Nevertheless, the human time spent is high.

The general lack of human resources in the civil service is also noticeable in the hospital pharmacy, with a low use of the potential of existing resources. In this way, there is no resource that makes the exhaustive management of stocks, to organize the space of storage, and that creates and manages KPI's. In this sense, one of the greatest weaknesses found is related to the same absence of KPIs. There is no control over stockouts, only the indication that they are sparse and spaced in time. There is an excess of stock for some medicines and the physical existence of certain medicines does not correspond to the existence in the system. Consumption forecasts are made empirically, using no scientific forecasting method. This method proves to be effective due to the wide experience of the stakeholders, but not very efficient due to the time spent, excess of stocks and no control over supplier lead times.

3.3. Demand forecasting methods

For this study, several demand forecasting methods were chosen, from simple to more complex ones, and statistically more relevant. In the following points, it will be explained which, its premises, applicability, and respective equations.

3.3.1. Naïve Method

Naïve Method uses the last value of the time series as the forecast for the next period. This method will be used as a point of comparison for the remaining methods, being the most simple and basic.

3.3.2. Simple Linear Regression

Linear regression finds the line that best represents the relationship between two variables. It is the simplest way to characterize a bivariate sample with quantitative data. When there is only one variable *X*, the model is designated by simple linear regression When there is more than one variable *X* the model is called multiple linear regression. Simple linear regression model analyzes the relationship between two variables of quantitative nature *X* and *Y*, whose tendency is

approximately represented by a straight line. Unless the linear correlation coefficient *R* is 1 or -1, all *Y* predictions from *X*'s are average forecasts. To make *Y* explicit in terms of *X*, there are other factors that also influence the variable dependent and are not specified in the model. These factors are included in the random variable ε_i.

The simple linear regression model is expressed by

$$Y_i = b.X_i + a + \varepsilon_i \qquad \textit{Eq. 1}$$

Where:

Y represents the dependent or response variable

X represents the independent or predictor variable

b represents the slope of the line, or slope of the line or change (increase or decrease) in the mean value of Y associated with a unit increase of *X*

a represents the ordinate at the origin, constant, or intercept the line with the *Y* axis, or the average *Y* value when *X* is zero

ε_i represents the residual random variable that describes the effects of Y_i not explained by X_i

Additionally, *R* represents the correlation coefficient and R^2 represents the proportion of variation explained by the model.

3.3.3. Moving average

The moving averages method uses the last *n* observations in the time series.

$$MA(n) = \frac{\sum last\ n\ observations}{n} = F_{t+1} = \frac{\sum_{i=t-n+1}^{t} A_i}{n} \qquad \textit{Eq. 2}$$

F_t = Forecast for period *t*

A_i = Demand occurred in period *i*

n = Number of periods

i = period index

The term moving indicates that when a new observation of the time series becomes available, will replace the oldest observation in the equation, so a new average is calculated.

3.3.3.1. Weighted Moving Average

A variation known as the weighted moving average involves select the different weights for each observation and then calculate the weighted average for the most recent n observations. In many cases, the most recent observations are given greater weight, decreasing according to its seniority.

$$WMA(n) = F_{t+1} = \frac{\sum_{i=t-n+1}^{t} A_i \times n_i}{\frac{n(n+1)}{2}} \quad \textit{Eq. 3}$$

F_t = Forecast for period *t*

A_i = Demand occurred in period *i*

n = Number of periods

i = period index

An alternative model was used in this study, where the algorithm adjusted the different weighting values to minimize the error associated with the forecast.

3.3.3.2. Exponential smoothing

Exponential smoothing uses a weighted average of past time series for the forecasts. It is a special method of weighted moving averages in which it is only selected one weight, the weight for the last observation. The basic model for exponential smoothing is:

$$F_{t+1} = \alpha A_t + (1-\alpha)F_t \quad \textit{Eq. 4}$$

F_{t+1} = forecasts for the time series for the period $t + 1$

A_t = *current value of the time series in period t, with* $(A_t = Y_t)$

F_t = *time series forecasts for period* t

α = *exponential smoothing constant,* $0 \leq \alpha \leq 1$

It is important to understand that the closest to zero 0 is the smoothing constant value, the smoother the behavior of the predicted values will be. Smoother, but less is the model's responsiveness (slower to react). On the other hand, the closer to 1 is the smoothing constant, greater is the model's ability to respond to variations but less is smoothing / smoothing of predicted values. In this study, the alpha value is calculated via an algorithm that allows to minimize the mean absolute error.

3.3.3.3. Exponential Smoothing with Trend (Holt)

The exponential smoothing model is suitable for series locally stationary but is unsuitable for series with other characteristics, namely when tend. This type of series shows a consistent increase or decrease during all the time in the series. Adjustment to the trend is done using a component of exponential smoothing (S_t) and trend (T_t) for period t.

Level $$S_t = \alpha A_t + (1-\alpha)(S_{t-1} + T_{t-1})$$ *Eq. 5*

Trend $$T_t = \beta(S_t - S_{t-1}) + (1-\beta)T_{t-1}$$ *Eq. 6*

Forecast for period t and t+m $$F_t = S_t + T_t \quad then \quad F_{t+m} = S_t + mT_t$$ *Eq. 7*

S_t is the value of the smoothed forecast for period *t*, and trend

T_t is the estimate of the trend value for period *t*

A_t is the real value observed in period *t*

α is the exponential smoothing constant, $0 \leq \alpha \leq 1$

β is the smoothing constant of the trend, $0 \leq \beta \leq 1$

F_{t+1} is the forecast value in the period *t+1*

F_{t+m} is the forecast value in the period *t+m*

Again, in this study, the alpha and beta values are calculated via an algorithm that allows to minimize the mean absolute error.

3.3.3.4. Exponential Smoothing with Trend and Additive Seasonality (Holt-Winters)

The robustness and accuracy of exponential smoothing methods as Holt-Winters have led to widespread use in applications where many series necessitate an automated procedure, such as inventory control [90].

Level $$S_t = \alpha \frac{A_t}{I_{t-L_t}} + (1-\alpha)(S_{t-1} + T_{t-1})$$ *Eq. 8*

Trend $$T_t = \beta(S_t - S_{t-1}) + (1-\beta)T_{t-1}$$ *Eq. 9*

Seasonality

$$I_t = \gamma \frac{A_t}{S} t + (1-\gamma) I_{t-L} \quad \textit{Eq. 10}$$

Forecast for period *t+1 and m*

$$F_{t+1} = (S_t + T_t) I_{t-L+1} \quad then \quad F_{t+m} = (S_t + mT_t) I_{t-L+m} \quad \textit{Eq. 11}$$

S_t is the value of the smoothed forecast for period *t*

T_t is the estimate of the trend value for period *t*

I_t is the seasonality value for period *t*

A_t is the real value observed in period *t*

α is the exponential smoothing constant, $0 \leq \alpha \leq 1$

β is the trend smoothing constant, $0 \leq \beta \leq 1$

γ is the seasonality smoothing constant, $0 \leq \gamma \leq 1$

F_{t+1} is the forecast value in period *t + 1*

F_{t+m} is the forecast value in the period *t + m*

L spacing of seasonality - number of periods in the seasonal cycle (must be constant in the time and the variation must be greater than the random variations or "noise"

Once again, in this study, the alpha, beta and gamma values are calculated using an algorithm that allows to minimize the mean absolute error of the forecast. This method is preferred when seasonal variations are constant through the series. The seasonal component is expressed in absolute terms in the scale of observed series and in the level equation, adjusting its seasonality by subtracting the seasonal component [90].

3.3.3.5. Exponential Smoothing with Trend and Multiplicative Seasonality (Holt-Winters)

The multiplicative method is preferred when seasonal variations are changing proportionally to the level of the series.

Level

$$S_t = \alpha(A_t - I_{t-L}) + (1-\alpha)(S_{t-1} + T_{t-1}) \quad \textit{Eq. 12}$$

Trend

$$T_t = \beta(S_t - S_{t-1}) + (1-\beta) T_{t-1} \quad \textit{Eq. 13}$$

Seasonality

$$I_t = \gamma \frac{A_t}{S} t + (1-\gamma) I_{t-L} \quad \textit{Eq. 14}$$

$$F_{t+1} = S_t + T_t + I_{t-L+1} \quad then \quad F_{t+m} = S_t + mT_t + I_{t-L+m} \quad \textit{Eq. 15}$$

Forecast for period *t+1 and m*

S_t is the value of the smoothed forecast for period *t*

T_t is the estimate of the trend value for period *t*

I_t is the seasonality value for period *t*

A_t is the real value observed in period *t*

α is the exponential smoothing constant, $0 \leq \alpha \leq 1$

β is the trend smoothing constant, $0 \leq \beta \leq 1$

γ is the seasonality smoothing constant, $0 \leq \gamma \leq 1$

F_{t+1} is the forecast value in period $t + 1$

F_{t+m} is the forecast value in the period $t + m$

L spacing of seasonality - number of periods in the seasonal cycle (must be constant in the time and the variation must be greater than the random variations or "noise"

Once again, in this study, the alpha, beta and gamma values are calculated using an algorithm that allows to minimize the mean absolute error of the forecast.

3.3.3.6. Errors

The error associated with the forecast is the difference between the value observed in the series time and forecast. The forecast error can be positive or negative depending on the forecast be too high or too low. An important consideration in selection of forecasting methods is their accuracy. Forecasting errors can be used to calculate forecast accuracy. The mean of the sum of the squared errors is referred to as the mean square error (MSE) is the most popular measure of synthesis of the forecast errors used in the evaluation of performance of each method. The model that leads to a better MSE is preferable. It is important to state that a variety of other forecast performance measures exists, scale-dependent measures, percentage-error measures, symmetric measures, and scaled-error measures. Although it was considered the MSE is the best method for this study for two main reasons, its widely usage and the series are evaluated under different conditions, consequently have the same measurement level as the underlying series [59].

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 \qquad \textit{Eq. 16}$$

3.4. Stock management policy - Stochastic model

Stochastic models apply when demand and/or supply behave randomly, uncertainly. This uncertainty increases the complexity of stock management, as it is now necessary to deal with the

possibility of stockouts. In order to deal with this random behavior, both on the side of the demand and on the supply side, it is necessary to establish a safety stock to absorb greater variations in the registered average values [3], [23]. In the stochastic models there are two base models: the continuous review model and the periodic review model. The sizing of the safety stock will depend on the stock management model implemented.

3.4.1. Continuous Review Model

The continuous review model corresponds to an adaptation of the economic order quantity model when demand and / or supply are random. The operation of the model is like the economic order quantity model, with the difference of the existence of the safety stock. This model is called "continuous review", as there is a constant (continuous) monitoring of stock levels. This continuous review is necessary, because when the stock level reaches a predefined quantity (order point) it is necessary to post an order to the supplier. If the order is not posted at the time the stock level reaches the order point, then the risk of breakage increases.

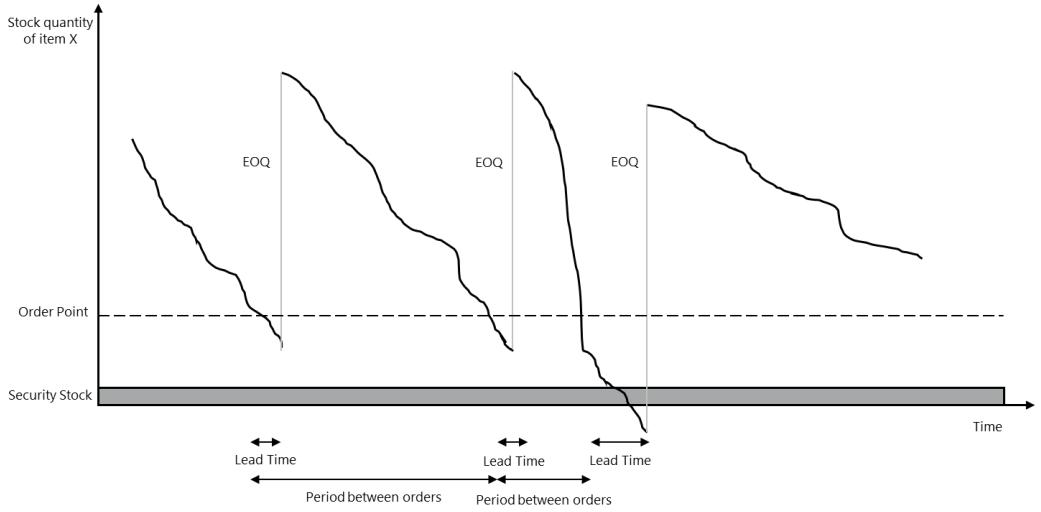


Figure 14 - Graphical representation of the functioning of the continuous review model [3]

In this model, the quantity to be ordered is fixed (EOQ), but the period between orders is variable (depends on the pace of demand in the period between orders). As demand and delivery times vary, there is a possibility of breakage. If the order cycle is divided into two parts (when the quantity in stock is greater than the order point and when the quantity in stock is less than the order point), the possibility of breakage exists only in the second part of the cycle, which corresponds to the supplier's delivery time. There will be disruption if the demand during the supplier's delivery period exceeds the order point. As demand during the delivery period is a random variable, it is necessary to identify it. It is important to note that it was not possible to collect data on suppliers' lead times. The information is in PDF online view mode, not exportable to Microsoft Excel. Thus, those responsible for pharmacy orders and recipes were asked about the lead times of the suppliers. According to them, deliveries are made between 24 and 48 hours, with occasional variations, and non-relevant variations. Thus, the Average Lead Time will be 36 hours, with a standard deviation of ±12 hours.

The security stock to be created will also depend on the variability of demand and/or supply in relation to the average values recorded. If the variability is very high, for the company to be able to

comply with the level of service it has defined, it will have to constitute a greater safety stock; if the variability is low, then the necessary safety stock will be less. The service level is expressed as a percentage and corresponds to the probability that the company will have the quantity demanded available at the time sought.

3.4.1.1. Economic Order Quantity

The stock management policy to choose depends on the relationship between the cost of unit order and the cost of possession of unit stock [3], [91]. Stockouts are situations in which customer or patient orders are not satisfied because there is not enough of the product to satisfy the order. So, it is intended to avoid these situations. The higher the service level, the greater the security stock maintained. The greater the variability of the supplier's demand or delivery time, the greater the safety stock. In this model, the quantity to be ordered is fixed, that is, the order is always same amount. As in the economic order quantity model, the quantity to be ordered must be that which minimizes total costs. In this way, it is necessary to find the balance between the frequency of orders and the stock level to maintain, which corresponds to the minimum of total cost function. Eq. 17, also known as Wilson's formula, corresponds to the amount of order that minimizes total costs and is called an economic quantity of order.

$$EOQ = \sqrt{\frac{2DA}{IC}} \qquad \textit{Eq. 17}$$

D - demand / consumption rate (units / time frame),

A - unit order cost (€ / order),

I - stock ownership rate (% / time frame),

C - unit acquisition cost (€ / unit),

$$SS_L = Z \times \sqrt{\sigma_D^2 \overline{L} + \overline{D}^2 \sigma_L^2} \qquad \textit{Eq. 18}$$

σ_D standard deviation of demand

$\overline{L}$ average delivery time

$\overline{D}$ average demand

σ_L standard deviation of delivery time

The order point corresponds to the average demand during the delivery period (D), plus a safety margin as there is variability associated with demand during the delivery period. This safety factor corresponds to the safety stock, Eq. 18.

$$s = \overline{D}_L + SS_L \qquad \textit{Eq. 19}$$

L - Replacement time (unit of time)

Z - Standard Normal Constant

σ_{DL} - Standard deviation of demand during replacement

σ_D - Standard deviation of demand

σ_L - Standard deviation of the replacement period

3.5. Pareto Analysis (ABC)

ABC analysis is a method that allows a set of articles to be classified into three classes: class A, class B and class C. Class A corresponds to the most relevant articles, class B to articles of intermediate relevance and class C to the least relevant articles relevant. The criteria used to measure the relevance of each article differs from sector of activity to sector of activity and, on the other hand, from what is intended to be done with the results of the ABC analysis. In this context, the ABC analysis will serve to differentiate stock management policies and the degree of control required for each item. Stock management is aimed at minimizing supply costs to a pre-set service level. therefore, criteria such as invoicing or contribution margin can be used to differentiate stock management policies for each item or set of items. According to this procedure, consumables can be divided into three classes:

- Class A: houses the group of most important items that correspond to a small number of medicines, about 20% of the items, which represents about 80% of the total value of the stock.
- Class B: represents a group of items in a situation and intermediate values between classes A and C.
- Class C: groups about 60% of the items, whose importance in value is small, represents about 5% of the stock value

It is important to understand that not all products should have the same weight in the management process. If the products have different degrees of importance, shipping policies must be adopted for different stocks as well. Basically, it is a matter of differentiating the “attention” and the remedies of the management of the articles. As an example. Products labeled as A's, higher service levels should be set, and the continuous review model adopted, as this model allows tighter control over stocks, as it implies continuous monitoring of them. The parameters used in the stock management policy should be revised frequently and more sophisticated methods used to forecast demand. If your resources are not spent on class A, you get much more significant results than using the same resources uniformly or indiscriminately across all articles. The ABC analysis is the instrument: to support the decision on which articles should be the target of greater investment in names of stock control.

3.6. Algorithm

The Algorithm implemented allows the calculation of the QEE, SS and break points for all items present in the inventory. This analyzes the historical consumption data, forecasting the consumption of the following month according to the methods presented above. Later, the method with the least error is proposed to the user. This proposal must be validated using the evolutionary graph of consumption, given that there may be factors such as seasonality or trend that may not have been considered. To analyze the impact of the service level on stocks and their costs, the algorithm was run in three different scenarios. In each of them the level of service was varied, 95%, 97% and 99%. The following figure shows the implementation pseudocode.

```
Initialize with reading of historical product demand with first ID
  Repeat
        For all products i
          Calculate
                Demand and absolute error
                      Naïve Method
                      Simple Linear Regression
                      Moving average
                      Weighted Moving Average
                            Calculate weights trough Excel Solver minimizing error
                      Exponential smoothing
                            Calculate α trough Excel Solver minimizing error
                      Exponential Smoothing with Trend (Holt)
                            Calculate α and β trough Excel Solver minimizing error
                      Exponential Smoothing with Trend and Additive Seasonality
                            Calculate α, β and γ trough Excel Solver minimizing error
                      Exponential Smoothing with Trend and Multiplicative Seasonality
                            Calculate α, β and γ trough Excel Solver minimizing error
                Economic Order Quantity
                Security Stock
                Order Point
                Stock rupture
          Choose method with lowest absolute error
          Update cells with this information
        EndFor
Until Stopping criteria
Show results to user
```

Figure 15 – Pseudocode for the application

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4. RESULTS AND DISCUSSION

In this chapter we will talk about those that were the results obtained and their respective discussion. Given the huge volume of different products analyzed, we will choose to illustrate the results of what represents the highest volume of spending in the hospital.

4.1. Data collection

Through the ERP of the hospital pharmacy, a varied list of information and listings were obtained. The software referred to was developed by the company GLINTT to help in the management of resources in healthcare area, with a strong focus on the pharmacy area. Nowadays there are already several national and international hospitals that enjoy this software, due to its vast versatility and for being compatible with other different software. Nevertheless, the program still has some weaknesses as far as data analysis is concerned. In this section we will talk about the data obtained, those that were not possible to obtain and extrapolations necessary for the calculations.

Table 5 - Data volume collected

Variable	Description	Volume
Medicines, pharmaceuticals, and laboratory supplies with registered consumes	ID and description	1346 different entries
Quantity Consumed	Registered value in ERP	40692 data regarding monthly consumption by product
Consumed Value	Value in euros corresponding to a given monthly consumption	40692 data regarding monthly consumption by product
Available stock	Existing stock of a given product	962 different entries
Suppliers	ID and name	257 different entries

The biggest problems were related to most of listings were only available through PDF Linearization. A linearized PDF file is a special format of a PDF file that makes viewing faster over the Internet. This helps online documents open instantly [92]. This characteristic of the documents does not allow the extraction of the information that is shown there. For this information to be obtained, application development is required, with the respective supplier cost. Thus, and since the data to be obtained were related to suppliers, order dates and reception dates, it was decided to use the referred values by the interviewed.

It is important to note that some of these 1346 products do not have sufficient historical data to create an accurate forecast. This lack of data has several origins, namely discontinuation, replacement, or months without consumption records. Thus, for the purposes of decision to the end user, a simple criterion of sensitivity to analysis is used. If there are at least 12 records in the last 24 months, and simultaneously, 24 records in the last 60, the message will appear to the user that there is sufficient data for analysis. However, the decision to accept or not the forecast will come from the user.

Table 6 - Criteria for validating sufficiency of historical data for analysis

Criteria	**12/24** last two years
	24/60 last five years
Number of products that meet the conditions	573
Number of products that do not meet the conditions	775

Given the huge amount of data, the results for only one product will be shown, the procedure being the same for the rest. The product *Paliperidone 100 mg* was chosen, with the identification code of 10104346 because it corresponds to the top of the list of value consumed in the last evaluated month, May 2020.

4.2. Demand forecasting - Product

With the start of local work, it was possible to collect some information regarding the way Pharmaceutical Services work regarding stock management. There are two fundamental points for this study, the stock review model is continuous, and they use the traditional method for distribution. This form of action may have an impact in terms of consumption records, that is, products that are delivered to medical services are considered consumed until their actual local consumption. This delay in the report may lead to minor errors associated with the forecasts, as these are monthly data. Table 7 aggregates information on monthly consumption of the product Paliperidone 100 mg during the last five years. It is important to note that there are no consumptions associated with the product before October 2017 as it was only introduced at that time.

Table 7 - Consumption history of Paliperidone 100 mg over the years

2017		**2018**		**2019**		**2020**	
Jan		Jan	4	Jan	13	Jan	23
Fev		Fev	3	Fev	13	Fev	21
Mar		Mar	9	Mar	16	Mar	17
Abr		Abr	8	Abr	15	Abr	21
Mai		Mai	9	Mai	2	Mai	22
Jun		Jun	1	Jun	13	Jun	
Jul		Jul	12	Jul	17	Jul	
Ago		Ago	14	Ago	19	Ago	
Set		Set	1	Set	14	Set	
Out		Out	16	Out	27	Out	
Nov	5	Nov	1	Nov	25	Nov	
Dez	1	Dez	8	Dez	21	Dez	

From the analysis of the graph in Figure 16, it is easy to see that this was a product introduced in the hospital scope 2017. Its consumption has some variation, but, in general, it has a growth trend in its consumption.

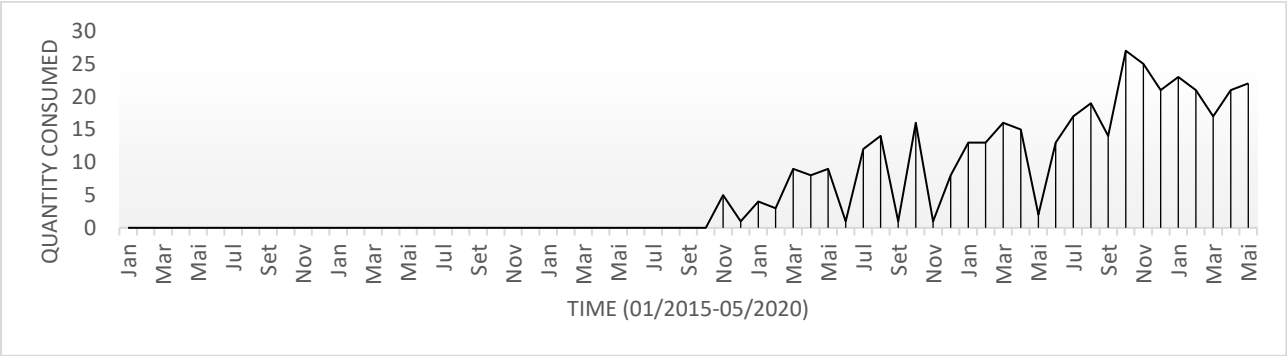

Figure 16 – Consumption history of Paliperidone 100 mg over the past five years

The graph in Figure 17 represents the evolution of the ABC classification of this product. It tends to be a product belonging to Class A, highly indexed to its unit value, more than the high consumption.

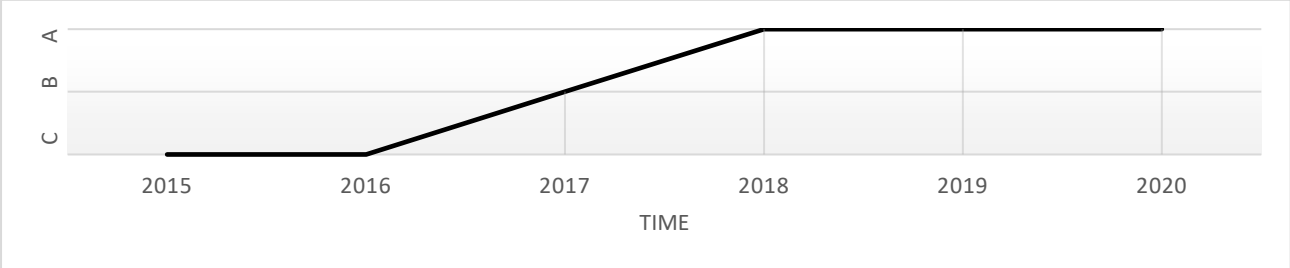

Figure 17 - Evolution of the ABC classification of product Paliperidone 100 mg

In order to calculate the intended outputs, some considerations had to be taken. These considerations are closely linked to the fact that there is no concrete and precise information that can be used in the context of the study. Thus, values described in the literature were common in the healthcare sector. Order cost considered two support administrators, part time of the pharmacy director, depreciation of the equipment associated with the administrative and management and depreciation of the computer program divided by the average number of annual orders. Additionally, the breakage cost was not estimated.

Table 8 - Assumptions taken to calculate the desired values

Variable		Value
Total Cost of Ownership		15%
	Storage	4%
	Material Handling	1%
	Cost of fixed capital	7%
	Personnel costs	2%
	Costs of losses, obsolescence	1%
Average Leadtime		1,5 days

Standard Deviation of lead time	0,5 days
Order cost	10€

Using these data, consumption forecasts for the following month were calculated according to the different methods referred to in the previous chapter. Part of the study also consisted of assessing the impact on the service level at the management level. That is, with different levels of service, namely 99%, 97% and 95%, what are the impacts on the general stock, annual costs, and possible impact on breakage rates. The data obtained are found in the Table. Each method will be addressed accordingly.

Table 9 - Results obtained for product demand and stock management considering different methods and different service levels

Method	Demand	MSE	SS			OP			EQO			SR			OPB		
Service Level			95 %	97 %	99 %	95 %	97 %	99 %	95 %	97 %	99 %	95 %	97 %	99 %	95 %	97 %	99 %
Naïve Method	22	4,9	1,9	2,2	2,7	4	5	5	11	11	11	0,02%			0,30%		
Moving average (n=6)	21	4,1	1,6	1,8	2,2	4	4	5	11	11	11	0,01%			0,32%		
Weighted Moving Average (n=3)	20	4,2	1,6	1,9	2,3	3	3	4	11	11	11	0,01%			0,34%		
Exponential smoothing	20	4,3	1,7	1,9	2,4	3	3	4	11	11	11	0,01%			0,34%		
Simple Linear Regression	19	4,6	1,8	2,0	2,5	3	4	4	10	10	10	0,02%			0,37%		
Exponential Smoothing with Trend	22	4,1	1,6	1,9	2,3	4	4	5	11	11	11	0,01%			0,31%		
Exponential Smoothing with Trend and Additive Seasonality	22	4,6	1,8	2,0	2,5	4	5	5	11	11	11	0,02%			0,31%		

Analyzing the Table 9, it is possible to notice that the method with the smallest MSE is Exponential Smoothing with Trend, also known as Holt's method. Also, by analyzing the graph of the variation in demand for this product, it is possible to perceive the growing trend in consumption, hence this better adjustment. As for the remaining methods, they obtained similar results, which can be explained by the relatively stable demand. It should be noted the high degree of confidence applied for the non-breaking of stock. These values may, eventually, be optimized using the break cost calculation and consequent recursive calculation of the optimal probability, saving even more resources. There are fields in the software for data insertion such as SS, OP and EQO, but for this specific product these values do not exist because the data was migrated from a previous application, where this product was not present. It is important to note that this method has limitations as considering instant receipt of the material and at once, do not consider volume discounts, only considers ordering and possession costs and does not consider delivery failures or provider stockouts.

In terms of costs with the annual stock, considering the values of the Holt method, the distribution of these is done as shown in the Table 10 - Annual product costs.

Table 10 - Annual product costs

Average monthly consumption in the last 12 months	Average value per unit	Annual acquisition cost			Annual order cost			Annual stock cost			Total cost		
		95 %	97 %	99 %	95 %	97 %	99 %	95%	97%	99%	95%	97%	99%
20	294,03€	7 0568€			218€			314€	324€	343€	71 100€	71 110€	71 130 €

The Paliperidone 100 mg product will have an annual acquisition cost of approximately € 70 568, € 218 will be related to the order cost (20 orders in a year). Considering the different levels of service, these are mainly reflected in the SS level and in the breakage rates. As previously explained, in the absence of a breakage cost history, the impact on the total annual cost is verified in the different proportions of this safety stock. The variation between a service level of 95% and 99% has a cost of approximately € 40.

4.3. Hospital stock

In terms of general data analysis for the 1347 runs made by the algorithm, some interesting data were found. In the Table are the data referring to the total costs of annual stock in the hospital, considering the historical data and the estimates made. In average, 85,032 items are consumed monthly, with an average cost of € 28.63. The total cost of stocks is around € 1,697,870, with a 3% share referring to amounts not directly related to the acquisition.

Table 11 – Annual stock cost of all products

Average monthly consumption in the last 12 months	Average value per unit	Annual acquisition cost			Annual order cost			Annual stock cost			Total cost		
		95%	97%	99%	95%	97%	99%	95%	97%	99%	95%	97%	99%
85 032,62	28,63 €	1 641768,3€	31536,8		22 883,7€	23 439,3€		24 490,4€	1 696 188,8€		1 69 6744,2€	1 697 795, 5€	

Regarding monthly expenses with pharmaceutical and laboratory products, these values tend to be stable, around € 150,000 monthly, with a growing trend in the last year. The values of post-covid spending tend to be lower than the homonyms of previous years, values justified by the behavioral changes of patients. Annual expenditure amounts to around 1.5M €, with a tendency to increase in the following years. As the data obtained referred only to the first five months of 2020, the associated expenditure is considerably lower. Nevertheless, expenditures in the first five months of the year were like the same period in the previous year, even considering the period of pandemic onset.

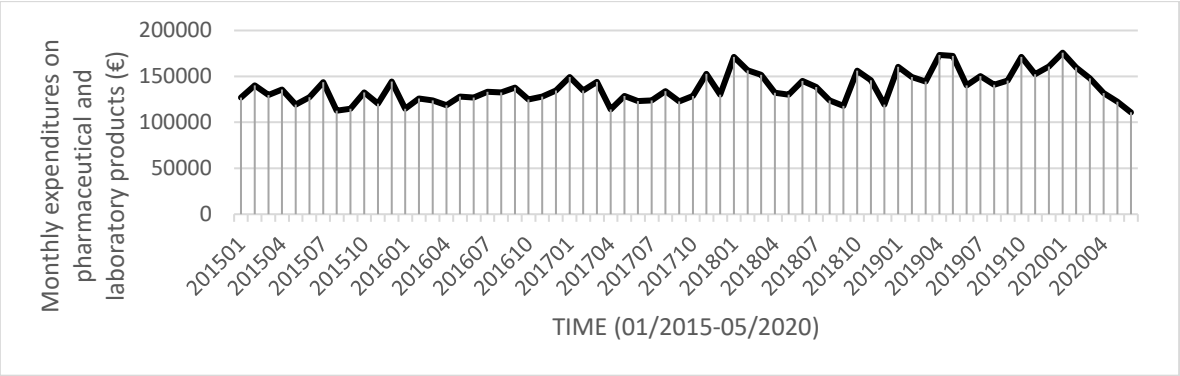

Figure 18 – Evolution of monthly expenditures on pharmaceutical and laboratory products (€)

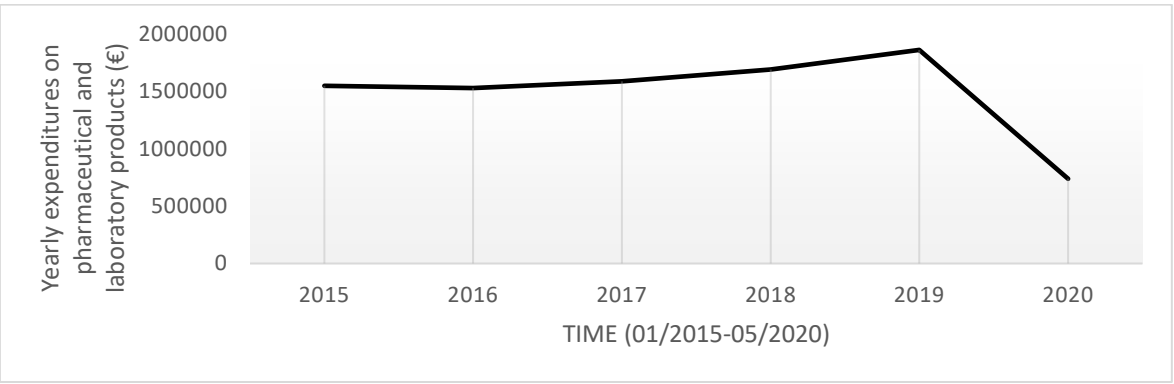

Figure 19 - Evolution of yearly expenditures on pharmaceutical and laboratory products (€)

The algorithm returned most of the products as modellable from simple linear regression. Despite these results, double attention is needed when analyzed one by one, for the reasons already mentioned, namely the current inability to analyze the graphs to detect whether there is a trend, seasonality, or irregularity. For this analysis, the naive method was excluded because it only works as a comparison.

Table 12 - Relationship between the method and the frequency of the best MSE

Method	Frequency of the best MSE	Percentage
Moving average (n=6)	136	10%
Weighted Moving Average (n=3)	47	3%
Exponential smoothing	26	2%
Simple Linear Regression	1122	83%
Exponential Smoothing with Trend	8	1%
Exponential Smoothing with Trend and Additive Seasonality	6	0,5%
Exponential Smoothing with Trend and Multiplicative Seasonality	1	0,01%

Based on the assumptions, and using the results obtained from the best methods identified, considering a service level of 99%, comparing with the current stocks indicated in the ERP, it was possible to conclude the following:

- 41% of products have a stock higher than what should be the maximum stock (safety stock + economic order quantity), Figure 20. This figure represents around € 147.908,87 of fixed assets
- 11% of the products were, at the time, at risk of out of stock, Figure 21

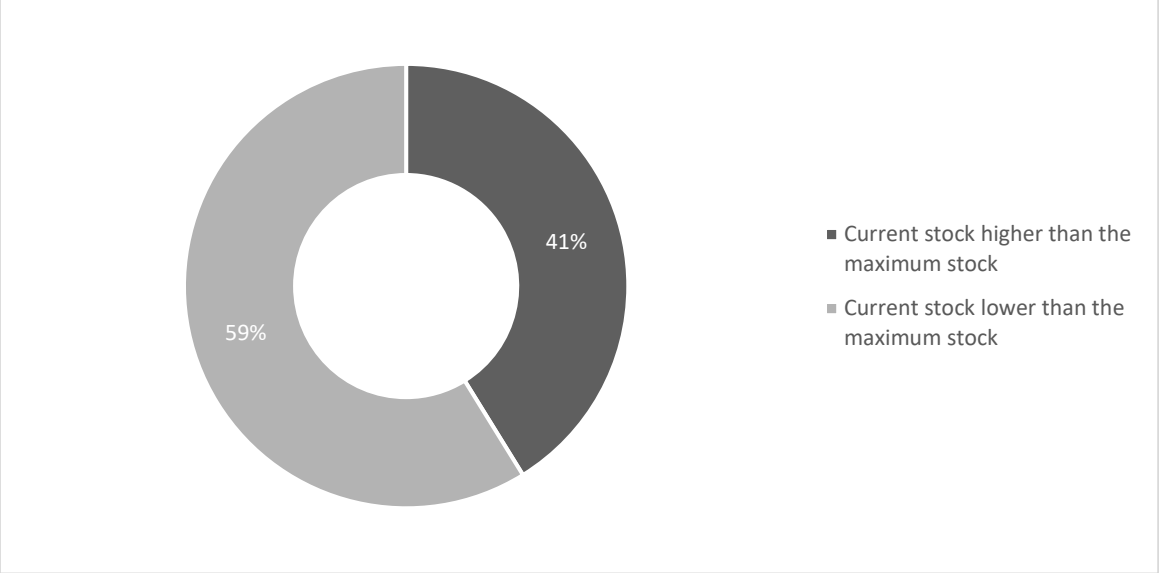

Figure 20 - Percentage of products with current stock above or below the maximum stock

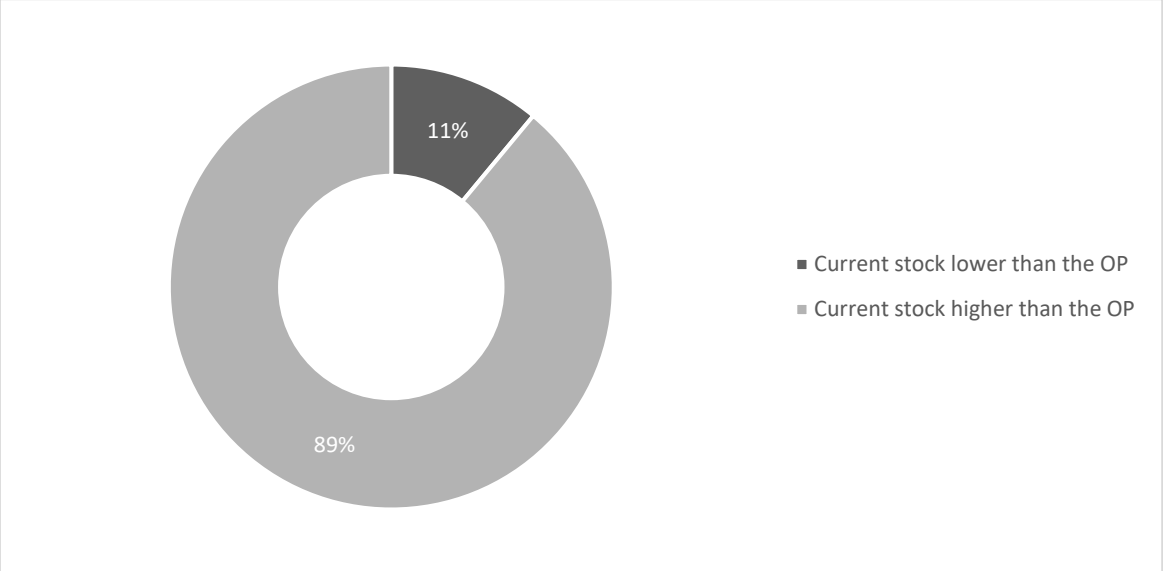

Figure 21 - Percentage of products with current stock below or above order point

Regarding on suppliers, it was possible to lay out in the following graphs the relationship between the number of suppliers per product and the number of products supplied by a specific supplier. Two relevant phenomena are easily perceived through the graphics. the first is that half of the products in the database are only supplied by a supplier, creating a liability in the value chain for

those products. Another is the great dependence on three suppliers, but with special emphasis on *Roche Sist.Diag.Soc.Unipessoal, Lda*, which supplies 1222 different products to the hospital.

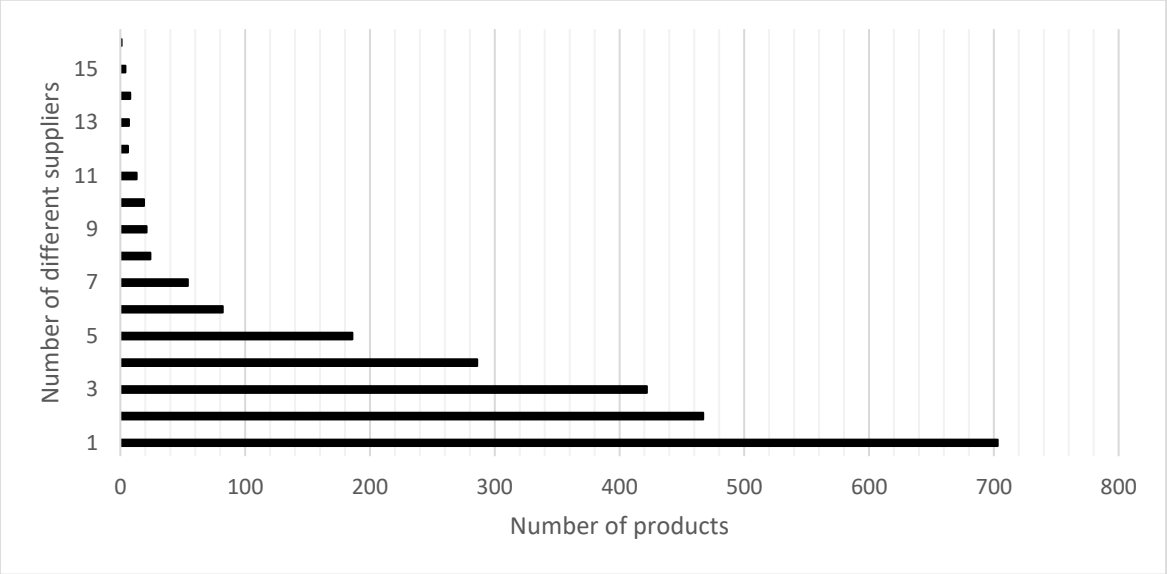

Figure 22 - Relationship between the number of products and the number of different suppliers

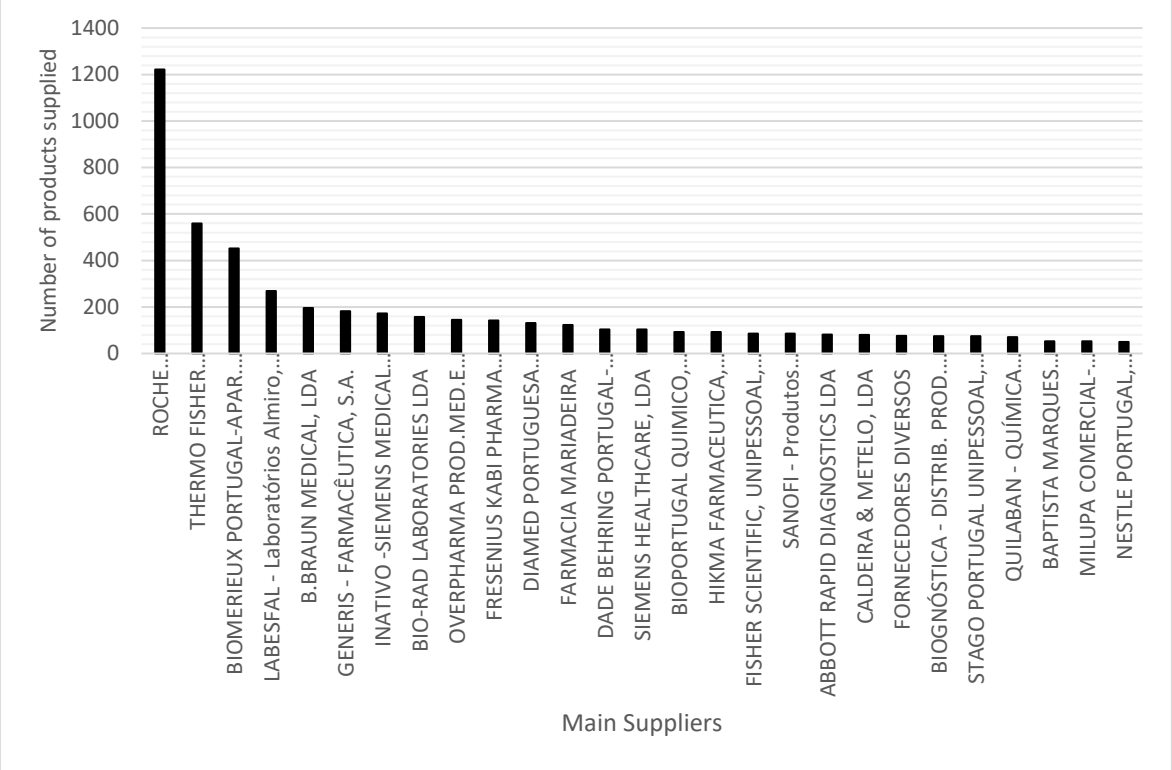

Figure 23 - Number of products provided by the main suppliers

4.4. Management Tool

The application developed using VBA language brings together everything that has been done so far, from forecasting to stock management and ordering. This consists of an interface sheet where the most relevant information is shown to the user and where he can choose which specific product he wants to analyze. It also has a space where you have an overview of stocks about to enter stockout.

Additionally, if the user considers that the chosen method may not be the most appropriate, he can change the method and the application will redo the necessary calculations for the new scenario. The algorithm, considering the previously mentioned parameters, takes 02:02:37 to make a complete return of the values. It can also be optimized from a code perspective to agile the process. Nevertheless, and given that it is a model that deals with monthly consumption, it is believed to be a good running time to start work. What may be an interesting feature is related to the relationship shown between a product, its different suppliers and the products supplied by them and which are below or close to safety stock. In this way, time can be saved and the order for a given supplier can be optimized.

Given the limitations of Glintt's software in relation to the extraction of data related to orders and receipt of orders, it is suggested that the services use the "Lead Time Suppliers" sheet to record these times and thus be able to further refine the results.

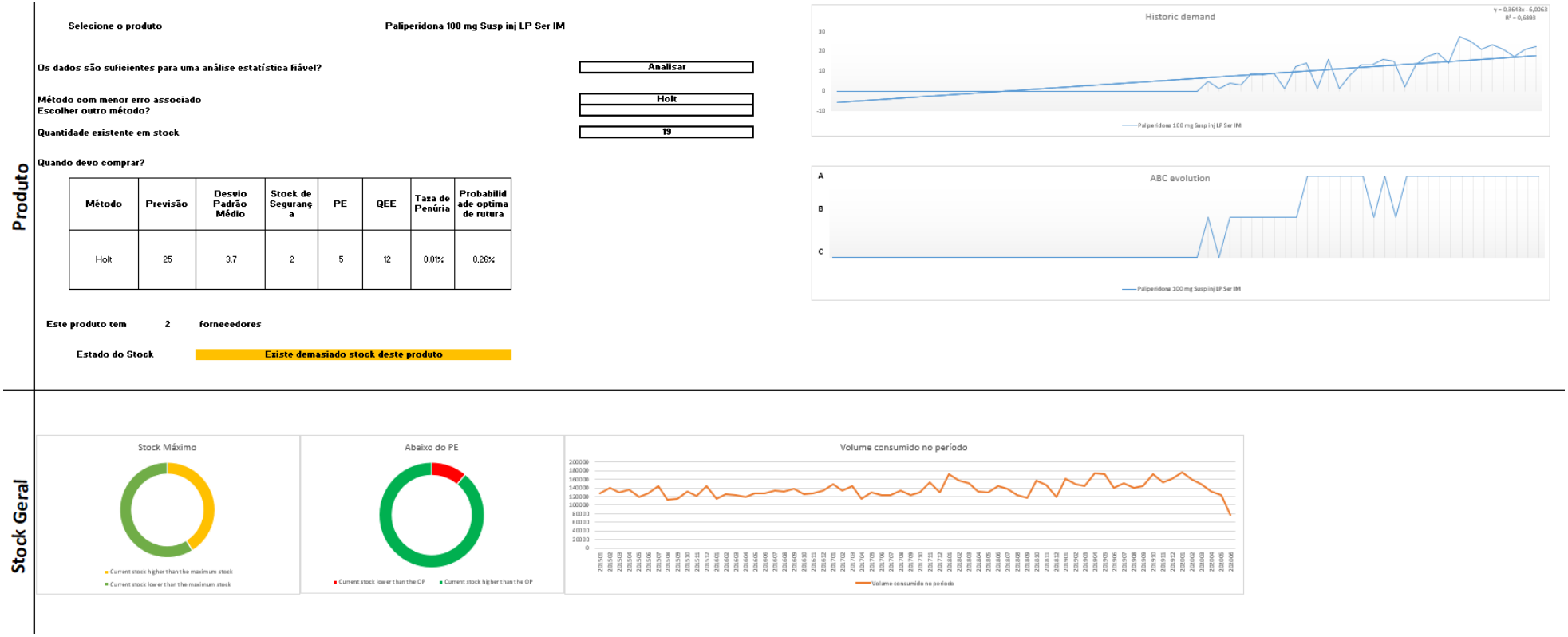

Figure 24 - Application interface

4.5. How COVID-19 affected the Hospital Supply chain

Regarding the impact felt at the hospital level, this was more felt at the level of demand, both for scheduled medical care and medication consumption. The following data were obtained from the NHS transparency portal, where these data are reported monthly, by the competent entities (hospitals or Regional Health Administrations). The available data refer to August 2020.

In the graphics of the Figure 25 and Figure 26 it is shown the data available in the portal, data related do monitoring the expenditure on medicines dispensed in the NHS hospital institutions with public management on a monthly basis. Current consumption data is for drugs covered by the National Hospital Medicines Code, which include medicines for human use with Marketing Authorization and Exceptional Use Authorization. By analyzing the graph, it is possible to understand that there is seasonality in the consumption of medicines in the NHS hospitals, with peaks in common in March and July. In 2020, there was a sharp drop in those that were the months associated with confinement, approaching values practiced in 2017 (around 20M €). The values for the months of September, October, November and December were estimated using two methods previously explained, Linear Regression and Holt-Winters with trend and additive seasonality, Table 13.

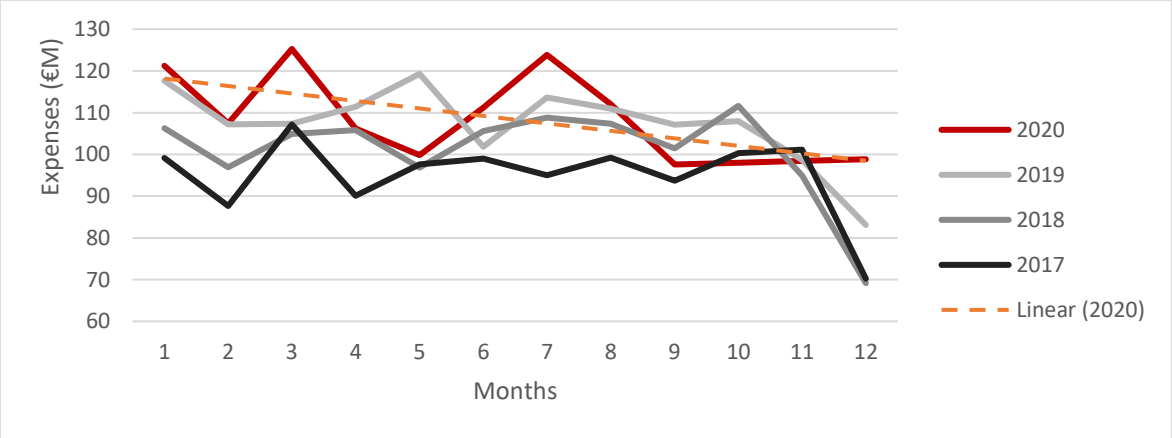

Figure 25 - Medicine Expenses in NHS Hospitals (Linear Regression) [93]

A self-feeding method was used, where the forecast for a given month would be considered in the following month. In certain months, such as October and December, linear regression showed results with lower MSE. Nevertheless, and analyzing the evolution of the curves, it is important to denote the trend and seasonality of these time series, making Holt-Winters as the most suitable method for analysis. This way, an additional cost of medicines for the last quarter of 2020 in the order of € 432M is expected, € 103M higher than 2019, Figure 27. It is also believed that the sharp drops in spending at the end of the year are related to the need for budgetary compliance with expenses already defined at the beginning of the year.

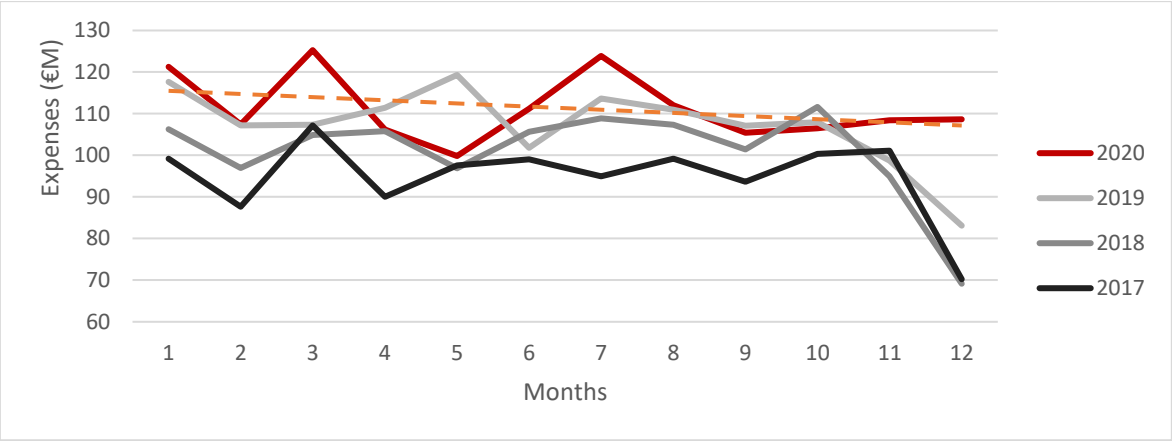

Figure 26 - Medicine Expenses in NHS Hospitals (Holt-Winters) [93]

Table 13 - Results obtained for Medicine Expenses in NHS Hospitals considering different two methods

Method	Sep 2020		Oct 2020		Nov 2020		Dec 2020	
	Forecast	MSE	Forecast	MSE	Forecast	MSE	Forecast	MSE
Simple Linear Regression	108990673	12288597	109271026	10376653,4	109192406	10303816	111371109	10233834
Exponential Smoothing with Trend and Additive Seasonality	105489547	10831800	105441421	10734797	110210993	11047949	110816570	10970268

According to the Ministry of Health Order No. 3219/2020 [94], dated March 11, 2020, health entities must follow the fastest acquisition procedures, in compliance with the "legal provisions for carrying out public expenditure" and adoption is also determined, by the Central Administration of the Health System, "of the mechanisms necessary for the respective financing" to reinforce their respective stocks by 20%. The list of softened products were mostly drugs considered necessary for the treatment and evaluation of suspected cases of infection with the new coronavirus. This action was permanently updated by the Directorate-General for Health (DGS) and Infarmed - National Authority for Medicines and Health Products. According to accessible data and official news, there was only a disruption in the supply of alcohol gel for disinfecting hands, the result of the peak demand resulting from the indications of health authorities.

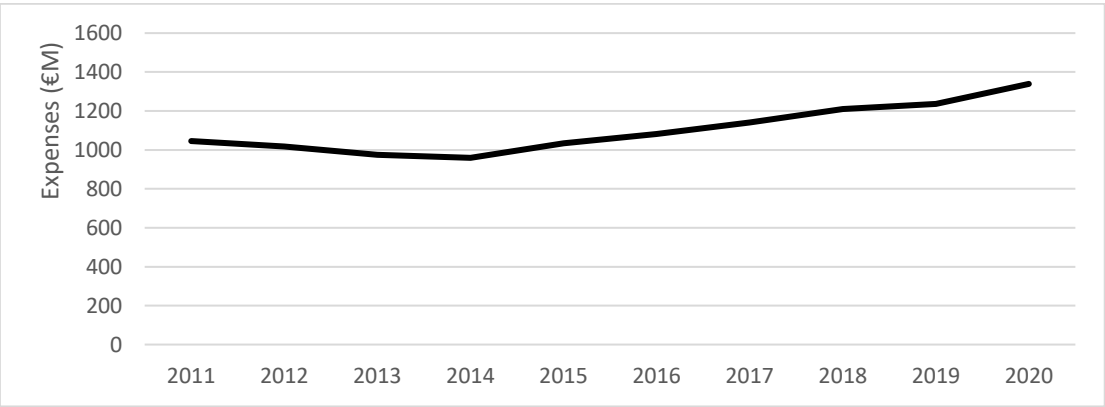

Figure 27 - Medicine Expenses in NHS Hospitals, by year, predicting medicine consumption using Holt-Winters [90]

April 2020 proved to be a month where the total number of hospital visits had a historical minimum, at least since 2013 (the graph only shows data from 2017 onwards). Also, at the local level, in the CHPVVC, historical minimums of demand were recorded. These values are explained by the confinement, where there was a general unmarking of the schedules by the providers. In a study published by the Order of Doctors and the Portuguese Association of Hospital Administrators in September 2020, it was shown that:

- 57% of Portuguese people believe that the pandemic has made access to health care difficult,
- 692 thousand Portuguese did not have a medical appointment scheduled during the pandemic,
- 210 thousand Portuguese who felt sick during the pandemic did not resort to healthcare,
- 40% of the Portuguese say that they would certainly use health care during the pandemic if necessary,
- 35% say they resorted to health care only if the situation was serious,
- more than 22% indicate that they "would probably resort" to care during the pandemic,
- About half of the population says they feel secure in accessing health care.

Those who express insecurity refer to the fear of contagion as the main justification [95].

These data were retrieved from monthly monitorization and report of the number of medical consultations in the country, by hospital, available at "NHS Transparency" [93]. First medical consultations are external consultations in which the patient is examined for the first time in a specialty service, referring to a clinical episode. Subsequent consultations are medical consultations to verify the evolution of the patient's health status, therapeutic and / or preventive prescription, using the first consultation as a reference. As seen earlier, some travel habits and access to health care have been affected by the pandemic, reducing demand for health care. The graph shows that there is a seasonality in the distribution of consultations, decreasing in summer and increasing in winter, in general. It is also possible to notice that there is a relative stability in the number of monthly consultations, around 950 thousand.

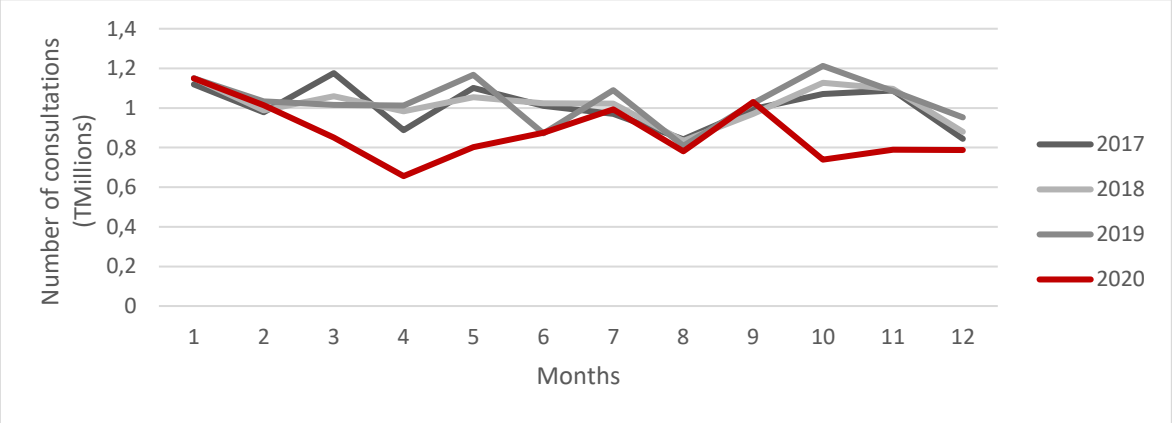

Figure 28 - Total number of consultations (first and subsequent)by year in all NHS hospitals, predicting consultations using Holt-Winters [96]

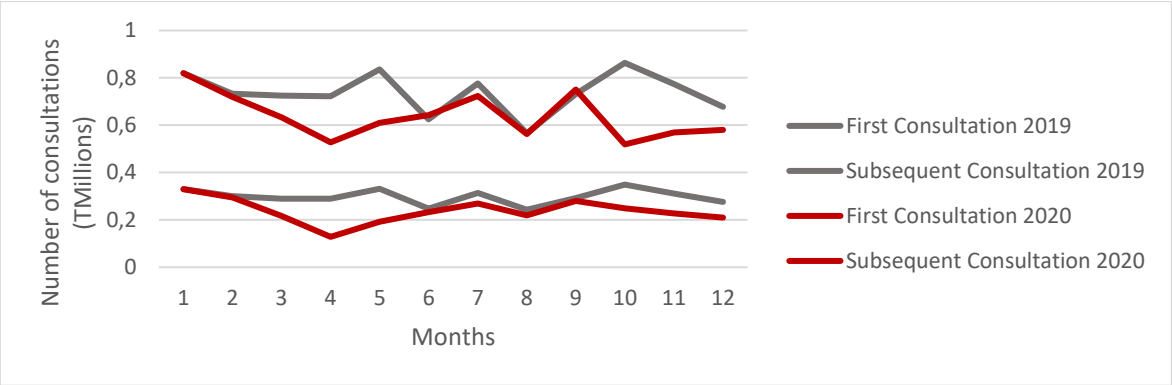

Figure 29 – Comparison of number of first and subsequent consultations, 2019-2020, in all NHS hospitals, predicting consultations using Holt-Winters [92]

Given the historical evolution of these values, with trend and seasonality, the Holt-Winters method, additive, was used to forecast consultations in the last quarter of the year. It is easy to understand the impact of reduced demand, by confinement, in the months of March, April and May, in these final months of the year. This impact totals a decrease of 1 915 499 consultations carried out in Portuguese Public Hospitals, compared to 2019.

Table 14 - Results obtained for Number of consultations in NHS Hospitals considering Holt-Winters method

Method	Oct 2020		Nov 2020		Dec 2020	
	Forecast	MSE	Forecast	MSE	Forecast	MSE
Exponential Smoothing with Trend and Additive Seasonality (first consultations)	248233	31618	227448	31926	210296	32656
Exponential Smoothing with Trend and Additive Seasonality (subsequent consultations)	518837	60448	568706	63499	580731	66156

The data obtained end up corresponding to the panorama experienced in the country, where there is difficulty in accessing all the hospital areas in need, deallocating resources from the clinical acts scheduled for the sections related to the infection. In this way, the total number of consultations provided is also affected, also considering the factors previously mentioned.

5. CONCLUSIONS

5.1. Overview

This work focused heavily on data analysis to increase productivity and efficiency. These data, obtained from the tools already existing in a hospital pharmacy, may evolve to meet the most operational needs of the service. With this, this work characterized and analyzed the medicines supply chain in a particular Health unit and develop tools that allowed adding value to it: to build a decision support tool to be used by the CHPVVC pharmacy service. That tool can, in a short and medium term, improve its efficiency and scope, reduce costs, reduce errors, and increase patient service level. The starting point was based on the literature review referring to supply chain and logistics in general and hospital in particular, the legal framework of the public health sector in Portugal with regard to purchases and finally the implementation of scientific models in the forecast of consumption and stock management. Given the current moment, an attempt was also made to extend the study to the impacts of Covid-19 on the supply chain in general and its concrete impact on hospital pharmacy consumption.

The evolution of core information system of Hospitals is in line with the guideline that aims to promote the evolution of the nuclear/structuring information systems and technologies of the NHS as a way of ensuring the evolution of the current hospital information architecture and thus ensuring the technological sustainability of the ongoing digital transformation, alignment with ICT rationalization measures, improvement of customer service and improvement of the quality of information available to the user.

In general, current hospital governance models favor better management of their assets, promoting a more efficient use of resources and providing the provision with greater responsiveness through greater autonomy of management teams in hiring resources and the acquisition of goods and services. Nevertheless, and with a view to rationalizing public expenditure and following a set of international norms and good practices, a large part of public purchases is made centrally, a fact that has more advantages than disadvantages.

5.2. Final conclusions

With the collection and analysis of data, it was perceived, in a first phase, the difficulty of effective management of forecasts and stocks due to the limitation of the tools used but also by the methods used by the pharmaceutical department. The non-monitoring of some important KPI's for this management drives the management methods already used. Highlight for the non-monitoring of stock ruptures and effective lead time by supplier.

Forecasts and stock management indicators were created for the 1346 different entries present in the system and with consumption recorded in the last five years. These indicators were analyzed individually according to the MSE, the smallest being chosen within the methods used in the forecast. Many products with forecasts based on linear regression prevailed, although there is the possibility of decreasing this value with more adjusted methods if we consider the graphical visualization of historical consumption.

In comparative terms of the results obtained with the in-house products, it was concluded that 41% of the products are above what would be the maximum stock, showing that purchases are being made with quantities greater than adequate, representing € 147.908,87 of fixed assets. Additionally, 11% of the products are below the order point, being at increased risk of breakage.

Still on the algorithm, the evaluation of the impact of the variation of service levels on the annual cost of stocks is included. Three levels were marked, 95%, 97% and 99%, with the impact on stock costs prevailing, which grow as we increase service levels. The difference between 95% and 99% is fixed at € 1607.

The change in the behavior of hospital patients led to two clear breaks in two relevant indicators, the number of hospital visits and spending on medication. These indicators show that there is less demand for scheduled hospital services, 1,9M less consultations carried out in Portuguese Public Hospitals, with consequent drug consumption. An additional cost of medicines in the order of € 432M is expected by the end of the year, € 103M higher than in previous years.

5.3. Study limitations

In terms of limitations, this study has some that can be listed. In a first point, the non-use of KPIs to monitor suppliers and stocks. The fact that the pharmaceutical services do not do this monitoring does not allow a comparison of the pre and post implementation status. The automation of the choice of the best predictive methods, being only for the smallest MSE, may not include trend or seasonal lines, being necessary human control in the visual analysis of the graphs of the historical consumption of certain products. Additionally, one disadvantage of exponential smoothing methods is that they are not outlier robust. An observation has an unbounded influence on each subsequent forecast. The selection of the smoothing parameters is also affected since these are estimated by minimizing a sum of squared forecasting errors.

5.4. Future work

With the implementation of this method, it was possible to achieve the proposed objectives, however, there are other tasks that can be done to improve more and more the service provided at the Pharmacy.

In general, there are several lines of action for the future. There are two clear lines, at the pharmacy level and at the tool level. As for the pharmacy, the future work may be very attached to the adoption of this tool as a support to the decision in the forecast of consumption and management of stocks and purchases. Creation of KPIs for this same management, and above all, a closer monitoring of suppliers and their delivery times and service level. Another line of action and looking at those that are the general functions of management, the automation of some administrative tasks using Robot Process Automation (RPA), for example. In this way, more resources could be freed up for other value-added activities.

In terms of the structure of the tool, it is proposed to work along two fundamental lines. Improvement of the algorithm so that it is more agile and quick in showing results. In a second line, the inclusion of new predictive methods or evolution of the existing ones to suit the most common

time series in pharmacy products. Also, the inclusion of artificial intelligence for automated analysis of the trend and seasonality lines of these same timelines.

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