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How to reduce clinical waste in an oral health unit - Case Study at Faculty of Dental Medicine of Lisbon University

Raquel Maria Fachadas Escalda

Master in Health Service Management

Supervisor:
PhD Teresa Grilo, Assistant professor and integrated investigator
ISCTE - Instituto Universitário de Lisboa

November, 2022

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Resumo

A toxicidade de alguns produtos utilizados na prática dentária causa graves danos ao meio ambiente. Nas unidades de saúde existem vários materiais que são comprados sem nunca serem utilizados, esses materiais causam um impacto ambiental económico que poderiam ser totalmente evitados se os materiais não fossem adquiridos. A Faculdade de Medicina Dentária da Universidade de Lisboa reconhece este problema, e tem como objetivo minimizar esse desperdício. Deste modo, desenvolveu-se um estudo de *action research*. Numa primeira fase, quantificou-se parte dos resíduos de 2021. Em seguida, foram estudadas as causas desse desperdício por meio de entrevistas semiestruturadas e foram escolhidas as três causas mais relevantes: falta de controlo de devoluções, dificuldade de previsão e carência de gestão de inventários. Para solucionar estas causas, duas soluções foram propostas. Primeiramente, foi desenvolvida uma ferramenta de reporte e controlo de devoluções para registar todas as devoluções de materiais não utilizados pelos serviços. Em segundo lugar, foi desenhada uma ferramenta de gestão de inventários, combinando análise ABC com modelos de previsão e políticas de gestão de stocks. Esta ferramenta fornece informação sobre quando e que materiais encomendar, minimizando a probabilidade de encomendar quantidades superiores e o desperdício associado. De forma a ilustrar a aplicabilidade da ferramenta, foi demonstrada a sua utilização a partir de um conjunto de materiais identificados como expirados (i.e. desperdícios) em 2021. Para este conjunto específico de materiais foram alcançadas poupanças de 100%. Para facilitar o uso diário das ferramentas na faculdade, foram desenvolvidos planos de implementação e monitorização.

Palavras-chave: Sustentabilidade, Desperdício, Materiais não utilizados, Saúde, Medicina Dentária

JEL: H4 Publicly Provided Goods, I1 Health

Abstract

The toxicity of some products used in dental practice causes severe damages to the environment. In health facilities there are several supplies that are purchased without being never used, causing an environmental and economic impact that could be totally avoided if they don't get purchased. Faculty of Dental Medicine of Lisbon University has recognized this problem, and aims at minimizing this waste. For that propose, an action research study is developed. First, part of the waste of 2021 was quantified. Then, the causes for this waste were studied through semi-structured interviews and the three most relevant causes were chosen to be solved: lack of returns control, difficulty in the forecast and lack of stock management. Two solutions were proposed: First, a report and control return tools were designed to register all the returns of materials that are not used in the services. Secondly, an inventory management tool was also designed, combining an ABC analysis with multiple forecasting models and inventory management policies. This tool provides information about when and which materials to order, minimizing the probability of ordering higher quantities, thus minimizing the related waste. In order to illustrate the applicability of the tool, its use was demonstrated using a set of materials that were identified as expired (i.e. waste) in 2021. And for this particular set of materials, savings of 100% were achieved. In order to facilitate the daily use of both tools at the faculty, implementation and monitoring plans were developed.

Key Words: Sustainability, Waste, Unused products, Health care, Dentistry
JEL Classification: H4 Publicly Provided Goods, I1 Health

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List of Acronyms and Symbols

FDMLU	Faculty of Dental Medicine of Lisbon University
LCA	Life cycle assessment
MAD	Mean absolute deviation
MAPE	Mean absolute percentage error
AR	Action research
PG	Post-graduation
LR	Linear regression
WMA	Weighted moving averages
MA	Moving averages
W	Weight
n	Period number
R	Reorder point
D	Demand
L	Lead time
SS	Safety stock
z	Safety factor
σ	Standard deviation
EOQ	Economic Order Quantity
S	Ordering cost
H	Holding cost
P	Revision period
TBO	Time between orders

1. Introduction

1.1. Context description

Health waste causes diverse forms of environmental damages like the air pollution formed during medical waste incineration. The toxicity of some pharmaceuticals, mercury and other substances are a threat to the environment. The microorganisms in the waste can infect hospital patients and resistance to drugs is also a problem for people's health (World Health Organization, 2018).

For example, in 2013 the U.S. healthcare system was responsible for significant fractions of national air pollution emissions and impacts: "*acid rain (12%), greenhouse gas emissions (10%), smog formation (10%) criteria air pollutants (9%), stratospheric ozone depletion (1%), and carcinogenic and non-carcinogenic air toxics (1–2%)*" (Eckelman & Sherman, 2016). It is clear the impact that healthcare can have in the environment.

According to various studies, dentistry also causes important environmental impacts. A common studied material for this environmental impact is the dental amalgam that contains mercury. "*Once released, mercury persists in the environment where it circulates between air, water, sediments, soil and biota in various forms*" (United Nations Environment Program, 2008). There are other materials like the lead shields contained in each film packet to radiography and unused films that have unreacted silver (Hiltz, 2007).

These environmental impacts concerns are in fact common to many organizations worldwide, and it is currently a key problem at the Faculty of Dental Medicine of Lisbon University (FDMLU). This institution has the goal to reduce their environmental impact by reducing the quantity of waste that remains in the warehouse and will have no future use. At an operational perspective "*waste occurs (1) in case of overpricing; (2) when less expensive but equally effective alternatives are not used (3) when purchased inputs are not used at all*" (OECD, 2017). It is the third point that is going to be analyzed in the master's thesis. The focus will be on the products that were not used in health care and thus have no positive contribute to health services and human life but have unnecessary negative impact in environmental and economical level.

An article with a similar concept but dealing with medication products refers to them as: "*unused medication was defined as medication that is expired, discontinued, deteriorated and/or not intended for any future use*" (Law, et al., 2014) . The same idea is going to be used here but for all the faculty products and not only medication.

In FDMLU, as in other health facilities, some products are purchased but will never be used. Some of these products have never left the warehouse and they are expired/ not used by the professionals, other products are delivered to the services but they are returned for the reasons expressed above. All of these products bring no contribution for the healthcare services since they are not used, and so they have economic and environmental costs that could be prevented.

Organization for Economic Co-operation and Development made a paper about wasteful spending on health, where it describes different forms of waste (materials and procedures) that lead to expenses that could be avoided. For example, preventable medical mistakes (10% of hospital expenditures), fraud and error (6% of health expenditure), showing that changing professionals behavior, changing payment incentives and improving procurement systems is crucial to minimize the waste (OECD, 2017).

"*The health care sector is a large contributor to financial waste, environmental waste and climate change*" (Tauber, et al., 2019). Not only environmental impact is relevant - the economic impact is also a critical concern nowadays. Since FDMLU is a public faculty, belonging to University of Lisbon, it has financial support from the state (with the funds that are given through the state budget). Besides this economic support from the state, FDMLU also has their one receipts, the most relevant comes from the university students' bribes, health services provision and rental of spaces. However a lot of expenses are also made, mainly remuneration and acquisition of goods and services, with about 16,5% of their own receipts being spent on acquisition of goods in 2018 (Universidade de Lisboa, 2017).

Since the budget is limited it is necessary to allocate the resources in the best possible way. By reducing the products that are never going to be used again it is possible to release budget and use it in products, services or other necessary costs that are really needed or just save the budget if no more products are needed.

1.2. Goal of the research

Given the context above, it is important for FDMLU to reduce the waste that can be avoided. The goal of this study is to propose solutions to reduce the unused products. In this way it will be possible to create a more sustainable practice of dentistry services and reduce the costs of supplying materials.

"*Cutting ineffective spending and waste will produce significant savings. For policy makers struggling to cope with ever-growing health care expenditure, all opportunities to move towards a more value-based health care system must be pursued*" (OECD, 2017). This topic is clearly relevant since reducing the unused products could reduce the negative impact of FDMLU products at environmental and economic level, these are products that have not contributed to anything in the health service or learning provision so they should never have been purchased.

1.3. Research question

In order to achieve the objective that was discussed before, there is a research question that must be answered:

How can FDMLU reduce or eliminate the waste associated with unused products that remain in the warehouse and have no future use?

This main objective of the study can be subdivided into different sub-questions that are important to analyze.

First, analyze what has already been studied by others

"How do other healthcare facilities promote the reduction of their unused products?"

To know the As-Is of FDMLU, the sub-questions are:

"How much unused products exist in FDMLU?"

"What are the causes for never having used those products?"

"What economic impact has that waste in the FDMLU?"

"What environmental impact is created by these products?"

Then it is important to establish a plan to solve the problem (To-be)

"Which strategies can we follow to reduce this waste?"

After the construction of the solution(s), the following questions must be answered:

"The solution(s) is/are in the most effective way to implement?"

"How can the solution(s) be implemented?"

"In what way the proposed strategies to eliminate this waste allow to achieve reduction in economic and environmental impact?"

1.4. Structure of the document

In order to reach the goal, the master thesis will follow the next steps:

First, a literature review will find the results and important concepts that were already studied about sustainability and reduction of waste, particularly in the health field. This will provide knowledge and concepts sustentation to the next parts.

Methodology will provide understanding about how all the work is going to advance, what is the methodology chosen and what are the tools, data collection and analysis that are used in order to reach the goal of the study.

Then, the information presentation and analysis will gather all the available data, understanding if the problem is valid and developing ways to eliminate or reduce the unused products that create waste at FDMLU.

The implementation will explain all the steps to implement the solutions that were proposed previously.

Conclusions will provide a view of the results obtained and provide guides to future research and improvement points.

2. Literature Review

The topic of sustainability is discussed in this section, along with some of the main issues surrounding it, such as the 3R rule or the three pillars of sustainability. Gathered information in prior studies about healthcare sustainability will be analyzed in order to acknowledge the topic in the health field. In this topic it will be possible to see various solutions created to specific problems and contexts, and a general topic remains to appear: the supply chain, with the procurement, forecasts and stock management being widely referred. After this, it is acknowledged the main concepts and examples of practice in other health facilities about forecasting and stock management.

2.1. Sustainability

According to the 3R (Reduce, Reuse and Recycle) to stop using single-use instruments and start using reusable ones would be important to minimize the harm caused to the environment (Duane, Stancliffe, et al., 2020). The possibility to reuse pharmaceuticals was tested in the USA for people who have no way to pay for them but there are safety and quality issues like the possible incorrect packaging, contamination, being unsealed or being counterfeit medicine (Abdullah Alshemari, 2020).

A particular study about the unnecessary waste focus on the 3R's rule mentions that reusing is a complicated issue because this practice is not recommended in order to reduce cross infections. This study supports that it is possible to reduce the carbon emission and at the same time increase profitability, that is, by reducing the unnecessary waste and adopting the best ways to recycle, we can reduce the negative environmental impact that dentistry services have while having a positive impact in the health service economy (Richardson, et al., 2016). Another R was added for rethinking – for example stop using disposable material and start using reusable one (Martin, et al., 2021). By reducing the unused products it will be possible to have an environmental and economic safety that is totally secure and does not have negative effects on the service delivery.

Sustainability can be divided in three main pillars: economic, environmental and wersdfersocial. The environmental impact can be approached in a variety of ways, the most scientifically trusted is the LCA (Life Cycle Assessment). This is a technique to evaluate how products and services can affect the environment, considering all the life cycle of the product or service. The economic impact must consider an efficient use of resources that lead to a profit to the organization, promoting economic expansion while minimizing the detrimental effects. Social pillar measures the social impacts that an organization has in the environment in which it operates. These impacts can be studied in separate but it is important to have in mind their balance (Mota, et al., 2015; Hansmanna, et al., 2012).

2.2. Sustainability in the health field

2.2.1. Quantification and causes

Since the focus of this study is the reduction of unused products, finding which main articles went unused and the causes for that is an important issue. A study has evaluated the unused medication at in-patient departments and their characteristics. First, interviews with heads of the wards were made, then the pharmacy stores and their warehouse were studied with interviews to the warehouse store operational and direct observation on the warehouse conditions. Key results showed that anti-infective medication were the most frequently unused. Only half of the hospitals had the desirable storage conditions and two common problems reported in the interviews were that the items arrived near the expiration date and the fact that nurses sometimes asked for more medication than needed (Ebrahim, et al., 2019).

Two techniques that offered the chance to learn what are the primary driving forces behind the production of waste at the facilities studied were interviews and direct observation. This is an important basis to do a previous solution planning.

2.2.2. Economic impact

Several health facilities have encountered the problem of products that went partially unused and took different strategies to minimize this. In an anesthesia department at a hospital, the amount of waste of anesthetic products used in surgeries was quantified during a 12-month period, with computerized anesthesia record determining the quantity administered. In this way, it was possible to perceive the amount of each product that should have been administered to the patient. A proposed solution was to use prefilled syringes for the commonly anesthetics, an annual saving of $185,250 was estimated (current market prices) (Atcheson, et al., 2016).

Other examples have a similar goal to minimize the waste with different methods to achieve it, since this depends on the products and facility in study. At Tampa General Hospital, in the USA, the problem found was that large amounts of medications for cardiovascular surgeries went unused because when left at room temperature they would only last 30 hours, if they were refrigerated they could last up to 9 days. The problem was that the refrigerator was in another building floor, so the solution was to relocate pre-existing refrigerators into the Operation Room. This allowed the hospital to save US$1188.59 per week (calculation based on the purchasing cost) and the average number of surgeries per week increased from 93.8 to 96.0 (Dawn K. Tsang & Camporesi, 2019).

Another study evaluated the wastage of anesthetic drugs in the operation room of a hospital, results showed that some types of drugs went regularly unused (with values of 100% and 93,6% of waste in adrenaline and lignocaine) and other types had a significant cost to the hospital that could be preventable. The total waste cost was of Rs.16. 044,01 (estimated through the maximum retail price of the drug according to market study), representing 46,57% of the total cost. Some strategies like not preparing anticipatedly the anesthetics that could not be needed, decreasing the quantity in the prepared syringes or adjusting that quantity to the body structure of the patient were provided in this paper (Chaudhary, et al., 2012).

A study about clean and unused medical supplies has presented the topic of surgical supply donations at a national level in the United States. The estimate was based in a system of donations of unused material of Johns Hopkins Hospital distributed to two Ecuador hospitals. A three year study with database describing the goods and their weight, along with price estimates allowed to acknowledge that 11,765 kg of waste were donated resulting in savings of $1,297, with the main contributors being the gauzes, needless disposable syringes, sutures and surgical towels. According to the estimation, if all the non-rural US academic medical centers involved themselves in a donation system, US$15.4 million would be possible to save (Wan, et al., 2015)

2.2.3. Environmental impact

Disposable materials are a big contributor to health care waste; a study used Life Cycle Analysis (LCA) to examine 15 packs of disposable material from various hospitals. LCA analyzed all the phases of the product life: raw material extraction, production, use, transportation and end-of-life. The results of the life cycle assessment reveal that cotton accounted for the greatest proportion of environmental damages across all categories – with 17,5kg CO_2. A new green custom pack was created, substituting the elements that caused more environmental impact (NicoleCampiona, et al., 2015).

A study conducted through a 24h audit on an emergency department has quantified all the waste (used and unused). Then, the pollutant emissions were calculated with a tool named M+ Waste Care Calculator, this tool gives the consequences to the waste, according to the state (only in the United States) the type of waste (Municipal Solid Waste, Regulated Medical Waste and Recycling), quantity and disposal method. Results quantified 671.785 kg of waste, in different types of waste, corresponding to 3110 kg CO_2 of waste disposal (Hsu, et al., 2020).

An article about food waste in a Portuguese hospital quantifies the amount of plate waste that comes from the patients meals through an audit by weighting the food that arrived from each department. On average, each patient throws away 953 g of food each day, 35% of the food served. The economic impact estimated to be around 1.5 million euros per year. A hospitalized patient generates food waste that costs 3.9 euros and is responsible for the emission of 1.8 kg of CO_2 (Dias-Ferreira, et al, 2015).

2.2.4. Ways to improve sustainability

It is possible to achieve sustainability in health facilities using different methods. A review of literature has indicated some recommendations to make dentistry more sustainable: awareness through education, reduce travelling, reducing waste and having engagement with the key stakeholders across the supply chain (Martin, et al., 2021).

An article studied the best ways to reduce expired pharmaceuticals in health facilities in low-income countries, where donations are accepted and remain unused and turn expired. This article focused on the importance of making reliable forecasts and computerize inventory management in order to predict the future needs avoiding accepting too much quantities of material (Kamba, et al., 2017).

Some practices in supply chain management are proposed to improve the sustainability in hospitals in a systematic review. The warehousing and inventory management represent about one-fifth part of the healthcare revenue, the best practices in this field are decisions being made based on information systems, determining the quantity to order and reorder points. It is a good practice to group the purchases and centralize the orders, minimizing the transportation impact. Suppliers are also mentioned in this paper, a long-term and secure relationship can give to both parts a lot of security (Duque-Uribe, et al., 2019).

All parts of the supply chain can contribute to a sustainable use of products. For example, in medication, manufacturers should be careful with storage conditions, adjust the package sizes and extend the expiration date. Distributors need to have a strong stock management with logistic systems that can calculate optimal stock volumes, also inventory control methods like first-in-first-out should be used. Prescribers also have a role on this, they must control the quantities that are prescribed to the necessary and not in excess. Pharmacists should, like the distributors, have an effective stock management, chose medications that are packaged in smaller doses to have a more efficient dispensing, and if possible, redispose the unused medication. Lastly, patients need to be conscious of the medication ordering and disposal methods (Smale, et al., 2021).

The supply chain importance to achieve this sustainability is a significant theme, the carbon footprint caused by the procurement in dentistry is around 19%, having a strong stock management, choosing the right products and recycling and packaging are again considered crucial topics to this issue (Duane, et al., 2019).

With the evidences shown above, it is possible to see that only a few papers were found about totally unused products in healthcare services, instead they focused on situations where products were only partially used. Also, a lot of studies about hospitals and clinicals were found, although there is a lack of studies about the dental field specifically. Nevertheless, existing studies, show that there is a major concern in the waste elimination and sustainability theme in the supply chain, with the inventory management being named several times as an important tool for improvement and the same applies to the process of building accurate forecasts. It thus reveals that it is important to study these topics more deeply in order to make progress in sustainability.

2.3. Forecasts

Health care managers need to order materials that will be used in the future service delivery, in order to have a realistic prevision of what will be needed.

There are several steps to make a good forecast The first step is to identify the goal of the forecast (see the amount of resources available and necessary level of accuracy). Then a time horizon must be placed (long time horizons tend to have less accuracy than a shorter period). A forecast technique is chosen, depending on several external factors and the type of the material. To properly conduct the forecast, it is important to use the appropriate data and make the right assumptions with the best forecast model. Lastly, it is necessary to monitor the accuracy of the forecast, where changes like the forecast technique or data can be necessary (Carvalho & Ramos, 2019).

There are two main types of forecasts: The judgemental forecasts use subjective inputs like "*executive opinions, contracts, insurance (...)*" and the non-judgemental forecasts that use objective data – also called time-series (Carvalho & Ramos, 2019). These approaches are represented in Annex A.

In order to control the forecast, it is important to measure the forecast error, this error is going to be used to validate the data set and select the appropriate method, assuring the efficacy of it (Fildes & Petropoulos, 2015). The main values to calculate are the actual demand, the forecasted demand, the mean absolute deviation (MAD), and the mean absolute percent error (MAPE) (Carvalho & Ramos, 2019).

The forecast method can be applied to all data series without consideration of specific characteristics, or it can be selected individually. The individual selection results in a better forecast rather than an aggregate selection because what can work for a time series may not work for the other, however if the data is very homogenous it can compensate to use the individual method (Fildes & Petropoulos, 2015).

A paper in University Health Centre studied what the best forecast methods would be for a specific material in 68 months of experiment. The best methods were calculated through the lower error, results showed that the three best methods were linear regression, double moving average and single moving average (Bon & Ng, 2016).

A study of the best forecasting methods for a hospital section – warehouse nutrition installation (food supply) – was taken because this sector had a lot of financial loss with expired products. This paper shows the importance to use time-series forecasting demand to products that have high volumes and high costs. Some services benefited of the moving average method and others of the simple exponential smoothing; this was analysed by the methods that had less error. The result shows that inventory value savings for service were between 90% and 23% (Setyaningsih & Mursyid, 2013).

2.4. Inventory Management

In order to make accurate inventory management it is important that an ABC analysis is made; it allows to classify the articles of a company in three types: A, B and C that goes from the most relevant to the least relevant. Pareto Law serves as a basis for the ABC analysis – about 20% of the materials correspond to 80% of the consume volume (A); about 30% of the materials represent 15% of the consume value (B) and 50% of the materials constitute 5% of the consume value (C) (Carvalho & Ramos, 2019).

In a hospital logistics system was used a multi-criteria inventory classification method. This means that several variants are used to determine the analysis. The study considers the usage value of an item's cost and critically. The results showed the importance of this analysis to optimize the inventory cost and that the critically of the items will impact the decisions that are going to be made (Al-Qatawneh, 2011).

The ABC approach in terms of costs can be completed by another analysis – the VED analysis – that seeks to find the criticality of the items (V means the vital items, E are the essential items and D the desirable items (Ahmadi, et al., 2018).

Warehouse and clinical stock is essential to a good provisioning of health services, having materials in stock allows to reduce the ordering costs (once it is not needed to be constantly making orders), the ordering of aggregated quantities and materials is usually accompanied with quantity discounts. Stock also allows to meet the variations in supply and demand – supply and demand are not constant, and it is impossible to forecast them with 100% certainty so having stock that enable to prevent stock outs is important so that the service continues to be provided (Carvalho & Ramos, 2019).

There are two main types of stock management models: the continuous revision model and the periodic revision model.

In the periodic revision model, the day of the ordering is previously established, there is a periodicity between the orders. In the day of the colocation of the order, the actual stock is compared to the target stock and the difference is ordered. On the other hand there is the continuous revision model, where the order is placed once the stock level reaches the ordering point, and the quantity that is needed to reach the optimum quantity point is ordered (Carvalho & Ramos, 2019).

A literature review about inventory management control of sterilized and surgical supplies has acknowledge that stochastic models like the two presented before should be followed since it takes into account several risks (like the uncertainty of demand and supply). It also enhances the importance of having available data to develop these control and implement the methodologies (Ahmadi, et al., 2018).

In healthcare the supply and demand are usually random – they are not known before happening. This is going to increase the complexity of the stock management, and it turns necessary to constitute a safety stock. How much to order and when to order have different forms to calculate in continuous or periodic revision (Carvalho & Ramos, 2019).

There are other aspects that must be considered when making stock management like quantity discounts, that is going to modify the costs and possibly the decision to make; aggregate ordering where one supplier provides various materials – here a periodic reviewand stock centralization can be beneficial – that is advantageous because the safety stock decreases and the consume forecast is easier to do (Carvalho & Ramos, 2019).

All of this calculus must consider some trade-offs like a less frequent order can benefit the ordering cost and time spent in the order making, however the warehouse has limited space. In an article that constructed a tool and calculated the optimal allocation based on ordering and holding costs and a tool to support the decision-making in inventory control procedures, could reduce inventory that was not needed representing 70-80% expenditures (Kelle, et al., 2012).

In some articles it is reported that a badly controlled stock management can cause shortage of some articles in stock and excessive amounts of stock in the other hand. Since we are talking about medical articles, most of them have an expiration date so the excessive stock will consequently generate waste once the products get expired or are not able to consumption.

This was studied by an article that seeks to find the main causes of the health care services having poor management control through semi-structured interviews with managers of 39 healthcare facilities in Nairobi. The results showed that the biggest causes are resource limitation (budget and time/ human resources), the skills and systems and market. 95% of the facilities are familiar with the term reorder point however they do not apply it to their work, no calculations or data are used to control the stock, only the experience of the professionals. Only 10% used the historic data to make decisions about acquisitions. About 60% had something to track the inventory but 90% the facilities did not use it. It is also clear that the professionals don't consider relevant factors like lead time, ordering or holding costs when making the decisions. Another big cause was the lack of human resources, since it is difficult for just one professional to take care of the stock management for bigger facilities, professionals are overwhelmed with the quantity of work. The budget limitation is also referred in all the interviews. In the market part, the relation with the suppliers was the main theme, the stock-out of the main suppliers were mentioned by 97% of the facilities. All of these problems, cause a mismatch between demand and supply, that provoke stock rupture of some items and excessive stocks of others (Karamshetty, et al., 2021).

A literature review about logistics management in hospitals provides a wide view about this topic. Most of the articles studied used the periodic review; however, in cases of costly stock-outs the continuous review is also used. Some research argue that the periodic review in healthcare is difficult to follow because the uncertainty in demand is very large. There are some challenges when putting the established inventory parameters into practice – frequently, instead of reflecting the measured inventory levels, inventory par levels represent the intended inventory levels of doctors and nurses, it also appears to be typical for care units to retain "hidden" safety stock in several locations (Volland, et al., 2016).

2.5. Conclusions

Sustainability is becoming a more relevant issue, changes in human behaviour is a crucial measure, in all sectors. In the health field, there are several forms to decrease the produced waste. Reduce the amount of unused products seems to be the way of waste decrease that, having a high impact in the reduction of environmental waste and economic waste, also has no negative impact in the quality of the health services that are provided.

Various studies have measured the economic and environmental impact of their waste (usually used or partially used waste, with lack of studies focusing only in unused products). The economic impact was measured through the price in every cases (maximum, average market price or the direct purchase value), no study has calculated holding cost or ordering cost. The environmental impact can be measured through calculators, LCA or estimates using other studies results.

Each facility has their own processes, resources, mission and vision. All of this makes each case unique, the causes for the waste are going to be different in each case and therefore the most appropriate solutions are going to be divergent. Despite this, there are general topics common to all facilities that are usually responsible for the large parts of economic and environmental waste – for example, the supply chain.

Changes in each part of the supply chain can contribute to big saves. To make a reliable stock management it is important to have some basis. The forecast allows the facility to have a sight of what are going to be the future needs. To make a good forecast it is important to analyse carefully the nature and behaviour of each material consumption in order to make the best possible decisions in terms of time-horizon, methods, etc. It is also crucial to understand the importance of the goods through an ABC analysis and criticality for example through VED analysis. An A article needs to have a higher service level and a higher safety stock, this means that a continuous revision should be made. A C article can have a lower safety stock and service level, and it can be a beneficiary of a periodic revision.

With all of these bases, it is possible to make a good stock management, by calculating safety stock, reorder point, holding and ordering costs, etc. After all, in conjunction with ABC analysis and other factor it will be possible to understand which products beneficiate of a periodic review or continuous review, as well as knowing when and how much to order. Not only this will reduce the stock waste that is created by materials that are not going to be used, but it also prevents from stock-outs.

The importance of control and evaluation of all parts of the processes is highlighted several times. In order to maintain this stock management useful we must understand some topics like what is the error of the calculation.

The health studies found do not usually do a complete identification of all the topics that are going to be approached: the causes, impacts and solutions, as they normally focus only in one of these parts or approach the other parts in a very superficial way. In this case study the goal is to understand the causes and impacts that unused products have in FDMLU so that useful solutions are taken and possibly implemented.

3. Methodology

This thesis is going to follow the methodology Action Research (AR) - "A*R is an approach to research that aims both at taking action and creating knowledge or theory about that action*". This methodology is participative and uses a sequence of events and leads to problem solving, it's about changing (Coughlan & Coughlan, 2002). With this study it should be possible to solve the problem of FDMLU having unused products, studying the problem, causes and solutions for it.

AR is composed by the following phases, summarized in Figure 3.1. (Coughlan & Coughlan, 2002).

1. Diagnosis – data is collected and analysed in order to find what the problem is and discover the causes that lead to this problem.
2. Action Planning – defines what needs to be corrected an how, taking into account the resources that already exist, it is important to have a systematic intervention with well-defined steps.
3. Implementation – where the actions are carried out with the plans made above.
4. Evaluation – to assess the results of the actions taken, identify the benefits and what needs to be redesigned to have better results.
5. (Meta-step) Monitoring – the improvements must be controlled to keep the progress going.

(Martins, et al., 2020)

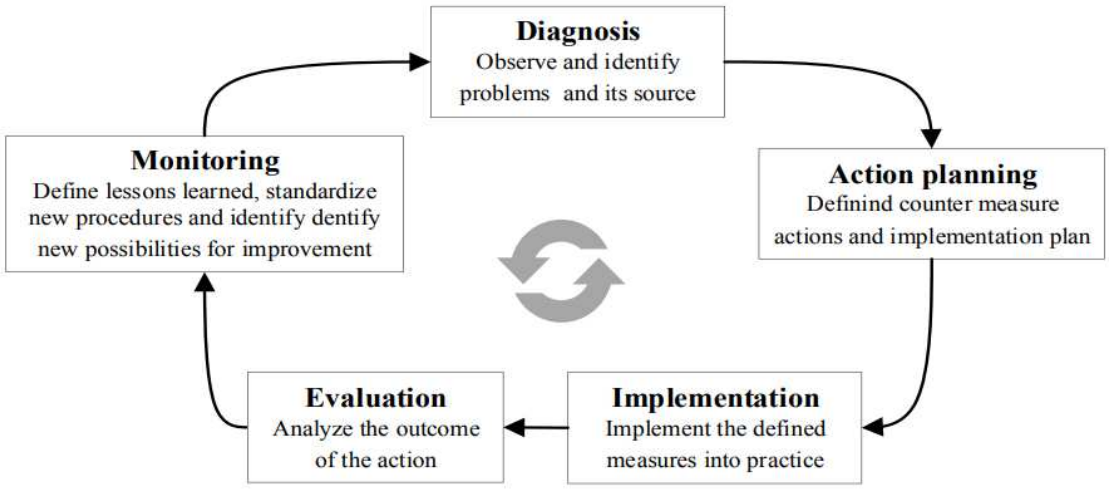


Figure 3.1 - Action research steps - (Coughlan & Coughlan, 2002)

The previous steps will be followed through the scheme represented below

Table 3.1 - Methodology steps

Phase	**Research stage**	**Data collection and analysis tools**
Diagnosis	Waste quantification	FDMLU documents Scientific articles Economic KPIs Environmental KPIs
	Causes gathering and analysis	Semi-structured interviews Direct observation FDMLU documents Scientific articles Fish-bone diagram
Action planning	Solutions planning	Semi-structured interviews
Implementation	Implementation planning	
Evaluation	Expected decrease of waste quantification	Environmental and economic KPIs
Monitoring	Monitor the implementation	Environmental and economic KPIs

Diagnosis

Problem identification

The problem was early identified – the waste created in FDMLU services. The awareness of this problem and the urge to create more sustainable and efficient processes leads to all of this investigation. With the papers studied in the literature review, it was possible to understand that a big part of the analysis made in other health facilities are the economic, followed by the environmental. Social impacts were not studied in any paper found. Considering this, an economic and environmental approach is going to be made with the obtained data. To understand the basis of all the processes it is important to read the Manual of Provisioning Procedures. This will provide a theoretical understanding of how the processes are supposed to happen.

To understand the quantities of expired material, the Physical Inventory 2021 is going to be consulted. Other documents will be used to collect data:

- *Control 2019, Control 2020, Control 2021* and *Control 2022* in Excel (containing entries and outs of each material, with the current stock);

- *Export (SAP output)* in Excel (this document gives information about the previous items purchase by FDMLU, including prices, quantities, suppliers);
- *Requisition Excel*
- *SAP Using Manual*

Scientific papers are also going to be consulted in order to understand how can the economic and environmental impact be analysed.

Causes analysis

Some interviews are being conducted to understand five big parts – the requestors (clinicals that make the requisitions of material to provisioning), the provisioning service (that is responsible for the acquisition of all the goods and their management), the warehouse operational (that has physical contact with the materials and communications with the clinics) and the clinical direction (responsible for all the clinic's work).

The interviews will use multiple informants with different roles so the information provided by one of them can be checked by the others, securing a good range of perspectives. By using a low degree of structure it is possible to leave openness to the interviewee (Meyer, 2001). An audio record will serve to facilitate the data collection and analysis.

All of these methods will contribute to a deep understanding of the problem and causes. With this, it will be possible to use a tool that graphically represents this – a fish and bone diagram. According to Testik, this tool is "*one of the major process improvement tools of statistical process control for solution-unknown problems*", used to identify the key factors that affect a determined problem through a graphical representation of a fishbone that identifies its possible causes (Testik, et al., 2017) (Testik, Shaygan, Dasdemir, & Soydan, 2017).

After the results of the causes are concluded, they will be shown to the executive director, clinical director and provisioning professional, since they are the main responsible for the processes. They will be asked to analyse the fish causes diagram and choose the three main problems to be solved and if the causes show the truth of the problems with reliability. The main processes involved in these causes are also going to be studied and schemed.

Direct observation will be used to understand all the processes related to the causes collected. It is possible to have a structured view of the function of the services with direct observation in every day work. Direct observation is unobtrusive and does not require direct interaction with participants, when combined with other methods it can illuminate the discrepancies of what participants said and what happens in reality when it is possible to maintain superficial contact with the participants (Meyer, 2001).

Action planning

In this phase, the solutions to the problems established before are going to be created, depending on the problems and data analysed before. The planning of the action must define what is going to be done and how.

Implementation

It will not be possible to implement the solutions, however a plan for this implementation is going to be drawn, using a timeline with the different phases of the solution, so that all the intervenient can be aware of the changes that would happen. It is important that everyone understands the importance and objective of the solution.

Evaluation

Since the implementation is not possible to achieve, only the expected impact is going to be evaluated. Previous purchase of materials that generated waste will be compared to an analysis made for that time. With the real consumption it will be possible to achieve the waste that was going to be created. Other important evaluations that appear as the work is made can be used.

Monitoring

Monitoring is achieved by the continuous evaluation of the solutions and the final results, in this way it will be possible to understand if the solutions were effective and implement the necessary changes.

4. Case Study

In this section, FDMLU most relevant topics about waste are going to be studied starting with a brief introduction of the faculty. Next, the diagnosis with the goal to understand the As-is of FDMLU is presented: quantification of the waste, calculation of economic and environmental impact of waste and evaluation of the causes for the waste. After that, the action planning will be developed where two solutions will be proposed: a return control tool and an inventory management tool. At the same time, a restructuring of the codes is also proposed in order to have better data and provide a more reliable analysis.

4.1. FDMLU presentation

FDMLU was the first Portuguese faculty to carry out the teaching of Dental Medicine in Portugal (Faculdade de Medicina Dentária da Universidade de Lisboa, 2022). This faculty has several courses in the clinics, laboratories and theory classes, it also has scientific research in the area of oral health. There are other departments such as: administrative, central management services and technical support units (Diário da República, 2013). Two warehouses intend to aggregate the necessary materials for the functioning of the FDMLU, one of the warehouses is next to the clinic 1 and the other on floor -1.

Clinics are divided according to the teaching areas of the faculty:

Clinic 2 – Post graduation (PG) in Periodontics, PG in Prosthodontics, PG in Endodontic, PG in Orthodontics, PG in Paediatric Dentistry, PG in Integrated Dental Clinic;

Clinic 1- Integrated master's Degree in Dentistry, Bachelor's and Master's Degree in Oral Hygiene;

Clinic 0 - PG of Implantology, PG of Oral Surgery, PG Oral Hygiene for People with Special Needs.

4.2. Diagnosis

In the diagnosis it will be identified and quantified the waste of unused products and their impact at an economic and environmental level. The causes to the existence of this waste will be collected through semi-structured interviews and the processes related to the causes will be studied.

4.2.1. Waste quantification

In the first section of this study, it was possible to understand that healthcare system is accountable for many pollution emissions. The first step to reach a deep understanding of the waste created by FDMLU is to do a quantification of the waste with the available data.

FDMLU has some documents used by the provisioning service that are useful to understand the processes and do this quantification. There is a list of 2002 items that are used by the different services of FDMLU. Every year, the physical inventory is counted and the warehouse operational registers: physical quantities of each product; quantities of the products that are going to be discarded due to expiration; information about what codes were not used anymore.

The analysis to the information of the physical inventory allowed to conclude that 58,49% of the codes were not used[1] as shown in Figure 4.1. Through direct observation and reports of previous purchases, it was possible to understand that there were also some materials that were used recurrently that didn't have a code, this shows a necessity of restructuring the codes. With the physical inventory and direct observation, it was possible to identify three main types of waste: the materials that are stuck in the warehouse with no future use; damaged materials and expired material.

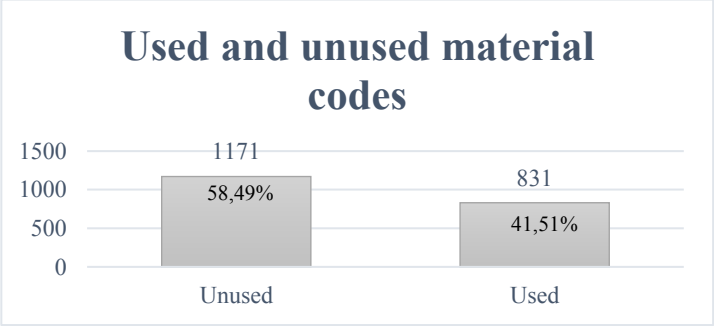


Figure 4.1 - Accounting of used and unused material codes

Materials with no future use: Materials that are in the warehouse with no future use were quantified, the most part being steel instruments, drills, disks and matrices supplies that are no longer consumed or are discontinued. The economic and environmental impact of these supplies was not possible to calculate since the largest part of them are discontinued and there is no sufficient information about them.

[1] Achieved through the analysis of the codes registered as not used in the physical inventory and the quantity of materials that were not consumed in the last four years

Damaged and expired materials: For these materials, an economic and environmental impact was assessed[2]. Damaged materials (Annex B) are not reported so only two situations were identified and counted through direct observation. These gave a total economic impact of 156.90€ and an environmental impact of 102.47kgCO_2. Expired materials (Annex C) were responsible for 4,869.92€ and 257.46kgCO_2, which represents about 4,82% of what was yearly purchased by FDMLU in average in the last 4 years. These wastes are, as mentioned before, lower than the reality because several situations and factors could not be considered since there was not enough data. Other environmental factors like raw material extraction and transportation were not calculated because no reliable data for these materials was found.

4.2.2. Causes gathering and analysis

Given the entire context and the goal of FDMLU to eliminate the waste, it is clear the importance of recognizing the causes for these products to go unused. This will be achieved through semi-structured interviews. Interviews are going to be conducted to clinical directors (responsible for all the clinic operations); clinic requestors (professionals who request the supplies needed for the clinic services); provisioning professional (who makes the orders and is in contact with the suppliers) and warehouse operational (who is in physical contact with all the entries and outs of the material). These interviews were audio recorded to facilitate the interview flow and posterior analysis and followed a guideline represented in Annex D, however other important questions were added during the interview.

The interviews to the multiple professionals were transcripted and six main problems in what concerns the causes for clinical waste were achieved, represented in the fish-bone diagram in Figure 4.2. and summarized below. Direct observation helped to confirm and complete these causes.

[2] The economic impact was calculated through the last purchase price or a market analysis for the materials that were not registered in the purchase data base. The holding cost represents about 25% of the product value (Jones, 2020). The ordering cost was calculated through and estimation of previous orders of 0,0039€ for each euro of order. The environmental impact was calculated with information from scientific articles in healthcare supplies for the production of the material – plastic items 3254kgCO_2/ton; steel items 2708kgCO_2/ton and glass 895kgCO_2/ton (MacNeill, Lillywhite, & Brown, 2017) and the disposal – 3110kgCO_2 per 672kg (Hsu, Cassandra, Michael, & Jonathan, 2020).

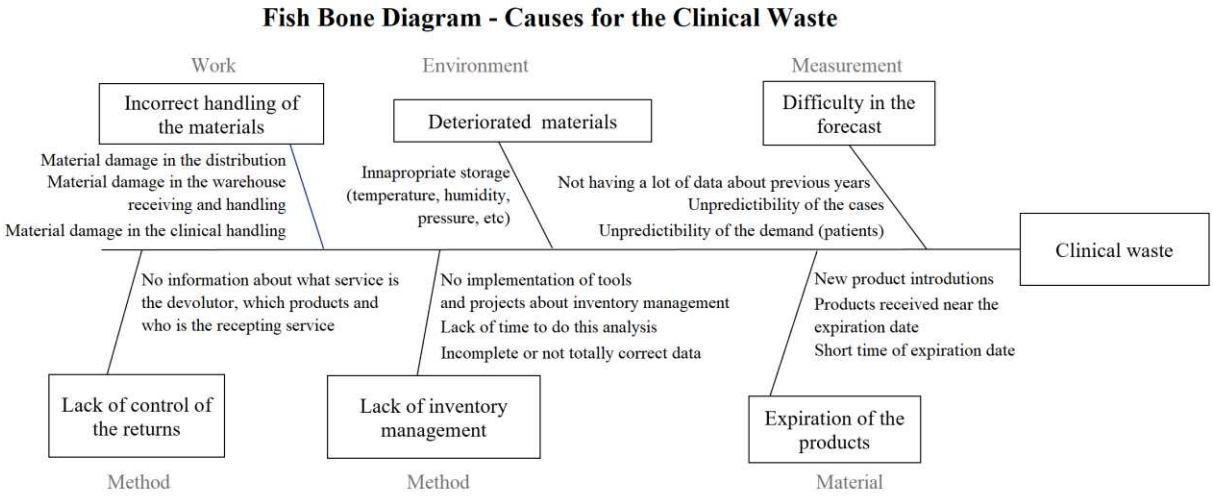


Figure 4.2 - Fish-bone diagram of causes for the clinical waste

- **Incorrect handling of the materials**: Sometimes the supplies arrive in the warehouse with defects that cannot be immediately detected, damage in handling the materials by warehouse operational or clinical professionals are also possible causes for clinical waste.
- **Deteriorated materials**: The storage conditions of some materials are crucial to their right conservation. Inappropriate storage conditions can lead to a fast material deterioration.
- **Difficulty in the forecast**: Forecast of future demand are a huge challenge. The health field has a lot of unpredictability in the demand of number of patients (it is not known how many patients are going to enter in the next period of time) and cases (it is also impossible to know previously what are the conditions and needs of each patient). Also FDMLU having limited quantity and quality of data can increase the difficulty to do these forecasts.
- **Lack of control of the returns**: Clinics return several supplies that are expired or damaged and have no future use. These materials and quantities are not controlled, it is not known who returned what and how much. Without this control it is more difficult to create the appropriate measures to solute the waste problem.
- **Lack of inventory management**: Inventory management is scarcely used, there are no specific tools for it – the requisitions, professionals experience and previous purchases are the basis to do the orders. There is a lack of time and human resources to do a complete stock management of every supplies and no automated tool is used. Also the fact that data, for example the material codes, are not very reliable, difficults the implementation of inventory management.

- **Expiration of the products**: Expired products are a cause of clinical waste due to excessive puchase (that also comes from the difficulty in the forecast), new product introduction (clinics start to use the new products and the previous are not used anymore), products being received near the expiration date (warehouse operational confirms if materials have a minimum of 1 year expiration date period but sometimes the product is not possible to return or has a short expiration period).

In order to understand what are the most relevant problems to approach in this topic, clinical directors, executive director and provisioning professional, were asked to choose the main causes that they considered that needed to be solved. Three of the causes were evenly chosen: *Lack of returns control; Difficulty in the forecast; Lack of inventory management*. These showed to be the causes that urge to be solved in order to reduce the clinical waste at FDMLU. These causes are aligned with the information collected in the literature review, where inventory management and its analysis and forecasts revealed to be extremely important to avoid waste.

4.2.3. Processes analysis

Processes related to the three main causes for waste were studied through direct observation. FDMLU lacks of returns control nowadays. The warehouse operational reports the material that was returned but there's no control of that return's information. Provisioning service only registers the changes in the stock quantities so there is no way to see what materials were returned in the past. The process is represented in the flow chart below in Annex E.

Forecasts are made twice a year by the clinics and provisioning (with simple average method), with a quick comparison between both forecasts and therefore the orders to the following semester are made. However, a lot of materials are continuously bought later because the forecast does not match the real consumption. In the rest of the year, material is ordered as long as the requisitions are made and a subjective control by the stock quantities is made in order to avoid stock ruptures. The flow charts of these processes are presented in Annexes F and G.

The order follows a process that takes some time and therefore, when there is no stock of the material, clinics are waiting all that time for the product to arrive. In addition, the control of stocks to the most important materials are subjective and the best timing and quantities to order can fail to be achieved.

4.3. Action planning

Given the problems presented before, it is clear that the solution to be proposed must create a control under the returns made by the clinics and give FDMLU reliable forecasts and a stock management method of the supplies, considering limited time and human resources. That means that it must be easy and not need too much effort that the professionals cannot give, but offering a reliable result that helps to improve their processes and minimize the waste. Thus it is proposed the creation of two tools:

1. Returns control – a tool that controls the materials to be returned, to whom, quantities and the reasons why they were returned (3.3.2.)
2. Stock management – a tool that gives information about each material code, like importance, forecasts and the best way to do their stock management (3.3.3.)

In order to have a realistic analysis and feedback of the consumptions and needs, it is important that the material list is homogeneous and representative of the items that are used by the clinics. Since more than a half of these codes are no longer used by the clinics and some products should be added or modified, it is proposed a code restructuring (3.3.1.).

4.3.2. Codes restructuring

For the codes restructuring, all the unused codes (physical inventory and consumption data) were eliminated and 787 codes were used to the next analysis. Not only an elimination of the unused codes is necessary but also changing of other codes units or names and adding new codes of supplies that have appeared or become more important in the last few years. Direct observation and previous purchase analysis allowed creating a list of supplies that needed to be added, presented in Annex H.

This codes restructuring will be possible to use for analysis only a some time after its implementation, because the data about consumption and purchase is not immediately achieved, so the subsequent creation of the tools will be based on the used codes and will not encompass the codes modification or addition because there is not enough data about it.

4.3.3. Returns control

In order to have a control of all the materials that are returned, it is proposed the implementation of a tool created with the information of the returned materials. The design of the tool is similar to another document used by these professionals (the requisition document) in order to avoid resistance. The inputs and outputs of the return report tool are the following:

Inputs (Figs. 4.4 and 4.5.)

Return service
Receiving service
Materials to be returned
Reason for the return
Quantities
Observations

Outputs (Fig. 4.6.)

Report of the returned materials

Figure 4.3 - Inputs and outputs of return report tool

RETURN MATERIALS CONTROL

Outdated and unusable materials must be delivered to Steril
Materials that are still suitable for use must be delivered to Proc

Material SAP	Pos.dpst.	Product Family	Name	Lot
1000001178	ZESC	MAT. ESCRIT. PAPELARIA DIVERSA	CAIXA DE CARTÃO P/MODELOS ORTODONTIA	125
1000001179	ZESC	MAT. ESCRIT. PAPELARIA DIVERSA	MARCADOR DE ACETATO	

Figure 4.4 - Return report tool inputs part 1

					Return Service:	086 PG ENDODONT
ization curement					Receiving Service:	017 ESTERILIZAÇAO
Reason of return	Observations	CPV	Unit	Qty	Date:	18/11/2021
Expired Material	material	30199500	UN	2		

Figure 4.5 - Return report tool inputs part 2

RETURN REPORT

Send

Date: 18/11/2021
Number: 01/01/2022

Devolutor Service: 086 PG ENDODONT
Requestor Service: 017 ESTERILIZAÇAO

Code	Description	Lot	Reason for return	Obs.	CPV	Unit	Q
1000001178	CAIXA DE CARTÃO P/MODELOS ORTODONTIA	125	Expired material		30199500	UN	2

Figure 4.6 - Return report tool outputs

Provisioning will receive this report verified by the warehouse operational and registers it in an Excel document with the Return Control, presented in Figure 4.7.

RETURN CONTROL

Material SAP	Name	Date	Lot	Reason of return	bservatio	CPV	Unit	Qty	Numbe	Return service	Receiving service
2100000041	SEDA CIRURGICA 2/0 HS 21 CO762270	24/05/2022	5568	Expired material		3314	CX	1	1/2022	005 CLINICA 1	017 ESTERILIZAÇAO
2100000042	SEDA CIRURGICA 3/0 DS 19 CO765210	08/06/2022	2226	Not the requested material		3314	CX	2	1/2022	005 CLINICA 1	016 APROVISIONAMENTO
2100000043	SEDA DAFILON BLUE 5/0 DS 19 C0935190	23/06/2022	2163	Without use conditions		3314	CX	1	2/2022	091 PG ODONTOPED	017 ESTERILIZAÇAO
2100000044	SEDA DEXON 4/0 AG.TB-15 BR.051220/6	08/07/2022	5132	Not the requested material		3314	CX	3	3/2022	075 P G PROSTOD	016 APROVISIONAMENTO

Figure 4.7 - Return control tool

4.3.4. Inventory management tool

The second tool of this action planning is the inventory management tool, created with the purpose to help the provisioning service to handle the large amount of supplies that it has in their responsibility and minimize errors in the ordering quantities and timing that could easily occur without a support. This inventory management tool is divided in three main phases, first a SKU analysis will be made through three ABC analysis (4.3.3.1), then a forecast to the supplies is going to be created (4.3.3.2) and finally the stock management will provide the information of what, when and how much to buy (4.3.3).

4.3.4.1. SKU analysis

ABC analysis is, as it was shown in literature review, crucial to do stock management. SKU analysis is going to be made through two main ABC criteria (1 and 2) and a secondary ABC criteria (3):

1. Volume – will measure the quantities of material that has been left for the services.
2. Clinics opinion – will count the articles that are critical to their service provision, that is, what articles they cannot work without.
3. Substitution level – will see how much substitutes a product has, an article that has substitutes has less criticality than an article that has no substitutes.

The first two factors were chosen to evaluate the importance of the products, however, sometimes they have results that are the complete opposite, the final decision can be subjective. In order to help the decision in these cases the substitution level criteria was introduced. Also a subjective decision will be made through direct observation and purchasing registers in order to reach the final analysis.

1. Volume

Volume was measured with the data available about the consumption quantities. Since the unities of the materials are different, it was made an uniformization to units[3]. The final ABC analysis by volume is presented in Annex I.

Volume analysis is the most used in other studies, however in this case, there are several materials that are really important to the service provision but are only used in small quantities, so other criteria are needed.

[3] for example the surgical masks are measured in packages, and they have 50 units in each package: the quantities collected in the data are going to be multiplied by 50 to reach the unitary value.

2. Clinical importance

Clinical importance was measured through a questionary to all the clinical services. A list of all the materials in FDMLU was distributed and professionals filled with an "x" the supplies that were essential to use – their absence will impede the service provision. After all the responses, the number of "x" (services that considered that material crucial) was calculated – if the result is zero or one it is considered as a C, if it has two it is a B and three or more is an A supply. Clinical responses and final clinical opinion ABC analysis are shown in Annex J.

VED analysis was not used because the goal is very similar with the ABC with the criticality, in order to facilitate the comparison between analysis it showed to be beneficial to use ABC.

3. Substitute level

Substitute level was made with the help of an assistant clinical professional with high knowledge of the different materials usage, where an indication of the products that could be substitutes of one another was given. The materials with no substitute were considered A, materials with one substitute are B and two or more substitutes are C. Most part was considered as A articles, since there are not a lot of substitutes, this analysis is showed in Annex K.

Final evaluation

The final evaluation of the ABC analysis is made by comparing the three previous analysis, with more relevance for the clinical importance and volume. In this example, in the first three items, the different criteria were concordant so no further analysis was made. For the next four items, the analysis was not the same. Substitution level and direct observation allowed to achieve the final analysis. The last three items had concordant analysis in volume and clinical opinion so no further analysis was needed, as seen in Figure 4.8.

The final analysis allowed to conclude that A articles represented 19,82% of the articles, B items reached 31,89% cumulative count, representing 12,07% of the articles and the C articles represented 68,11% of the articles.

ABC ANALYSIS

ABC ANALYSIS WITH THE 3 CRITERIA								
Código	Material	U	C1 - Clinical criticity	C2 - Volur	C3 - Substitute Level	ABC	ABC Final Anlys	
2300000025	MASCARAS CIRURGICAS VERDES	CX	A	A	A	A	A	3.43%
2300000026	COMPRESSAS DE GAZE 5*5	PAC	A	A	A	A	A	3.56%
2300000027	BARRETE VERDE C/ELASTICO	PAC	A	A	A	A	A	3.68%
2700000003	ALGINATO ORTHOPRINT	PAC	A	C	A	Manual Revision	A	11.94%
2300000146	ASPIRADOR CIRURGICO EURONDA EM-21	PAC	B	C	A	Manual Revision	B	20.97%
2700000021	PASTA IMP. TURBOFLEX LIGHT NORMAL SET	UN	B	C	A	Manual Revision	B	25.79%
2700000295	ACONDICIONADOR CANAIS GLYDE-DENTSPLY	UN	B	C	A	Manual Revision	B	31.13%
2300000130	SERINGA ENDO NEEDLE 5 ml	UN	C	C	A	C	C	35.71%
2400000064	CERA ALMINAX	CX	C	C	A	C	C	40.03%
2700000785	CONE PAPEL Nº 70	CX	C	C	A	C	C	45.62%

Figure 4.8 - ABC final analysis

4.3.4.2. Forecast

In order to have a prediction of the future demand, it is crucial to have a forecast. Considering the previous quantities used, the forecast will be calculated on three techniques and two scenarios each: Linear Regression, Moving Averages, Weighted Moving Averages, based on the previous three and six months.

The forecasts with quantitative data show to be more used in other papers, and it is normally more reliable because there are proven data of the previous demand. Forecasts that were too simplistic (Naïve methods and simple averages) were not considered in order to have better results. Forecasts that contemplate seasonality (additive model and multiplicative model) were neither used because no relevant seasonality was showed in the demand of these materials. The used methods showed good results in other facilities. Short-term (less than a year) will be used because of the fast change in the materials' needs – some materials that were used a year ago are no longer used / there are a lot of new products always entering the markets.

The two scenarios are explained bellow with the example of Linear Regression methods. For the other methods the same rational is used.

Scenario 1 - 3 months based

In this scenario, the last three months are the basis to the forecast. To calculate the July forecast, for example, it is used the demand of periods 4, 5 and 6 (April to June). To find the next periods, the three base periods are the previous three, for example, the period 12 (December) is calculated through the 9, 10 and 11 (September to November).

The final forecast (annual) is given by the sum of the 12 previous periods. When the result is negative, it was asked through the function not to show the value, since this one is not reliable - it's not possible to have negative demand. WMA and MA have no negative results so this topic is only a problem in LR. Final forecast is represented as showed in Figures 4.9. and 4.10. and it is similar to the other scenario and methods.

FORECASTS TO THE NEXT YEAR

			4	5	6
Código	Material	Unid	a-2022	m-2022	j-2022
2300000130	SERINGA ENDO NEEDLE 5 ml	UN	0	0	0
2700000003	ALGINATO ORTHOPRINT	PAC	10	19	3
2300000146	ASPIRADOR CIRURGICO EURONDA EM-21	PAC	1	25	15
2400000064	CERA ALMINAX	CX	3	4	2
2700000785	CONE PAPEL Nº 70	CX	0	2	0
2300000025	MASCARAS CIRURGICAS VERDES	CX	27	2	15
2300000026	COMPRESSAS DE GAZE 5*5	PAC	18	14	32

Figure 4.9 - Three-months based forecast

Linear Regression 3 moths based												
7	8	9	10	11	12	13	14	15	16	17	18	
FLR JUL	FLR AUG	FLR SEP	FLR OCT	FLR NOV	FLR DEC	FLR JAN	FLR FEB	FLR MAR	FLR AP	FLR MAY	FLR JUN	LR3
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3,67	-6,78	-9,81	-17,79	-22,47	-29,35	-34,77	-41,16	-46,90	-53,07	-58,95	-65,03	
27,67	25,22	32,85	33,77	39,16	41,56	45,96	49,03	52,98	56,35	60,10	63,60	528,24
2,00	0,67	0,22	-0,81	-1,46	-2,36	-3,09	-3,94	-4,71	-5,53	-6,31	-7,12	
0,67	-0,44	-0,37	-1,09	-1,28	-1,82	-2,12	-2,58	-2,94	-3,37	-3,75	-4,16	
2,67	7,22	0,52	1,32	-2,88	-3,75	-6,84	-8,44	-11,04	-12,97	-15,35	-17,43	
35,33	48,44	55,04	65,98	74,02	83,99	92,67	102,22	111,19	120,54	129,64	138,91	1057,96

Figure 4.10 - Forecast for Linear Regression with 3 months based

Scenario 2 - 6 months based

The same idea presented in the previous analysis is followed here, but instead of having a 3 months basis, it has a basis of 6 months now (Figures 4.11. and 4.12.). That is, to calculate the forecast to period 10 (October) demand, the calculus will be based in the periods 4 to 9 (between April and September).

FORECASTS TO THE NEXT YEAR

			2022					
			1	2	3	4	5	6
Código	Material	Unid	j-2022	f-2022	m-2022	a-2022	m-2022	j-2022
2300000130	SERINGA ENDO NEEDLE 5 ml	UN	0	0	0	0	0	0
2700000003	ALGINATO ORTHOPRINT	PAC	8	6	4	10	19	3
2300000146	ASPIRADOR CIRURGICO EURONDA EM-21	PAC	0	0	0	1	25	15
2400000064	CERA ALMINAX	CX	0	0	0	3	4	2
2700000785	CONE PAPEL Nº 70	CX	0	0	2	0	2	0

Figure 4.11 - 6 months base for forecast

Linear Regression 6 moths based												
7	8	9	10	11	12	13	14	15	16	17	18	
FLR JUL	FLR AUG	FLR SEP	FLR OCT	FLR NOV	FLR DEC	FLR JAN	FLR FEB	FLR MAR	FLR AP	FLR MAY	FLR JUN	LR6
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.33	11.49	11.88	10.37	9.48	12.72	11.48	11.39	11.63	12.26	12.55	12.18	137.77
21.93	28.36	34.67	39.53	41.22	49.14	53.76	58.33	63.00	68.16	73.68	78.07	609.84
4.00	4.87	5.51	5.61	6.28	7.40	7.74	8.31	8.96	9.70	10.30	10.83	89.50
1.07	0.98	0.62	0.88	0.54	0.86	0.62	0.61	0.64	0.57	0.58	0.49	8.46

Figure 4.12 - Forecast for Linear Regression with 6 months based

These two scenarios were used in each one of the following methods of forecast:

Method 1 - Linear Regression

Linear regression is adequate to apply to supplies that have a linear behaviour and is calculated according to Eqs.(1-3), where a = interception of the line at the origin, b = slope of the line, $\bar{y}$ = average of all y's, $\bar{x}$ = average of all x's, x = value of x at each point, y = y value at each point, n = number of points (Carvalho & Ramos, 2019).

$$Y = bx + a \tag{1}$$

$$b = \frac{\sum xy - n\bar{x}.\bar{y}}{\sum x^2 - n\bar{x}^2} \tag{2}$$

$$a = y - b\,\bar{x} \tag{3}$$

Method 2 - Moving Averages

Moving averages calculates a simple average of the previous periods, as presented in Eq. 4, where A = demand values in each period and n = period number (Ozcan, 2009).

$$Forecast = \frac{A1 + A2 + \cdots + An}{n} \tag{4}$$

Method 3 - Weighted Moving Averages

Weighted moving averages (WMA) calculates an average of the previous periods giving a specific ponderation to each period according to Eq. 5, where A = demand values in each period, n = period number and W = weight in each period (Ozcan, 2009).

$$Forecast = A1 * W1 + A2 * W2 + \cdots + An * Wn \tag{5}$$

Weight was calculated in two different forms:

a. Lower Error Weighting

In this method the weights are calculated through the Solver tool by defining the goal to minimize the error, with the restriction that the sum of the weights must be equal to one. The error is given by the absolute value of the actual demand less the forecast to the same periods (Figure 13). This tool will give the final results of each weight that minimizes the error, with the goal of giving the more accurate results.

After the weights are known, the forecast is calculated through the formula of WMA, for the two scenarios of three (Figures 4.13. and 4.14.) and six months.

	CB	CC	CG	CH	CI	CJ	CK
1	FORECASTS TO THE NEXT YEAR						
2	SAÍDAS			Weights 3 months			
3							
4	Código	Material	Unid	1	2	3	Sum
510	2300000078	LUVAS ALTA PROT. S - NITRILO - 200 unid	UN	0.040934	0.040682	0.009907	1

Figure 4.13 - Weights with the lower error calculation

DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED
Weighted Moving Averages 6 months															
FWMA JUL	FWMA AUG	FWMA SEP	FWMA OCT	FWMA NOV	FWMA DEC	FWMA JAN	FWMA FEB	FWMA MAR	FWMA AP	FWMA MAY	FWMA JUN	Forecast WMA6 1 year	July demand	Error 3 month	Error 6 month
193.97	221.35	226.50	234.93	242.27	203.20	20.26	18.12	15.01	11.74	8.21	4.45	1400.00	6000.00	4600	4600

Figure 4.14 - Weighted moving averages forecast with lower error weight

This method needs to be done in each material code at a time, which takes a lot of time and needs to be done every time the professional wants to calculate a forecast. Since one of the goals of this action planning is to help professionals in their day-to-day work, a more automatic formula to calculate the weight would be beneficial.

b. Exponential Weighting

In the exponential weighting, the weights are calculated through Eq. 6, where W = weigh an n = period number, with the final result for a six period scenario presented in Figure 4.15. (CFI Team, 2022).

$$W = \frac{n}{\sum n} \tag{6}$$

This way, the latest periods will have a higher importance and will impact more the final result. The use of some products is in constant change and this method can avoid that early periods misrepresent the final result.

6	5	4	3	2	1
Jun-22	May-22	Apr-22	Mar-22	Feb-22	Jan-22
0.285714	0.238095	0.190476	0.142857	0.095238	0.047619

Figure 4.15 - Exponential weighting

Error calculation

To determine which is the best method of the forecasting , the error will be calculated through the months of July, August, September and October , comparing the forecast to that month and the effective demand, it will be possible to achieve the absolute error and the mean absolute deviation (MAD), presented in Eqs.(7-9) (Ozcan, 2009).

$$Absolute\ error = |Actual - Forecast| \tag{7}$$

$$\text{MAD} = \frac{\sum|Actual - Forecast|}{n} \tag{8}$$

$$\text{MAPE} = \frac{\sum|Actual - Forecast|}{\sum Actual} \tag{9}$$

The forecast that gives the lower error (lower MAD, MAPE and absolute error – presented in Figures 4.16. and 4.17.) is the one that is going to be used in the inventory management; this is achieved automatically and shows as the final forecast in Figure 4.18.

Código	Material	Unid	Abs Error LR3	Abs Error LR6	Abs Error MA3	Abs Error MA	Abs Error WMA	Abs Error WMA
2700000732	ABRAS. 655 204 243 523 050 VER.CHAMA 66	UN	20.00	35.05	20.00	22.27	20.00	20.72
2700000001	ACONDICIONADOR TECIDOS VOCO-UFI GEL	UN	2.00	2.00	2.00	2.00	2.00	2.00
2400000013	ACRILICO AUTO ROSA PÓ	PAC	2.00	5.44	2.00	3.82	2.00	3.08
2400000014	ACRILICO AUTO TRANSP PÓ	PAC	3.00	3.00	3.00	3.00	3.00	3.00
2400000015	ACRILICO FOTOPOLIM. ROSA P/MOLD. INDI	PAC	2.00	2.00	2.00	2.00	2.00	2.00
2400000016	ACRILICO TERMO ROSA PÓ	PAC	2.00	3.30	2.00	2.71	2.00	2.42
2400000017	ACRILICO TERMO TRANSP PÓ	PAC	2.00	4.51	2.00	2.40	2.00	2.13
2400000020	ACRILICO AUTO POL. TRANSP. LIQ. SIMPLE	PAC	1.00	2.25	1.00	1.20	1.00	1.06

Figure 4.16 - Error calculation part 1

Error											
MAD LR3	MAD LR6	MAD MA3	MAD MA6	MAD WMA3	MAD WMA6	MAPE LR3	MAPE LR6	MAPE MA3	MAPE MA6	MAPE WMA3	MAPE WMA
5.00	8.76	5.00	5.57	5.00	5.18	1.00	1.75	1.00	1.11	1.00	1.
0.50	0.50	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	1.00	1.
0.50	1.36	0.50	0.96	0.50	0.77	1.00	2.72	1.00	1.91	1.00	1.
0.75	0.75	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00	1.
0.50	0.50	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	1.00	1.
0.50	0.82	0.50	0.68	0.50	0.60	1.00	1.65	1.00	1.35	1.00	1.

Figure 4.17 - Error calculation part 2

Código	Material	Unid	Lower error I	Forecast
2300000034	MANGA MISTA SEM FOLE 5 cm	UN	18.20	**81.41**
2300000036	NEODISHER MIELCLEAR	PAC	2.00	**0.00**
2300000037	NEUTRALIZADOR P/MÁQ. LAVAR (NEODISHE	PAC	4.00	**0.00**
2300000040	PAPEL TECIDO NÃO TECIDO - 130 x 150 cm	UN	300.51	**3.85**
2700001262	GODETS P/SISTEMA ADESIVO	CX	6.49	**26.44**
1900000048	PEDRA POMUS PO - BALDE 4 Kg	KG	8.49	**34.88**
1900000066	ESFREGONAS COM CABO	UN	2.00	**0.00**
1900000070	FRANJAS PARA VASSOURA T/60	UN	1.00	**0.00**

Figure 4.18 - Final forecast calculus

For the supplies that only had one forecast method associated to the lower error, an analysis allowed to comprehend that Weighted Moving Average with 3 months based was the most used, with 66%. Moving Averages with 6 months based was not used for any of these supplies, according to Figure 4.19.

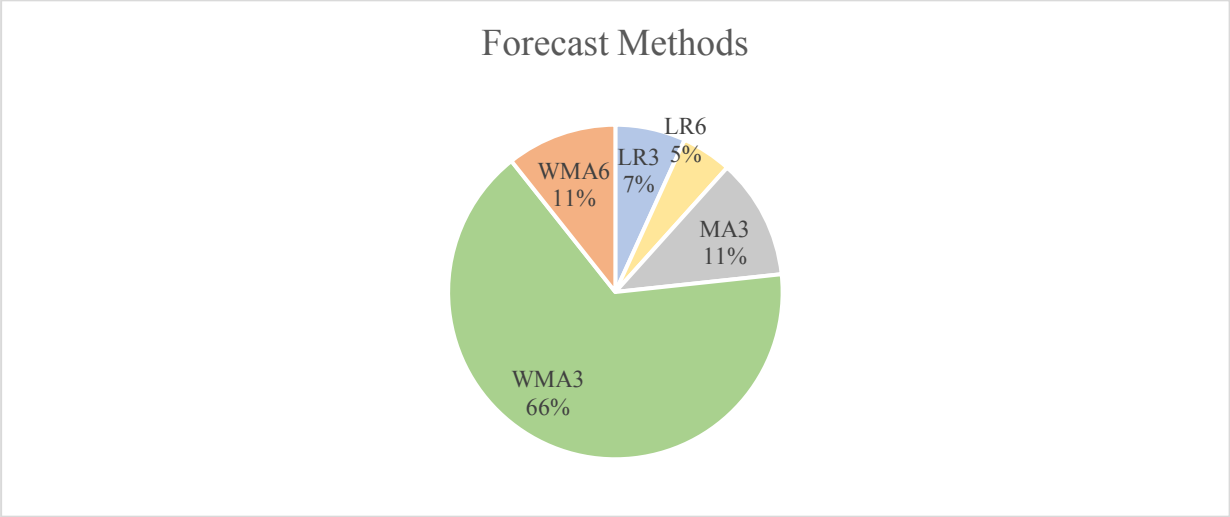


Figure 4.19 - Forecast methods used

4.3.4.3. Inventory management

After the previous topics, it is possible to start the inventory management. There are two possible ways to do the materials review – continuously or periodically. Materials that have a high importance must be closely accompanied, because a rupture of these materials would have a huge consequence in the providing service (Carvalho & Ramos, 2019).

The list of used codes and their respective importance (analysed previously by the ABC analysis) is presented in the stock management in order to choose the most appropriate review – A articles must have a continuous review, C articles have a periodic review and B articles can have any type of review, depending on what would be most accurate. It is also shown the stock (current units in the warehouse) and the forecast for one year, according to Figure 4.20. After this, both reviews were calculated to each supply.

FORECASTS TO THE NEXT YEAR

Código	Material	CPV	Unid	ABC	Type of Ordering	Code Type of Ordering	Stock	Forecast
2700000499	ASTRINGEDENT TISSUE MANAGEMENT	33141810	UN	B	Continuous Review	1	1	2,50
2700000501	CABOS P/PINCEIS	33131300	UN	C	Periodic Review	2	18	31,97
2700000502	CAVIFIL INJECTOR (PISTOLA)	33141810	UN	A	Continuous Review	1	0	33,32
2700000515	PONTAS P/ADESIVO (TIPO COTONETE)	33131300	UN	A	Continuous Review	1	30	3,43
2700000517	SCOTCHBOND ETCHING GEL 7523 SERINGA	33141810	UN	A	Continuous Review	1	7	12,00
2700000525	FILTEK Z500 CERAM A4	33141810	PAC	C	Periodic Review	2	3	3,65
2700000527	FILTEK Z500 CERAM A2	33141810	PAC	A	Continuous Review	1	0	34,46

Figure 4.20 - Inventory management first analysis

Continuous review

Starting with Model Q (continuous review), "*an order is placed with the supplier when the stock level reaches a pre-defined quantity, the order point*" (Carvalho & Ramos, 2019).

When to order?

The best timing to order is presented by the Eq. (10-12), where R = Reorder point, D = Demand, L = Lead Time, SS = Safety Stock, Z = Safety Factor (Table 4.1.) and σ = Standard deviation (Ozcan, 2009).

$$R = \bar{D} \times L + \text{SS} \tag{10}$$

$$SS = z \times \sigma \tag{11}$$

$$\sigma = \sqrt{\bar{L} \times \sigma_{D^2} + \bar{D}^2 \times \sigma_{L^2}} \tag{12}$$

z (depends on the service level that the company intends to have)

Table 4.1 - Safety factor

Service level	70%	80%	90%	95%	99%	99,9%	99,99%
Possibility of rupture	30%	20%	10%	5%	1%	0,1%	0,01%
Safety factor (z)	0,52	0,84	1,28	1,64	2,33	3,09	3,72

How much to order?

The optimal quantity to order is presented in Eq. 13 where EOQ = Economic order quantity, S = Ordering cost and H = Holding cost (Ozcan, 2009).

$$\text{EOQ} = \sqrt{\frac{2\ X\ D\ (annual)\ X\ S\ (unitary)}{H}} \tag{13}$$

Calculation of each variable is presented in the Table 4.2. below.

Table 4.2 - Continuous review calculations

Variable	**Description**	**Font**
1. Lead time	There is not a fixed lead time within the suppliers, and each material can be bought to multiple suppliers,	FDMLU data – purchases SAP output

		so an estimated lead time was calculated with previous data of the time between the order and the itemsarrival in thewarehouse (in months), as represented in Annex L.	
2. Standard Deviation	a. Standard deviation of Demand	With the Excel Formula *STDEV.S* to each supply (Annex M).	FDMLU data – consumptions from Jan 2021 to June 2022
	b. Average Lead Time	It was calculated the average – Excel formula *AVERAGE* (Annex M), this value was used to all supplies.	FDMLU data – Lead time calculated in 1
	c. Standard deviation of Lead Time	With the Excel Formula *STDEV.S* (Annex M).	FDMLU data – Lead time calculated in 1
	d. Average Demand	With the Excel Formula *AVERAGE* to each supply (Annex M).	FDMLU data – consumptions from Jan 2021 to June 2022
3. Safety Stock	a. Safety Factor	It was chosen a 99% service level for A articles, 95% for B articles and 90% for C articles, ordering the service level by their importance.	Table 2 – Safety factor
	b. Standard Deviation	Final value of the topic 2.	Standard Deviation (2.)
4. Unitary Cost		This data was taken from the established unitary cost.	SAP software
5. Reorder Point[4]	a. Demand while lead time	Values for the annual forecasted demand	Calculated in 4.3.3.2 times the lead time (1.) in years.
	b. Safety Stock	Final value of the topic 3.	
6. EOQ[5]	a. Demand	Values for the annual forecasted demand calculated in 4.3.3.2.	

[4] With a limit of six months of the demand forecast, so that no product is longer than this time without being consulted

[5] With the limit of one year, because FMDUL practices establish that articles are only accepted if they have a minimum of one year until they expire.

	b. Ordering Cost	It is current practice that for each order lower than 100€, 5€ are taxed (ordering costs), above 100€ the ordering cost is normally 0€. In this case, 5€ will be considered ordering cost because if no aggregated order or minimal quantity order are followed, that will be the normal value to pay.	FDMLU data and quotations from suppliers.
	c. Holding Cost	Represents about 25% of the product value	(Jones, 2020)
7. Necessity of order		If the stock is lower or equal to the reorder point, it shows a "YES" in the order. If it is above the reorder point, no order is needed yet.	Inventory management tool data

All of these results are presented in an Excel sheet, presented in Figures 4.21. and 4.22.

Código	Material	CPV	Unid	Lead Time (in years)	Demand Std dev	Average Lead Time	Lead time Std dev
2700000445	CORRENTES PORTA BABETES	33141800	PAC	0,06	3,1885211	0,8233333	0,7365158
2700000449	ELUGEL - GEL BUCAL	33141850	UN	0,06	8,5732141	0,8233333	0,7365158
2700000450	PICOSILK SPRAY	33138000	UN	0,06	1,6733201	0,8233333	0,7365158
2700000452	CLAMP P/DYQUE Nº 201	33134000	UN	0,06	2,3452079	0,8233333	0,7365158
2700000456	FIO RETRACCÃO ULTRAPAK Nº 00	33133000	UN	0,06	1,9748418	0,8233333	0,7365158

Figure 4.21 - Continuous Review part 1

CONTINUOUS REVIEW												
									Max 6 months		Max 1 year	
Average Demand	Standard deviation	Safety factor	Safety Stock	Demand while lead time	Unitary cost	Ordering cost	Holding cost per year	Reorder Point	Reorder Point	EOQ	EOQ	Order
3.833333	4.042479	2.33	9.42	0.24	4.92	5.00	1.23	9.65	9.65	19.59	19.59	NO
3.5	8.195125	2.33	19.09	0.21	2.89	5.00	0.72	19.31	19.31	28.41	28.41	YES
1	1.687539	1.28	2.16	0.06	23.33	5.00	5.83	2.22	2.22	5.12	5.12	YES
0.166667	0.390244	1.28	0.50	0.01	7.26	5.00	1.82	0.51	0.00	0.00	0.00	NO
1.5	2.397678	1.28	3.07	0.09	20.61	5.00	5.15	3.16	3.16	7.20	7.20	YES

Figure 4.22 - Continuous review part 2

Periodic review

In Model P, "*the day for placing an order with the supplier is pre-defined, with a fixed frequency between orders*" (Carvalho & Ramos, 2019).

When to order?

The time between orders, (TBO) is calculated through the Eq.14 (Ozcan, 2009).

$$\text{TBO} = \frac{EOQ}{D} = \frac{\sqrt{\frac{2\,X\,D\,X\,S}{H}}}{D} \tag{14}$$

How much to order?

The most appropriate quantity to order is presented by the Eqs.15-17 (Ozcan, 2009). Where P= Revision Period.

$$T = D\ \times (P + L) + SS \tag{15}$$

$$SS = z\ \times\ \sigma \tag{16}$$

$$\sigma = \sqrt{(P + \bar{L}) \times \sigma_{D^2} + \bar{D}^2\ \times \sigma_{L^2}} \tag{17}$$

Calculation of each variable is presented in the Table 4.3. below.

Table 4.3 - Periodic review calculations

Variable		**Description**	**Font**
8. TBO	a. EOQ	Calculated in the topic 6.	
	b. Demand	Calculated in the topic 6a.	
9. Target Stock	a. Demand	Calculated in the topic 6a.	
	b. Period Revision	Calculated in the topic 8.	
	c. Lead Time	Calculated in the topic 1.	
	d. Safety Stock	Calculated in the topic 3.	
10. Quantity to order		Quantity that must be ordered right now.	Given by the Target Stock (9.) less current Stock (Inventory management tool)
11. Order necessity		If the quantity to order is higher than zero, it shows a "YES" in the order. If it is equal or lower than zero, no order is needed yet.	Inventory management tool data

12. Revision Periods	Orders with the minimum gap of one month[6], according to the TBO, as shown in Annex N.	Inventory management tool data

Results of these topics are present in Figures 4.23.and 4.24.

FORECASTS TO THE NEXT YEAR

Código	Material	CPV	Unid	Demand Std dev	Average Lead Time	Lead time Std dev	Average Demand
2700000445	CORRENTES PORTA BABETES	33141800	PAC	3,19	0,82	0,74	3,83
2700000449	ELUGEL - GEL BUCAL	33141850	UN	8,57	0,82	0,74	3,50
2700000450	PICOSILK SPRAY	33138000	UN	1,67	0,82	0,74	1,00
2700000452	CLAMP P/DYQUE Nº 201	33134000	UN	2,35	0,82	0,74	1,50
2700000456	FIO RETRACÇÃO ULTRAPAK Nº 00	33133000	UN	1,97	0,82	0,74	1,50
2700000457	FIO RETRACÇÃO ULTRAPAK Nº 000	33133000	UN	1,51	0,82	0,74	1,67

Figure 4.23 - Periodic review part 1

PERIODIC REVIEW

Standard deviati	Safety facto	Safety Stock	Target Stock	Quantity Orde	Order	TBO''	TBO'	EOQ/D TBO	Rev P jan	Rev P feb	Rev P mar	Rev P apri	Rev P may	Rev P june
4.53	2.33	9.42	512.04	465	YES	0.41	0.41	0.41	X	X		X		X
10.15	2.33	19.09	1362.60	1304	YES	0.49	0.49	0.49	X	X		X		X
1.95	1.28	2.16	35.39	20	YES	0.33	0.33	0.33	X	X		X		X
0.39	1.28	0.50	0.00	0	NO	0.00	0.00	0.00						
2.69	1.28	3.07	82.37	56	YES	0.27	0.27	0.27	X	X	X		X	X
0.00	1.64	0.00	0.00	0	YES	0.00	0.00	0.00						

Figure 4.24 - Periodic review part 2

This tool has a lot of data and complexity that is not necessary to consult every time the provisioning professionals want to do an order. All the inputs calculated and presented above will be the basis to the sheet where the professionals will consult the data, with a simple and intuitive *design* as shown in the Section 5.2.4. below.

[6] This minimum was defined because FMDUL orders take considerable time and resources waste, so orders less than a month apart are not viable

5. Implementation, evaluation and monitoring

5.2. Implementation of the action planning

Since the implementation of the action planning presented above is not possible, a plan to that implementation is presented next – first the codes restructuring (5.1.1.), next the returns control (5.1.2.) and finally the inventory management tool implementation (5.1.3.). Both tools would be implemented in Portuguese, once that is the language used by FDMLU professionals.

5.2.2. Codes restructuring implementation

As it was seen, codes restructuring will help to have more reliable data. This would be made by provisioning professionals through the following steps:

1. List the materials to be eliminated, added or modified
2. Eliminate, add or modify the materials in SAP (management software)
3. Eliminate, add or modify the materials in Control document
4. Eliminate, add or modify the materials in Requisitions document
5. Send the new Requisition document to the clinics, with the new codes list

The processes of requisition, order, entries and outs of materials would remain the same but with a renewed list of materials. Since the provisioning service already has the knowledge to do this task, no training is needed.

5.2.3. Returns tool implementation

To implement return report and control tools, it is proposed a training afternoon directed to the returns responsible (three professionals), being opened to others who might be interested as well. The following program is suggested:

14h00 – Welcome and presentation of the tool idea and its importance.

14h15 – Demonstration about how to use the tool, answering to all the doubts and allowing clinics professionals to experiment the tool.

14h45 – Delivery of the user manual and sending the tool to the e-mail of each clinic return responsible. The user manual is presented in Annex O.

After that, every time the service wants to return some material, the process will follow the steps given by the flow chart in Annex P.

5.2.4. Inventory management tool implementation

A similar idea to the return control implementation is followed here, with an afternoon formation with the program presented next, this time to the provisioning professionals.

14h00 – Welcome and presentation of the tool idea and its importance.

14h15 – Demonstration about how to use the tool, answering all the doubts and allowing provisioning professionals to experiment the tool.

14h45 – Delivery of the user manual, presented in Annex Q.

Provisioning service should then make their inventory management by opening the sheet "Quick search" presented in Figure 5.1.

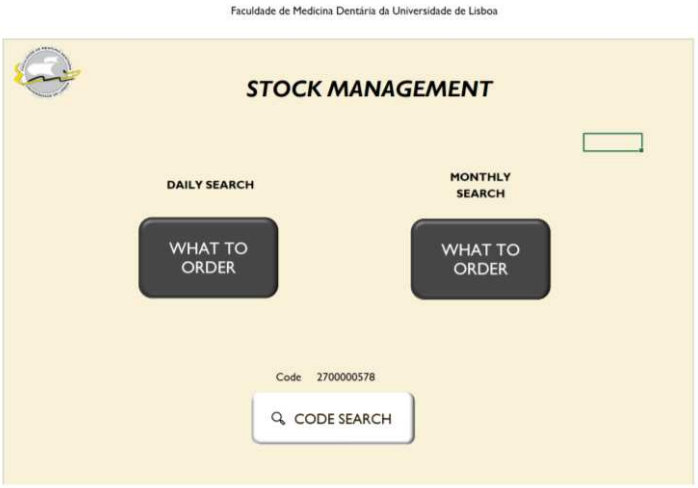


Figure 5.1- Inventory management quick search

1. Continuous Review (Figure 5.2.) – every day, the continuous review is made by clicking in the "Daily Search – What to order". All the materials that have a continuous review and the stock is equal or bellow to the reorder point will appear in a list that the provisioning professionals should order as fast as possible.

CONTINUOUS REVIEW

Código	Material	Unid	Stock	Reorder Point	EOQ
1000001178	CAIXA DE CARTÃO P/MODELOS ORTODONTIA	UN	0	111	191
1000001335	PAPEL BRANCO A/4 80 gr	RES	50	74	75
1900000078	LIXIVIA - 5%	UN	6	7	31
19000001 16	BENZINA	L	0	3	0
2100000003	ANESTESIA - ARTICAÍNA/EPINEFRINA 1/200.000	CX	10	18	8
2100000006	ANESTESIA - TÓPICA - TOPI GEL 30 ml	UN	10	14	8
2100000008	CHLOROHEXIDINA DENTAL GEL	UN	0	8	14
2100000021	ALCOOL ETÍLICO 70% - 250 ml	UN	15	25	82
2100000027	COTONETES	CX	5	5	10
2100000047	SOLUÇÃO DE ERITROSINA DENTO-PLAQUE	UN	1	4	8
2100000049	SORO FISIOLÓGICO 20 ml	UN	233	378	416
2100000053	VASELINA - LIQUIDA	L	0	1	5
2100000066	SEDA SAFIL VIOLET REAB. 4/0 DS 19 C1048420	CX	0	5	2
2300000016	KAVO SPRAY - OLEO KAVO	UN	0	10	8
2300000033	MANGA MISTA SEM FOLE 10 cm	UN	4	13	12

Figure 5.2 - Continuous review list

2. Periodic Review (Figure 5.3.) – in the beginning of every month, professionals should click in the "Monthly Search – What to order", here all the materials that have to be bought in that month will show.

PERIODIC REVIEW

Código	Material	Un	Sto	Target Sto	Quantity Ord
1000001184	AGRAFES NORMAIS 24/6	CX	14	12	10
1000001190	ARQUIVADORES 31/60	UN	57	60	46
1000001194	BLOCOS MEDIOS	UN	161	10	6
1000001195	BLOCOS PAPEL AMARELO (Post-It) 38x51	UN	42	72	57
1000001196	BLOCOS PAPEL AMARELO (Post-It) 76x127	UN	45	72	57
1000001197	BLOCOS PAPEL AMARELO (Post-It) 75x75	UN	36	72	57
1000001198	BORRACHAS PARA LAPIS	UN	13	10	6
1000001210	CLIPS Nº 1	CX	29	62	45
1000001211	CLIPS Nº 10	CX	11	40	25
1000001212	CLIPS Nº 2	CX	6	26	15

Figure 5.3 - Periodic review list

3. Suppliers search and order – analyze the possible suppliers as they normally do and ask for quotations; Analyze the quotations; Make the orders.
4. If they want to make a search by material, there is a button in the bottom of the sheet where the code of the material is written and the main information about the product appears, like in the Figure 5.4.

CODE SEARCH

Código	Material	Unid	ABC	Type of Ordering	Stock	Foreca	Reorder Point	EOQ	Order	PEE	Order Q	Rev P jan	Rev P feb	Rev P
2700000578	AÇO 310 206 679 336 090 GATES Nº3	UN	B	Continuous Review	0	0		0	0 NO		0 YES			

Figure 5.4 - Code search

With this implementation, processes will follow a different path, represented in Annex R.

5.3. Evaluation and monitoring

Diverse methods for evaluating the tools, their results and estimations of the impact in the final goal to decrease waste are also proposed (5.2.1. and 5.2.2.). Evaluation of the tools is crucial to understand if they are implemented in the best way, it provides the opportunity to improve the tools in order to be more user-friendly and effective, giving the best results and lower errors. The final goal of these tools is to decrease the waste created in FDMLU, so it will be important to compare the waste that is created before and after these implementations. Since it was not possible to implement the tools, the methods of evaluation are going to be created and executed to give an estimation of the results. Through the continuous evaluation of all these topics, it will be possible to monitor the effectiveness of the implementations made.

5.3.2. Returns tool evaluation and monitoring

The evaluation and monitoring of the return tool can be made in two main aspects: the use of the tool itself and the results that this tool offers.

Use of the tool

This tool is going to be used by the clinic services in order to create and deliver the report and by the provisioning service where the report is registered in the Excel of Return Control. It is proposed that, one month after the implementation of the tool, a questionnaire is made to clinics and provisioning services, according with Table 5.1.

Table 5.1 - Questioner about return tool

Service	Document	Evaluation goal	Questions
Clinics	Report	Tool relevance	- How many times do you use this tool?* - Do you consider this tool important to FDMLU control?*
		Tool effectiveness	- Is the tool user-friendly?* - What aspects could be improved?* - When you make a return, this tool gives you all the information you need to do the report?* - Do you have any additional suggestions related to the tool?
Provisioning	Control	Tool relevance	- Do you consider this tool important to FDMLU control?*
		Tool effectiveness	- Is the tool user-friendly?* - What aspects could be improved?* - Are all the important data about the returns being collected by this tool?* - What other data should be collected?* - Do you have any additional suggestions related to the tool? **Mandatory*

The tools were showed to the provisioning professional and a clinical professional and the questionnaires were answered by them (excluding the first question because it is only possible to evaluate after the implementation). The evaluation has demonstrated that bought professionals consider this tool relevant, easy to use and intuitive. It was suggested that the causes for the product devolution were included in the report and control tools, for example: Expired material – *why? It was received near the expiration date? A wrong prevision was made?*. Also, the need for having a more accurate list with less diverse items was highlighted in order to reduce the errors and increase the facility to use – already proposed in Section 4.3.2.

Results of the tool

This tool will give information that was unknown until now. Some results can be important to evaluate:

- The services that return more materials
- Materials that are returned in more quantity
- What are the major causes for the returns

A comparison and monitoring of these topics during the periods is important in order to spot outliers and situations that are not normal, find solutions to it and create plans to avoid waste.

5.3.3. Inventory management tool evaluation and monitoring

Similarly to the return control tool, the inventory management tool can be evaluated in terms of use by the user and results of the tool.

Use of the tool

In order to understand how the provisioning service is adapting to the implemented tool and collect possibilities for improvement, a questionnaire is suggested according to Table 5.2.

Table 5.2 - Questioner about inventory management tool

Service	Evaluation goal	Questions
Provisioning	Tool relevance	- Do you consider that this tool can help the provisioning service to do the inventory management?*
	Tool effectiveness	- Is the tool intuitive and easy to use?* - Are the daily and monthly search suitable intervals for ordering materials?* - Is the information presented in an easy form to work with?*

		- Is the available data adequate to the needs of the provisioning service?* - Are the results accurate?* - How could the tool be improved?* - Do you have any additional suggestions related to the tool? **Mandatory*

The tool was showed to the provisioning professional and the questions made allowed to understand that the professional considers the tool intuitive, concrete and a quicker way to identify the articles that must be purchased. Underlines the need to review the results of the tool in order to understand whether it fits reality in all the cases demonstrated and proposes that an analysis of suppliers is also carried out in order to facilitate even more the process of acquiring goods

5.3.3.1. Waste evaluation and monitoring

Not only the evaluation of the tool is important but also the evaluation of the final goal, the waste produced by FDMLU – this will give real understanding about the effectiveness of the tools, acknowledge if the action planning is contributing to the final objective of decreasing the amount of waste.

Since the implementation of the tool was still not possible, an estimation of the potential benefits that might be achieved with its use is obtained using information of 2021. Materials associated with the highest waste are the ones indicated as expired by the warehouse operational in the physical inventory of 2021, being these the ones now analyzed to determine if the use of the tool would promote a reduction of the associated waste.

1. **Analyze the previous purchase of materials**

The highest purchased quantity associated with each expired material is registered. Materials not purchased after 2017 are discarded. This information should then be compared to the quantities to be purchased as suggested by the tool.

2. **Forecast of the consumption for that year**

A forecast to the year of the largest consumption is calculated based on the previous year data.

3. **Collect the consumption of the year with the largest purchase**

The real consumption of the materials was also collected to compare with the forecast made.

4. Calculate the economic and environmental saves

The economic and environmental saves of these materials are calculated with the same basis as the impacts were achieved in the waste quantification.

For the expired materials of 2021, only part of the items had data after 2017, presented in Table 4.3., the analysis of these items concluded that the forecast for all of these supplies was zero and the real consumption was also zero. With the use of this tool, these supplies would not have been purchased and the total waste avoided.

Table 5.3 - Waste saves estimation

Name	UN	Major purch	Y	Forec*	Consump*	Saves	Total environmental saves	Total economic saves
PELICULA DENTAL EKTASPEED	CX	14	2019	0	0	8	12.61116	384.71 €
PASTA IMP. TURBOFLEX REG N SET	UN	52	2018	0	0	15	12.4267	334.69 €
ACOND TECIDOS - FITT	CX	10	2019	0	0	4	5.522976	224.75 €
REVEL PERIOMAT - DURR	PAC	8	2019	0	0	2	63.05581	167.70 €
PELIC DENTAL KODAK IP-21	CX	94	2019	0	0	5	7.881976	140.37 €
SEEK CARIES INDIC 209 KIT	PAC	2	2017	0	0	1	2.20919	64.18 €
HARVARD CIMENTO PÓ	UN	8	2017	0	0	3	2.485339	56.06 €
FRASCO DE ANALISE/BIOPSIA	UN	750	2017	0	0	230	18.12855	46.00 €
CONE GUTTA PERCHA 40	TUB	204	2018	0	0	42	16.55215	38.94 €
ELUGEL - GEL BUCAL	UN	15	2017	0	0	10	5.522976	29.38 €
CONE PAPEL Nº 70	CX	15	2021	0	0	5	1.970494	24.69 €
PAPEL ARTIC VERM. BK 14	PAC	14	2018	0	0	2	1.576395	23.45 €
CONE PAPEL Nº 80	CX	16	2021	0	0	4	1.576395	19.75 €
AGULHA P/SERINGA 30G	CX	6	2019	0	0	3	3.301189	13.88 €
FITA MATRIZ 5 mm	UN	11	2018	0	0	1	0.733598	6.19 €
							155.5549 kgCO_2	**1,574.72 €**

*Forecast and consumption calculated for the year of the purchase

With this analysis, it was possible to demonstrate that the tool would be very effective to avoid the waste of previous purchase, which is a good indicator of the effectiveness of the inventory management tool in the goal of FDMLU to eliminate waste.

6. Conclusion

Sustainability is a topic that is becoming more and more pertinent. Health systems are a significant source of CO_2 emissions and healthcare institutions frequently employ various tactics to reduce their detrimental effects on the environment. FDMLU is aware of this problem and has the goal to decrease the waste by eliminating the waste of unused products that remain in the warehouse with no future use – these supplies have no good impact in service providing and their elimination would decrease their environmental and economic impact.

In order to acknowledge the As-is of FDMLU, the waste was quantified and the economic and environmental impact was studied with the available data. Expired products in 2021 accounted a total of 4,854.74 € and 257,46kgCO_2 This shows that waste it is a real problem at FDMLU and is an important topic to be studied. Three main causes for this amount of waste in FDMLU were collected through semi-structured interviews: Lack of returns control; Difficulty in the forecast; Lack of inventory management.

Two main solutions were designed to solve these problems. Besides these solutions, a restructuring of the material codes was proposed in order to have a more accurate list of materials that are actually used.

First, return report and return control were created where the services describe what materials they want to return, why, how much, to whom and other necessary information. The report is then received by the provisioning service that registers it in the return control, this documents are important because they allow to control all the returns made and help to identify possible errors or problems that are happening in order to create solutions.

Secondly, an inventory management tool was created in order to support the provisioning service to make the orders, this tool has information about the relevance of the products through ABC analysis and also give the forecast to the next year of each code. Then, inventory management reviews are applied to each product to know when the supply should be ordered and how much would be necessary. Provisioning service will daily review the articles that have higher importance through a continuous analysis and monthly review the articles that have lower importance through periodic review. This will help the service to base their decisions in proven methods with the most reliable data possible and not in subjective assumptions. Since more reliable forecasts and inventory management methods are applied, the accuracy between these methods and real consumption must increase.

Besides these two solutions, it is important to make a restructuring of the codes: 58,49% of the material codes are not used anymore and should be eliminated, other materials are used a significant number of times and should have their own code. This will provide much more accurate data that will improve further analysis about inventory management.

The implementation of these tools was not possible to achieve, however a plan for a future implementation was designed with training and distribution of the documents and user manuals. It is important that every professional understands the importance of the tools and their design was created in order to be as user friendly as possible and similar to other documents used nowadays so that the resistance to these new introductions would be minimized.

The evaluation made by the provisioning professional and clinical professional concluded that the tools were really intuitive and facilitate the processes of returning materials and purchasing goods, proposes like adding the cause for the return, having a restructuring of the codes or having a supplier analysis in the inventory management tool were given by the professionals.

The goal of all the action planning is to eliminate the waste, so an estimation of the results were calculated. Some of the expired materials had enough data to understand where the largest purchases were made (these are the orders that more probability had to cause the excessive amount of stock and lead to waste). After that, it was made a forecast to the year of that purchase, all the forecasts were zero and the real demand in that year was also zero – that showed that none of that materials would have been bought if the inventory management tool had been used, so no waste was created. Results are very positive since 100% of the analysed waste would have been prevented by this tool.

Limitations

The biggest limitation in this study was the lack of data in some topics that would allow doing a more accurate and reliable analysis. For instance, the economic and environmental estimation yields lower results than what is actually the reality because the products with no future use and damaged materials have no sufficient data. In addition, the environmental impact has no analysis about the raw materials and extraction because no relevant data was found. Other limitation was the impossibility to implement the tools. It will only be possible to have real results and an effective evaluation with the actual implementation , however an estimation of the waste decrease was made.

Future search

As the work progressed, some interesting topics appeared to be studied:

In the inventory management tool, a previous supplier selection would be an additional facilitator for the provisioning service as it was mentioned in the evaluation questionnaires, each code could have the information of three possible suppliers so that he provisioning service would not need to do the supplier search. This search was not made because the data available was very difficult to work with and other analysis were prioritized. Also having relevant data about the demand and quantities missing would be beneficial to make a more accurate evaluation, calculating the service level and breakage rate.

When the causes for the waste were collected, only three of them were used and analysed, the other three causes could serve as a basis to other solutions. Incorrect handling of materials and deteriorated materials highlights the need for training for those who use the supplies (warehouse operational and clinical professionals) so that they can fully understand the best way to handle and store the materials. The expiration of products could be minimized by having a better control on them, when the materials arrive to the faculty a registration of the expire date should be added. In this way, a control of the expiration date of the arrivals and current stock would be made.

In the report and control return tools it was important to add the field “Cause” in order to collect the main reasons why the materials are returned.

Lastly, despite having a plan for the implementation and respective evaluation, it would be interesting to implement and evaluate the tool after the implementation in order to identify possible improvements and assuring the success of the tool.

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A. Annexes

Annex A – Forecast Methods

From: (Ozcan, 2009) (Carvalho & Ramos, 2019)

Table A.1 - Forecast methods

Approach	Method	Concept	Vantages	Disadvantages
Judgemental Forecasts	Delphi	Series of questionnaires is circulated to a group of experts; each new questionnaire is developed from the previous one and seeks to find a consensus.	Save costs compared to assembling many experts; useful to forecast technological changes; eliminates the bandwagon effect and the anonymity of the participants is secured	Ambiguous questions can lead to false consensus; there is almost no accountability for each one's response; if the process takes a long time, the probability of the respondents changing their ideas is higher
	Jury of executive opinion	Uses the consensus of a group of experts (normally from diverse departments)	Low cost and facility to use the resources	Using only internal resources can deviate the results, since they normally don't know the reality of many companies
	Naïve extrapolation	Make a simple assumption about the economic outcome of the next period, or a subjective extrapolation from the results of current events	Low cost and facility to use	Does not rely in various periods, too simplistic – results may not be accurate in case of variations
Time-Series	Naïve Forecasts	Assumes that the previous period's actual value it's the same as the forecast for the next period	Low cost; easy to prepare and use and easy to comprehend	Simply replicates the previous data - the probability of not being realistic is higher

	Simple Averages Moving Averages	A simple average is made with the previous periods The most recent periods are considered and an average of these periods is made. Over time passes, more periods appear and the old ones are dropped. To decide the number of periods of the moving average the manager should consider: if the goal is to have more responsiveness the number of periods must be smaller	Low cost; easy to prepare and use and easy to comprehend Various periods are considered, the forecast does not rely simply on one period - it is more reliable, since it does not reflect all the variations	Timeline is not considered - the probability of not being realistic is higher The oldest values are considered to be as realistic as the newest values - the trends (what it is used most recently) do not have a bigger height. The oldest values can reflect a higher forecast of items that does not have that importance nowadays
	Weighted Moving Average Single Exponential Smoothing	Similar to a moving averages but assigns more height to the most recent values - the values are subjective and their sum must be equal to 1.0 The new forecast is based on the previous forecast plus a percentage of the difference between that forecast and the actual value of the series at that point	It reflects more the most recent data - it can be more reliable than a simple average.	Only possible to see a period at a time (the manager only can see the forecast to the next period)

	Linear Regression (Trends)	Shows the behaviour of a variable in function of the other variable.	Useful when the consumption of a determined item is linear over time - in the cases where the consumption is increasing/ decreasing the averages could not bring a forecast so realistic	When there is not a linear increase or decrease, this tool would not provide the right forecasts
	Additive model (Seasonality)	A determined quantity is added or subtracted from the period where the seasonality happens	When the seasonality is always the same units	Used when the material suffers seasonality
	Multiplicative model (Seasonality)	A determined quantity is multiplied - the value (seasonal index) represents the seasonality	When the seasonality is dependent on the value that is consumed before	Used when the material suffers seasonality

Annex B – Deteriorated Materials

Table A.2 - Deteriorated materials economic and environmental impact

Code	Name	Situation	Quantity	Price UN	Total	Weight UN	Total weight	Disposal EI	Production EI	UN
27000 00455	DUBLECCOS MODIFIED EAGLES MEDIUM - HIG	Incorrect storage	6	25.60 €	153.60 €	0.5	3	13.88	9.762	kg CO_2
19000 00078	LIXIVIA - 5%	Transportation deterioration	2	1.65	3.30 €	5	10	46.28	32.54	kg CO_2
					156.90 €			**60.16**	**42.302**	**kg CO_2**
									102.4657	**kg CO_2**

Annex C – Expired Materials

Table A.3 - Expired materials economic and environmental impact

Code	Name	UN	Expired Quantity	Economic impact	Environmental impact (CO_2)
24000000 22	ACRILICO AUTO POL. PRÓ BASE COLD LIQ.	PAC	11	583.44 €	30.37636905
27000000 119	PELICULA DENTAL EKTASPEED SIZE 0 IP-01 1FILM	CX	8	385.91 €	12.6111619
27000000 30	PASTA IMP. TURBOFLEX REGULAR NORMAL SET	UN	15	335.73 €	12.42669643
27000000 882	LIMA HEDSTROEM 31 mm 80	CX	18	326.14 €	6.602378571
27000000 873	LIMA HEDSTROEM 31 mm 20	CX	19	305.74 €	6.969177381
27000000 901	LIMA TIPO K 25 mm 70	CX	17	280.52 €	6.235579762
27000000 904	LIMA TIPO K 25 mm 90	CX	16	264.02 €	5.868780952
27000000 002	ACONDICIONADOR TECIDOS - FITT	CX	4	225.45 €	5.52297619
27000000 870	LIMA HEDSTROEM 31 mm 10	CX	11	182.30 €	4.034786905
27000000 911	LIMA TIPO K 31 mm 50	CX	16	174.54 €	5.868780952
27000000 886	LIMA TIPO K 25 mm 110	CX	11	171.72 €	4.034786905
27000000 127	REVELADOR PERIOMAT - DURR	PAC	2	168.22 €	63.05580952
27000000 116	PELICULA DENTAL (3x4) KODAK IP-21	CX	5	140.81 €	7.88197619
27000000 875	LIMA HEDSTROEM 31 mm 30	CX	9	137.30 €	3.301189286
27000000 912	LIMA TIPO K 31 mm 55	CX	17	120.44 €	6.235579762
27000000 874	LIMA HEDSTROEM 31 mm 25	CX	6	91.54 €	2.200792857
27000000 881	LIMA HEDSTROEM 31 mm 70	CX	5	90.59 €	1.833994048
27000000 907	LIMA TIPO K 31 mm 30	CX	10	85.58 €	3.667988095
27000000 903	LIMA TIPO K 25 mm 80	CX	5	82.51 €	1.833994048
27000000 688	ACIER INOX HAWE NEOS 382 CIR. MOLAR	CX	7	74.61 €	2.567591667
27000000 368	SEEK CARIES INDICATOR 209 KIT	PAC	1	64.38 €	2.209190476
27000000 098	HARVARD CIMENTO PÓ	UN	3	56.24 €	2.485339286
27000000 880	LIMA HEDSTROEM 31 mm 55	CX	3	52.04 €	1.100396429

2700000906	LIMA TIPO K 31 mm 25	CX	6	51.35 €	2.200792857
2700000885	LIMA TIPO K 25 mm 100	CX	3	46.83 €	1.100396429
2700000388	FRASCO DE ANALISE/BIOPSIA	UN	230	46.14 €	18.12854524
2700000765	CONE GUTTA PERCHA 40	TUB	42	39.06 €	16.55215
2700000879	LIMA HEDSTROEM 31 mm 50	CX	2	34.69 €	0.733597619
2700000910	LIMA TIPO K 31 mm 45	CX	3	32.73 €	1.100396429
2700000449	ELUGEL - GEL BUCAL	UN	10	29.47 €	5.52297619
2700000914	LIMA TIPO K 31 mm 60	CX	4	28.34 €	1.467195238
2700000909	LIMA TIPO K 31 mm 40	CX	3	25.67 €	1.100396429
2700000785	CONE PAPEL Nº 70	CX	5	24.76 €	1.970494048
2300000134	PAPEL ARTIC. EXTRA FINO VERM. BK 14	PAC	2	23.52 €	1.576395238
2700000786	CONE PAPEL Nº 80	CX	4	19.81 €	1.576395238
2700000908	LIMA TIPO K 31 mm 35	CX	2	17.12 €	0.733597619
2700000876	LIMA HEDSTROEM 31 mm 35	CX	1	15.26 €	0.36679881
2700000877	LIMA HEDSTROEM 31 mm 40	CX	1	15.26 €	0.36679881
2300000116	AGULHA P/SERINGA INTRA LIGAM. 30G (0,3x12)	CX	3	13.92 €	3.301189286
2700000695	FITA MATRIZ 5 mm DENTAURUM 831-701	UN	1	6.21 €	0.733597619
				4,869.92 €	257.4570298kg CO_2

Annex D – Interviews Guidelines (conducted in Portuguese)

Initial considerations

"Antes de mais obrigada por aceitar participar nesta entrevista"

"Esta entrevista está alinhada com o tópico da minha tese de mestrado: como reduzir o desperdício clínico de produtos, com caso de estudo aqui na faculdade, considerando produtos/artigos que nunca chegaram a sair do armazém para serem utilizados, assim como produtos/artigos que foram preparados para ser utilizados em serviços de cirurgia mas que, por algum motivo, acabaram por não ser utilizados. Com esta entrevista eu pretendo saber como são alguns processos, perspetivas sobre o tema e comportamentos habituais"

“Volto a relembrar que será uma entrevista com gravação de áudio no entanto nenhuma informação vai ser atribuída especificamente a nenhum participante e os nomes também não serão revelados, apenas as profissões para contextualização”

“Tem o direito de não responder ao que não quiser e também adicionar qualquer informação relevante”

“Peço então autorização para iniciar a gravação e a entrevista”

Requisition and devolution responsibles

1 “Qual a sua profissão na FDMLU? E quais as tarefas e responsabilidades tem inerentes ao seu trabalho”
2 “Como se processa a requisição de materiais?”
3 “Costuma requisitar a quantidade de material adequada ou tem por hábito pedir a mais ou a menos?”
4 “Com que regularidade necessita de realizar devoluções de materiais?”
5 “Considera que é desperdiçado muito material que não chega a ser utilizado?”
6 "Quais os materiais que estão mais frequentemente nesta situação (de devolução)?"
7 “Porque é que costuma realizar essas devoluções?” (Tentar realizar o 5-Why até chegar à raiz dos problemas)
8 “A quem costuma entregar os materiais?”
9 “Considera que existe controlo nesse processo?”
10 “Considera que a faculdade tem a preocupação de, de alguma forma, minimizar o desperdício? Se sim, qual?”
11 "Como considera que este processo poderia ser melhorado?"

Clinical Direction

1 “Qual a sua profissão na FDMLU? E quais as tarefas e responsabilidades tem inerentes ao seu trabalho”
2 “Existe algum tipo de controlo para a devolução de material pelas clínicas? Se sim como se processa? Se não, considera que seria importante?”
3 “Existem algumas normas ou procedimentos a adotar para o descarte de materiais fora do prazo? E os materiais que já não irão ser utilizados pelas clínicas?"
4 “Sendo este espaço uma faculdade, considera que seria possível a utilização dos materiais fora do prazo por alunos de pré-clínico (os que ainda não têm contacto com pacientes)? Ou seria esta prática potencialmente perigosa?”
5 "Que outras opções considera interessantes para promover a reutilização dos materiais não utilizados? (Tanto os que estão "parados" no armazém assim como os que foram levados mas não foram utilizados na cirurgia)
6 “Pela sua experiência quais considera serem as maiores causas de desperdício nas clínicas (referindo desperdício como material que não foi utilizado e é descartado)?"
7 "Como considera que este processo poderia ser melhorado?"

Provisioning professional

1 “Qual a sua profissão na FDMLU? E quais as tarefas e responsabilidades tem inerentes ao seu trabalho”
2 "No processo de requisição como é garantido que o material comprado é o correto?"
3 "Como são determinadas as quantidades a encomendar de cada material?"
4 "Quando o material é requisitado erradamente o que lhe é feito?"
5 "Existe alguma forma de controlo sobre o material sem possibilidade de utilização? O aprovisionamento tem conhecimento destes casos?"
6 "Pela sua experiência quais são as causas para materiais não serem utilizados?"
7 "Como considera que este processo poderia ser melhorado?"

Warehouse professional
1 “Qual a sua profissão na FDMLU? E quais as tarefas e responsabilidades tem inerentes ao seu trabalho”
2 “Relativamente ao desperdício clínico, sente que existem muitos materiais que são deitados fora ou que ficam aqui no armazém sem terem tido utilização nem terem utilização futura?”
3 "Quais os materiais que estão mais frequentemente nesta situação?"
4 “As clínicas têm por hábito entregar ao aprovisionamento os materiais que já não querem utilizar?”
5 "Pela sua experiência quais são as causas para materiais não serem utilizados?"
6 "Existe algum tipo de controlo para a entrega e receção destes materiais?"
7 "Onde são guardados esses materiais? Existe alguma forma de armazenamento específica"
8 "Qual o processo de descarte?"

9 “Qual considera ser a visão da faculdade quanto ao desperdício produzido? Se há preocupação, se poderiam existir mais normas”/ "Como considera que este processo possa ser melhorado?"

Annex E – Return process As-Is

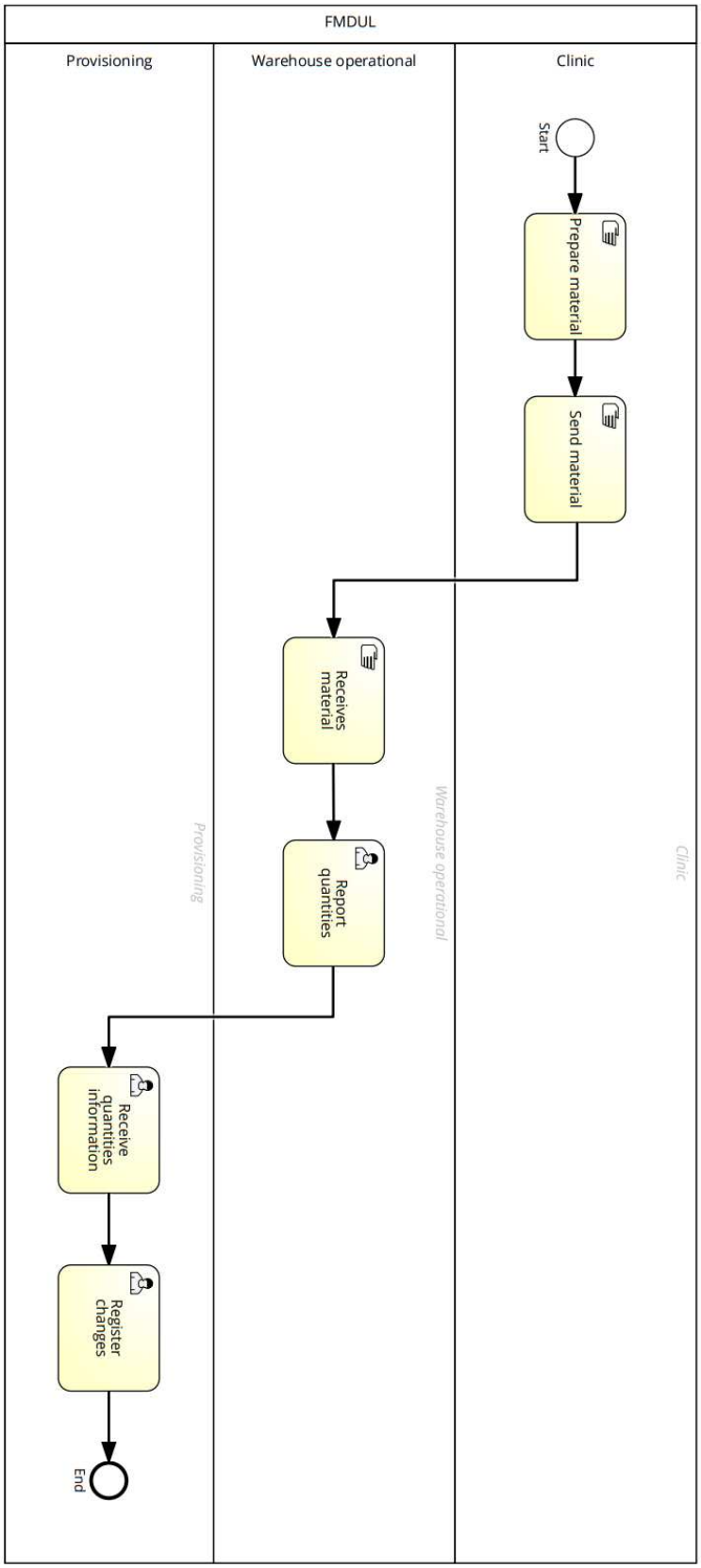
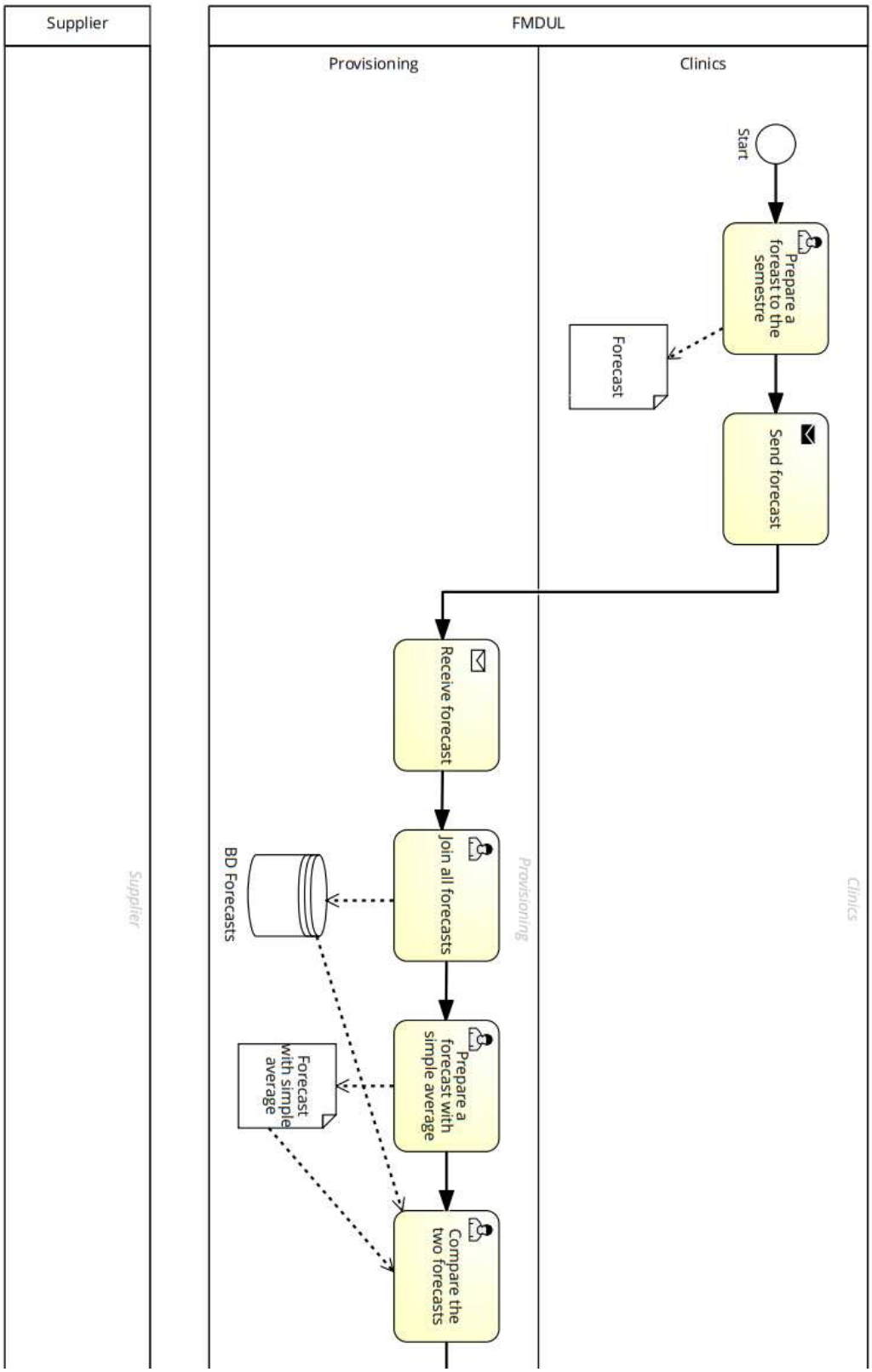


Figure A.1 - Return process As-Is

Annex F– Semestral forecasts and orders As-is



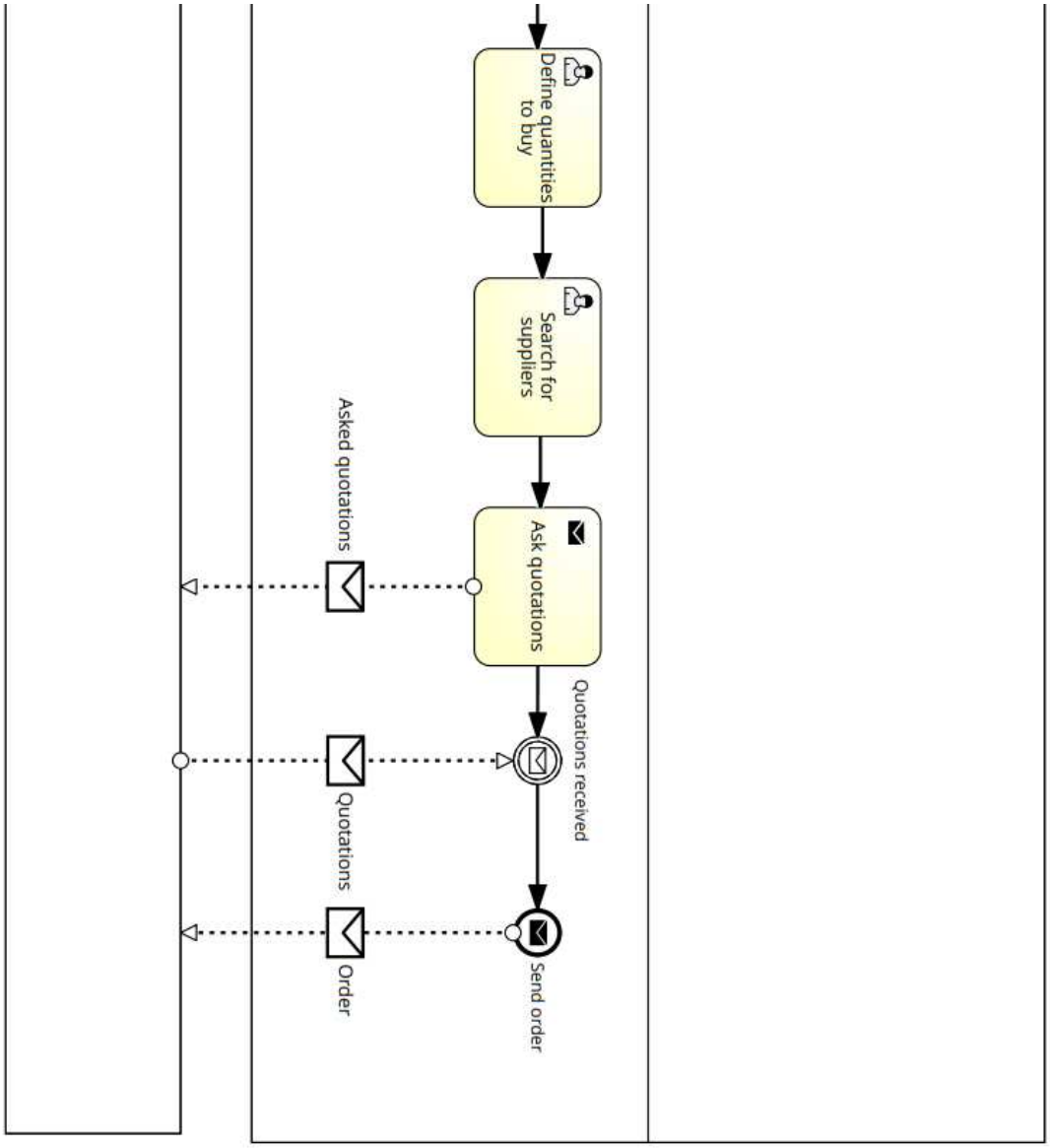


Figure A.2 - Semestral forecasts and orders As-is

Annex G - Daily ordering process As-is

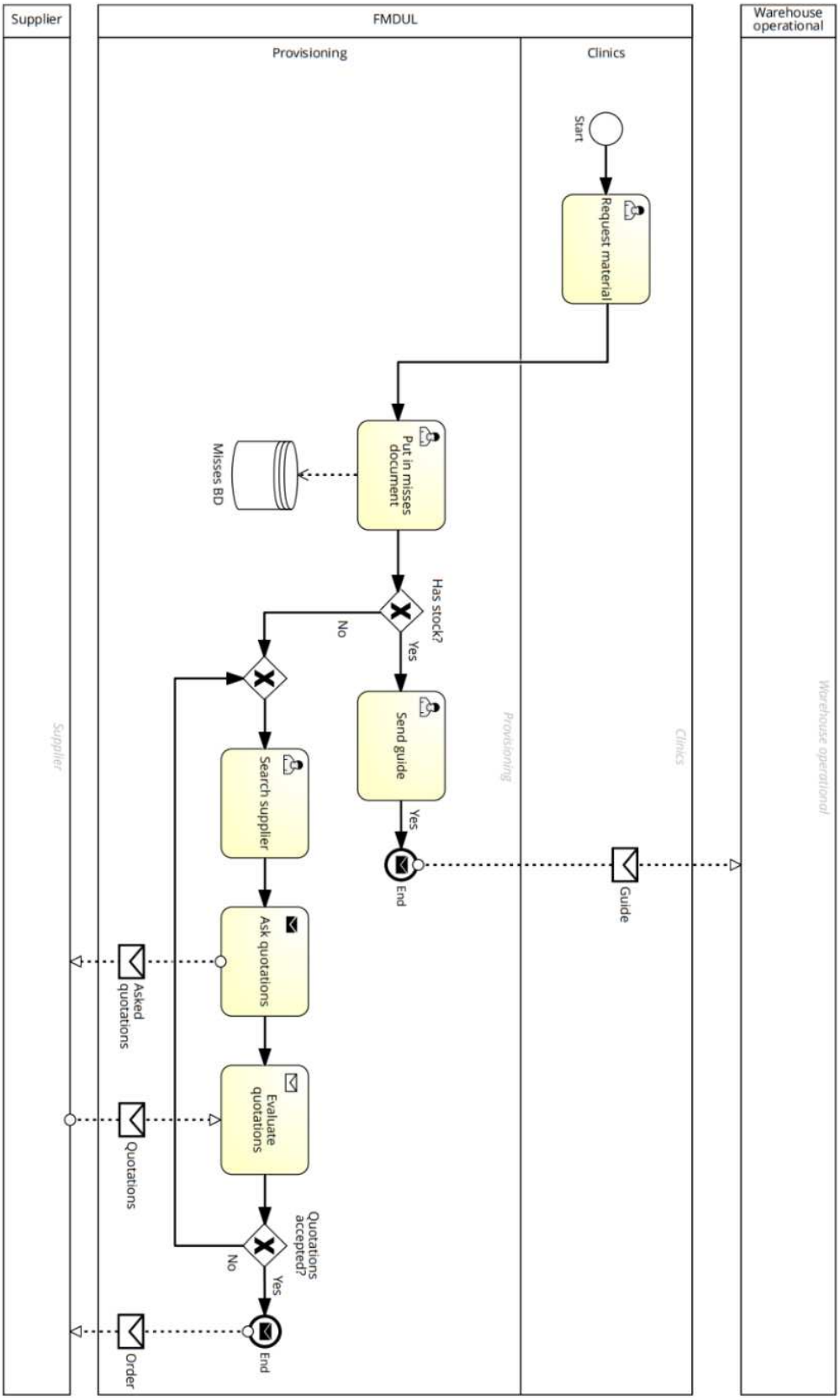


Figure A.3 - Daily ordering process As-is

Annex H – Codes addition propose

Table A.4 - Propose of the codes to add to the supplies list

Code name	Measuring unit
Ah plus	UN
Ionoseal- seringa 3x2,5	UN
Cones de gutta wave one gold small- conform fit	PAC
Cones de gutta wave one gold large- conform fit	PAC
Cones de gutta wave one gold primary- conform fit	PAC
Cones de gutta protaper next- comform fit- x3	PAC
Cones de gutta protaper next- comform fit- x4	PAC
Limas reciproc nº25- 25mm	PAC
Limas c+ 25mm - nº 08	PAC
Limas c+ 25mm - nº 10	PAC
Limas c+ 25mm - nº 15	PAC
Limas c- pilot 25mm - nº10	PAC
Limas c- pilot 25mm - nº15	PAC
Limas wave one gold 25 mm- small	PAC
Limas wave one gold 25 mm- medium	PAC
Limas wave one gold 25 mm- large	PAC
Limas wave one gold 25 mm- primary	
Protetor para sensor rvg	PAC
Rubber dam/ dique sem latex	PAC
Escovilhões curaprox cps prime 06	PAC
Escovilhões curaprox cps prime 07	PAC
Escovilhões curaprox cps prime 08	PAC
Escovilhões curaprox cps prime 09	PAC
Escovilhões curaprox cps prime 011	PAC
Escovilhões curaprox cps perio 405	PAC
Escovilhões curaprox cps perio 406	PAC
Escovilhões curaprox cps perio 408	PAC
Escovilhões curaprox cps perio 410	PAC
Escovilhões Curaprox CPS Prime 0,8mm	PAC
Escovilhões Curaprox CPS Prime 0,9mm	PAC
Escovilhões Curaprox CPS Prime 1,7mm	PAC
Escovilhões Curaprox CPS Prime 2,5mm	PAC
Escovilhões Curaprox CPS Prime 2,2mm	PAC
Escovilhões TEPE Rosa 25un	PAC
Escovilhões TEPE Laranja 25un	PAC
Escovilhões TEPE Vermelho 25un	PAC
Escovilhões TEPE Azul 25un	PAC
Escovilhões TEPE Amarelo 25un	PAC
Escovilhões TEPE Verde 25un	PAC
Escovilhões TEPE Roxo 25un	PAC
Escovilhões TEPE Cinzento 25un	PAC
Escovilhões TEPE Preto 25un	PAC
Opalescence pf 10% regular	PAC

Ácido fluorídrico	UN
Sutura nylon arago 5/0 19mm	CX
Sutura nylon arago 4/0 19mm	CX
Alicate prefurador de dique	UN
Relyx unicem automix	PAC
Optagrate abrebocas	PAC

Annex I – ABC Volume

VOLUME

Consumos 2020-2022

Código	Material	Unid	UN	Cummul Count	Cummul Count %	Quantity	Quantity U	Cummul Quant	Cummul Quant %	Level
2300000044	TESTE QUIMICO TST BROWNE	CX	20	70	8.91%	52	1040	2497861	98.28%	C
2300000043	CLINICHECK USW - TESTE EFICÁCIA LAVAGEM	CX	100	71	9.03%	10	1000	2498861	98.32%	C
2300000068	LUVAS ESTERILIZADAS Nº 7	PAR	2	72	9.16%	500	1000	2499861	98.35%	C
2100000075	ANESTESIA - OCTOCAÍNA 1/100.000	CX	100	73	9.29%	10	1000	2500861	98.39%	C
2700000776	CONE PAPEL Nº 15	CX	200	74	9.41%	5	1000	2501861	98.43%	C
2700000884	LIMA TIPO K 25 mm 10	CX	6	75	9.54%	164	984	2502845	98.47%	C
2700000337	ESCOVAS PARA DENTES	UN	1	76	9.67%	948	948	2503793	98.51%	C
2700000707	NYSTROMS CLASS V V	PAC	12	77	9.80%	73	876	2504669	98.54%	C

Figure A.4 - ABC analysis with the volume criteria

Annex J – Clinical importance measuring

			Material essencial C0		Material essencial C1		Material essencial C2						
Código	Material	Un	M Implan	PN Esp	HO	MIMD	Perio	PG C Int	PG Pros	C Ext Or	PG End	PG Odontop	Tota
2300000130	SERINGA ENDO NEEDLE 5 ml	UN									X		1
2700000003	ALGINATO ORTHOPRINT	PAC	x			x				x			3
2300000146	ASPIRADOR CIRURGICO EURONDA EM-21	PAC						x				x	2
2400000064	CERA ALMINAX	CX				x							1
2700000785	CONE PAPEL Nº 70	CX				x							1
2300000025	MASCARAS CIRURGICAS VERDES	CX	x	X	x	x	x		X	x	X	x	9
2300000026	COMPRESSAS DE GAZE 5*5	PAC	X	X	x	x	x	x	X		X	x	9
2300000027	BARRETE VERDE C/ELASTICO	PAC	X	X	x	x	x	x	X		X	x	9
2700000295	ACONDICIONADOR CANAIS GLYDE-DENTSPLY	UN				x					X		2
2700000021	PASTA IMP. TURBOFLEX LIGHT NORMAL SET	UN	X			x							2

Figure A.5 - Clinical importance data collection

CLINICAL IMPORTANCE - OPINIONS

Número total de serviços = 10 3-10: A 2: B 0-1: C

Código	Material	Number of Services	ABC	Coun	Count %
2100000008	CHLOROHEXIDINA DENTAL GEL	3	A	147	18.68%
2100000051	ESPONJA HEMOSTÁTICA - CLINIX	3	A	148	18.81%
2100000053	VASELINA - LIQUIDA	3	A	149	18.93%
2100000066	SEDA SAFIL VIOLET REAB. 4/0 DS 19 C1048420	3	A	150	19.06%
2100000073	SORO FISIOLÓGICO 10 ml	3	A	151	19.19%
2100000076	LAMINAS PARA BISTURI Nº 15 C	3	A	152	19.31%
1000001179	MARCADOR DE ACETATO	3	A	153	19.44%
2300000028	BOTAS DE PLASTICO / COBRE BOTAS	3	A	154	19.57%
2700000456	FIO RETRACCÃO ULTRAPAK Nº 00	3	A	155	19.70%

Figura A.6 - Clinical importance ABC

Annex K – ABC Substitute Level

SUBSTITUTE LEVEL

A: 0 substitutos B: 1 substituto C: 2 ou mais subtitutos

Code	Material	CPV	Unity	Substituto	Nível de substituição	ABC
2700000965	DISCOS PAPEL SOFLEX 3M 1982 M	33131114	CX	14	2	B
2700000938	DISCOS AÇO CARBONO 1	33138000	UN		0	A
2700000934	DISCOS PAPEL SOFLEX 3M 1981 M	33138000	CX	14	2	B
2700000935	DISCOS PAPEL SOFLEX 3M 1981 F	33138000	CX	13	2	B
2700000960	DISCOS PAPEL SOFLEX 3M 1982 C	33131114	CX		0	A

Figure A.7 - Substitute level ABC

Annex L – Lead Time standard deviation and average

Figure A.8 - Lead time average and standard deviation

NE	Date of ordering	Date of arrival	Lead Time		
4080003073	26/01/2022	11/02/2022	16.00	0.533333	months
4080003137	18/02/2022	23/02/2022	5.00	0.166667	months
4080003125	17/02/2022	03/03/2022	14.00	0.466667	months
4080003125	17/02/2022	31/03/2022	42.00	1.4	months
4080003245	11/03/2022	08/04/2022	28.00	0.933333	months
4080003282	28/04/2022	06/05/2022	8.00	0.266667	months
4080003321	10/05/2022	24/05/2022	14.00	0.466667	months
4080003371	24/05/2022	30/05/2022	6.00	0.2	months
4080003357	18/05/2022	15/06/2022	28.00	0.933333	months
4080003413	09/06/2022	27/06/2022	18.00	0.6	months
4080003364	20/05/2022	28/06/2022	39.00	1.3	months
4080003440	24/06/2022	06/07/2022	12.00	0.4	months
4080003236	25/03/2022	11/07/2022	108.00	3.6	months
4080003460	06/07/2022	28/07/2022	22.00	0.733333	months
4080003514	05/08/2022	19/08/2022	14.00	0.466667	months
4080003512	29/07/2022	31/08/2022	33.00	1.1	months
4080003530	23/08/2022	06/09/2022	14.00	0.466667	months
4080003498	28/07/2022	07/09/2022	41.00	1.366667	months
4080003551	25/08/2022	15/09/2022	21.00	0.7	months
4080003603	26/09/2022	07/10/2022	11.00	0.366667	months
		Average	24.70	0.823333	months
		Stand dev	22.10	0.736516	months

Annex M – Example of standard deviation and average demand

Table A.5 - Standard deviation and average demand calculation

		2021													2022						
Material	U	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	$\bar{D}$	$\bar{\sigma}$
AGULHA DENTAL 27G LONGA (0.40x35)	CX	10	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0.0	0
ASPIRADOR RECTO DE PLASTICO	PAC	35	0	0	8	0	6	0	1	19	12	2	22	10	5	14	10	26	15	13.3	7.146
KAVO SPRAY - OLEO KAVO	UN	10	0	0	0	0	4	6	0	4	3	0	4	0	0	4	2	10	4	3.3	3.72
AGUA OXIGENADA 10 VOLUMES	UN	35	0	10	20	0	24	3	0	37	30	2	38	0	30	21	6	31	10	16.3	12.94
SORO FISIOLÓGICO 20 ml	UN	100	0	0	0	200	0	100	0	280	60	0	160	280	0	120	200	521	61	197.0	187.14
ALMOFADA DE GELO	UN	10	0	100	0	0	0	0	0	20	110	60	0	0	180	130	50	170	180	118.3	76.27

Annex N – TBO correspondence

Table A.6 - TBO levels correspondence to months review

PEE Level	Jan	Feb	Mar	Ap	May	Jun	Jul	Aug	Sep	Oc	Nov	Dec
11/12 – 12/12							X					
10/12 – 11/12		X					X	X				
9/12 – 10/12		X				X				X		
8/12 – 9/12	X			X			X			X		
7/12 – 8/12		X		X		X		X		X		
6/12 – 7/12	X		X		X		X		X		X	

5/12 – 6/12	X	X		X		X			X		X	X
4/12 – 5/12	X	X		X		X		X	X	X		X
3/12 – 4/12	X	X	X		X	X		X	X		X	X
2/12 – 3/12	X		X	X	X	X	X	X	X		X	X
1/12 – 2/12	X	X	X	X	X	X		X	X	X	X	X
0,001 – 1/12	X	X	X	X	X	X	X	X	X	X	X	X

Annex O – User Manual to Returns Control

First, it is asked if you want to clear the order – if you click "Yes", all the information and quantities are going to be eliminated; if you click "No", all the information that was there previously will remain there.

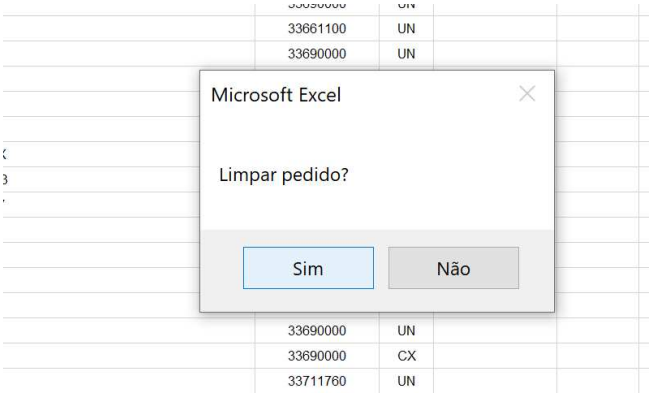


Figure A.9 - Cleaning option in the return report tool

The sheet "Pedidos" is going to be opened and filled with all the information.



Figure A.10 - Sheet "Pedidos"

In the header, it must be select which service will return the material and which service will receive the material:

- Esterilização (sterilization) – materials that cannot be used again, for example out of date or damaged

- Aprovisonamento (warehouse) – when they can still be used by other services

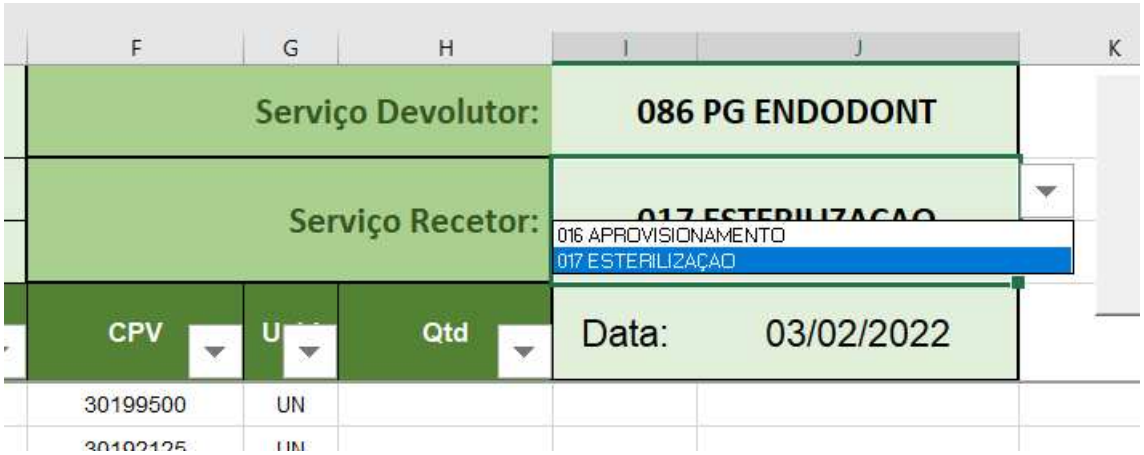
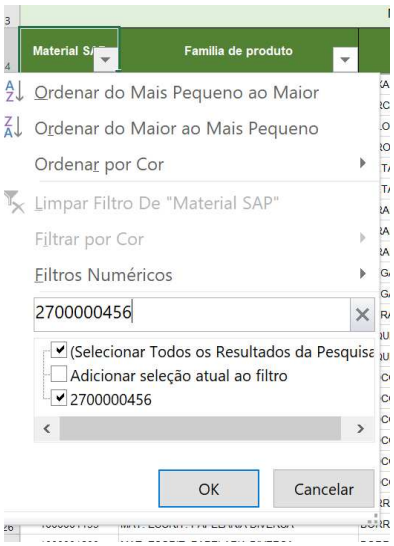


Figure A.11 - Service choosing

To search for the material more quickly, it can be used the material code or the text – for example, to search for material 2700000456 (ULTRAPAK RETRACTION WIRE Nº 00):

Click on the down arrow next to "SAP Material" or "TxtBreveMaterial" and type the material code or material name and "OK".



Or

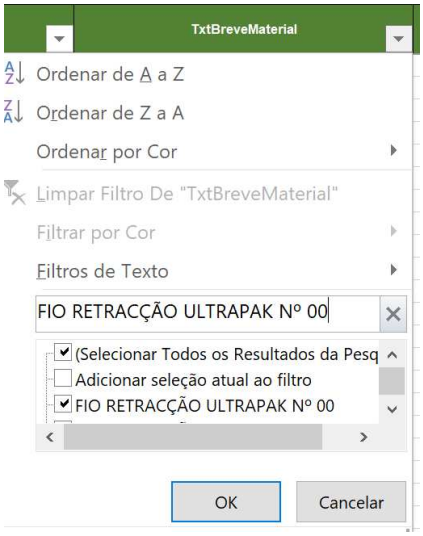


Figure A.12 - Search by code or material name

In the return reason, by clicking on the down arrow, several options appear to justify why the material is returned – expired, damaged or not what the service wanted. If the reason is not one of those mentioned, the option "Other" is selected and justified in the observations. In the remarks it can also be indicate the batch of material and important notes. In the column "Qtd" indicate the amount that will be returned.

Material SAP	Família de produto	TxtBreveMaterial	Motivo de devolução	Obs. (Mat especif / Lotes / Notas)	CPV	Unid	Qtd	Dat
2100000014	FARMACIA	XILONIBSA SPRAY 80 ML			33661100	UN		
2100000015	FARMACIA	VENTILAN INALADOR			33690000	UN		
2100000016	FARMACIA	ADESIVO ANTI ALERGICO 10 cm	Fora do prazo de validade		33600000	UN	2	
2100000017	FARMACIA	ADESIVO ANTI ALERGICO 5 cm	Material sem condições de utilização	Nota A	33600000	UN	1	
2100000018	FARMACIA	ADESIVO ELASTOPLAST 10 cm	Material sem condições de utilização		33600000	UN	5	
2100000019	FARMACIA	ADRENALINA - AMPOLAS 1 ml	Outro (indicar qual)	Razão X	33690000	UN	1	
2100000020	FARMACIA	AGUA OXIGENADA 10 VOLUMES	Fora do prazo de validade	Lote 123	33690000	UN	3	
2100000021	FARMACIA	ALCOOL 70	Material sem condições de utilização	Razão Y	24322500	UN	1	
2100000022	FARMACIA	ALCOOL PURO 90	Fora do prazo de validade		24322500	UN	2	
2100000023	FARMACIA	APYROL POMADA 50 gr			33690000	UN		
2100000024	FARMACIA	BETADINE - POMADA DERMICA			33690000	UN		
2100000025	FARMACIA	BETADINE - SOLUÇÃO DERMICA			33690000	UN		
2100000026	FARMACIA	BETADINE - SOLUÇÃO ESPUMA			33690000	UN		
2100000027	FARMACIA	COTONETES			33690000	CX		
2100000028	FARMACIA	FIO DENTÁRIO EXTRA WIDE			33711760	UN		
2100000029	FARMACIA	FIO DENTÁRIO EM BOBINE			33711760	UN		
2100000030	FARMACIA	PENSOS RÁPIDOS			33690000	CX		
2100000031	FARMACIA	LAMINAS PARA BISTURI Nº 12 D			33141411	UN		
2100000032	FARMACIA	LAMINAS PARA BISTURI Nº 15			33141411	UN		

Figure A.13 - Register of return information

After all the fields are completed, it is registered the list of materials and their information must appear in the sheet "Impressão Pedidos".

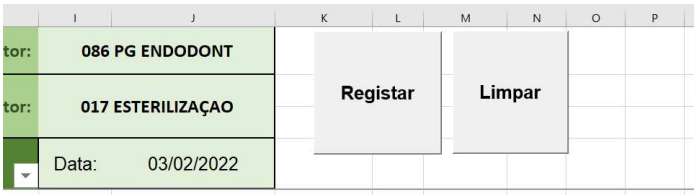


Figure A.14 - Register button


DEVOLUÇÃO DE MATERIAIS

Data: 03/02/22
Devolução: 01/2022

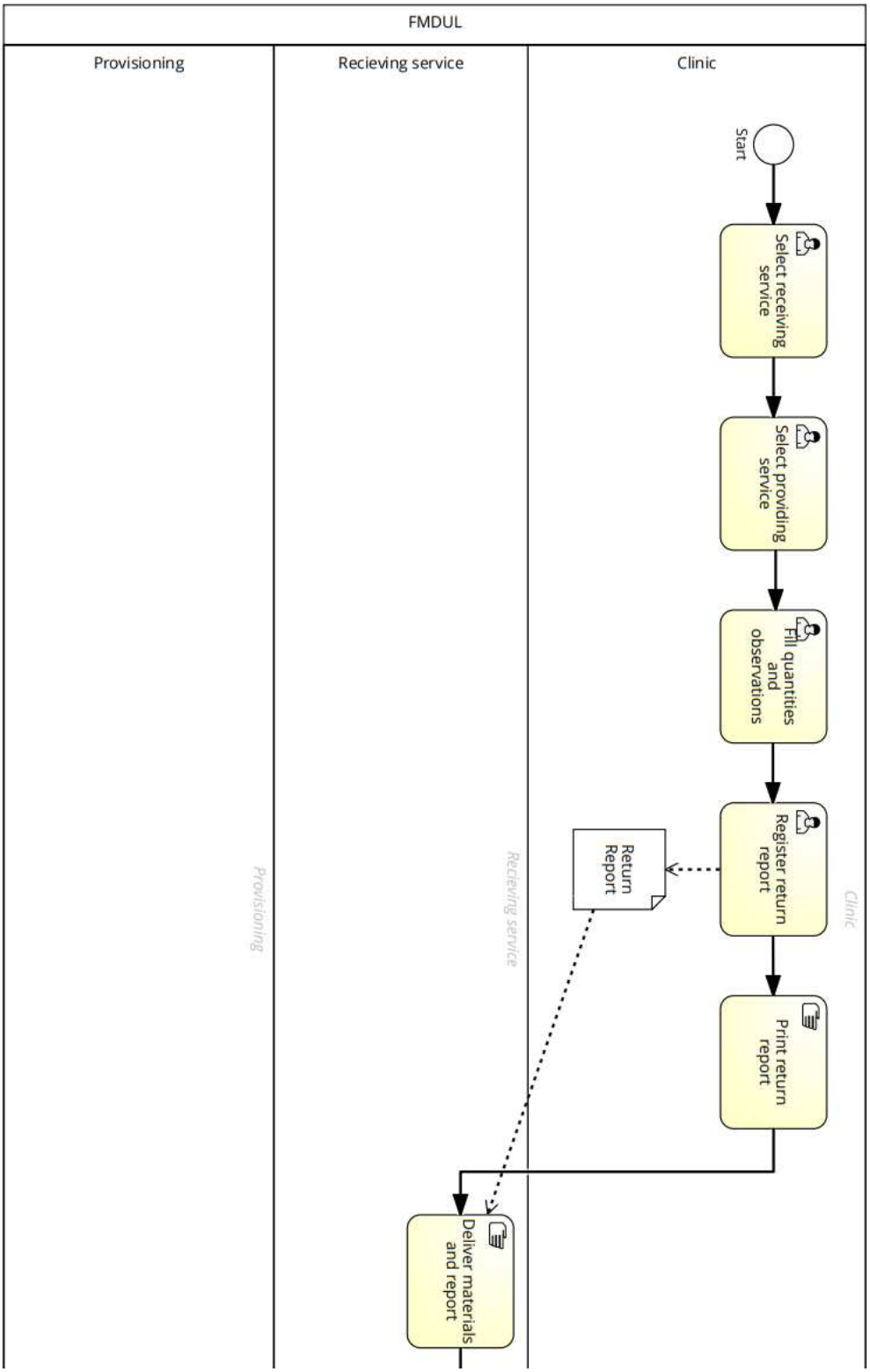
Cod. Material	Descrição	Motivo	Obs.	CPV	Unid.	Qtd
2100000016	ADESIVO ANTI ALERGICO 10 cm	Fora do prazo de validade		33600000	UN	
2100000017	ADESIVO ANTI ALERGICO 5 cm	Material sem condições de utilização	Nota A	33600000	UN	
2100000018	ADESIVO ELASTOPLAST 10 cm	Material sem condições de utilização		33600000	UN	
2100000019	ADRENALINA - AMPOLAS 1 ml	Outro (indicar qual)	Razão X	33690000	UN	
2100000020	AGUA OXIGENADA 10 VOLUMES	Fora do prazo de validade	Lote 123	33690000	UN	
2100000021	ALCOOL 70	Material sem condições de utilização	Razão Y	24322500	UN	
2100000022	ALCOOL PURO 90	Fora do prazo de validade		24322500	UN	

Devolutor: 086 PG ENDODONT
Assinatura e data

Recetor: 017 ESTERILIZAÇAO
Assinatura e data

Figure A.15 - Report output

Annex P – Return materials process To-be



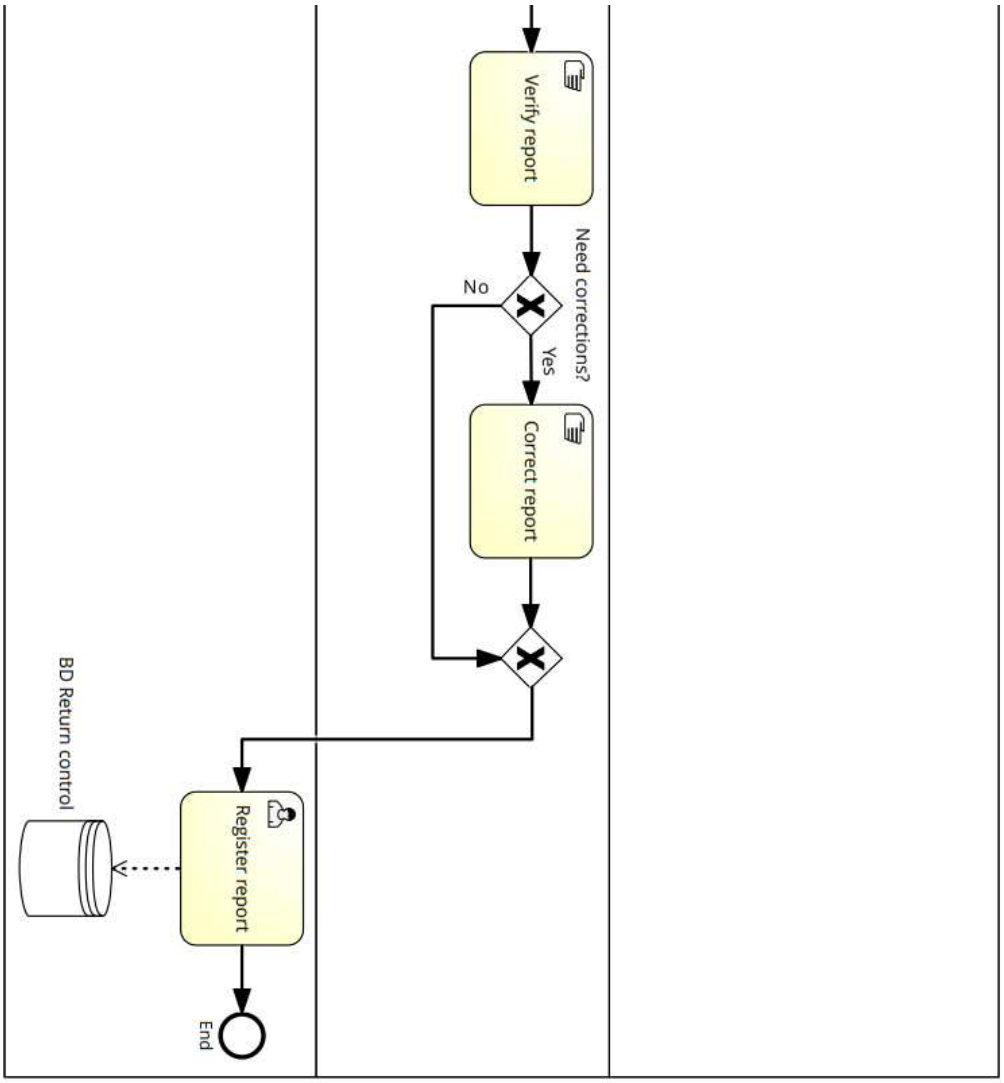


Figure A.16 - Return material processes To-be

Annex Q – User Manual to Inventory Management Tool

Inventory Management will follow two types of reviews to the material codes: Continuous Review (every day consult); Periodic Review (monthly consult), explained bellow.

In the "Quick Search" sheet, the continuous review is made by clicking in the button "What to Order" bellow the daily search and the periodic review is made by clicking in the button "What to Order" bellow the monthly search.

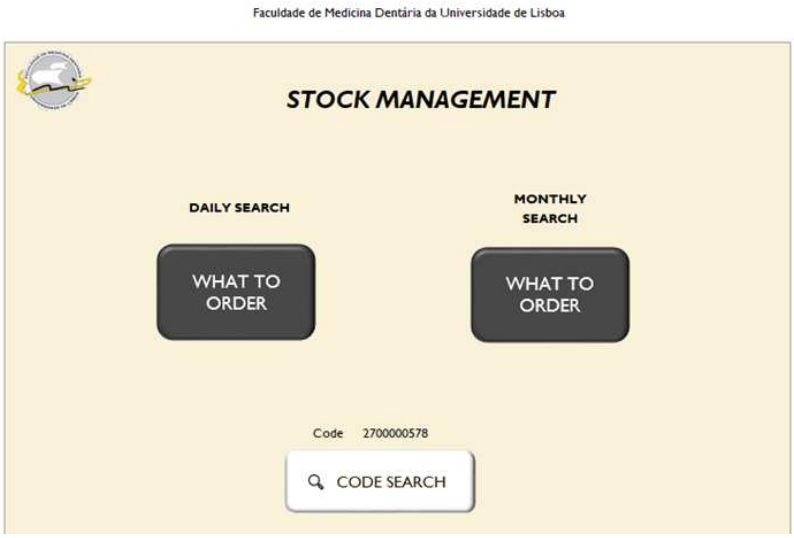


Figure A.17 - Quickly search view

1. Continuous review

Every day, provisioning service will see if there are some materials that needs to be ordered. These are the most critical supplies so a close monitoring must be secured.

After clicking in the "Daily Search – What to order", a list with the supplies that need to be order appears, similar to the next Figure

CONTINUOUS REVIEW

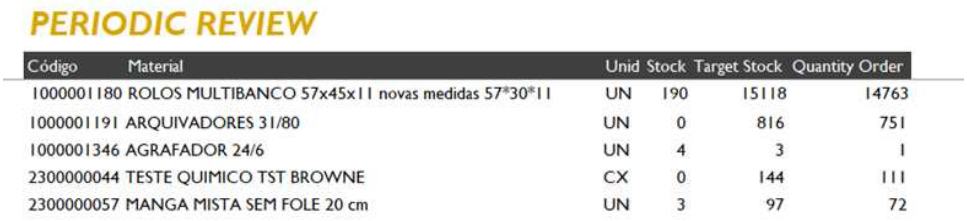
Código	Material	Unid	Stock	Reorder Point	EOQ
1000001178	CAIXA DE CARTÃO P/MODELOS ORTODONTIA	UN	0	111	191
1000001335	PAPEL BRANCO A/4 80 gr	RES	50	74	75
1900000078	LIXIVIA - 5%	UN	6	7	31
1900000108	LIXIVIA	UN	4	9	52
1900000116	BENZINA	L	0	3	0
2100000003	ANESTESIA - ARTICAÍNA/EPINEFRINA 1/200.000	CX	10	18	8
2100000006	ANESTESIA - TÓPICA - TOPI GEL 30 ml	UN	10	14	8
2100000008	CHLOROHEXIDINA DENTAL GEL	UN	0	8	14
2100000021	ALCOOL ETÍLICO 70% - 250 ml	UN	15	25	82
2100000027	COTONETES	CX	5	5	10
2100000047	SOLUÇÃO DE ERITROSINA DENTO-PLAQUE	UN	1	4	8
2100000049	SORO FISIOLÓGICO 20 ml	UN	233	378	416
2100000050	SORO FISIOLÓGICO 250 ml	UN	70	106	82
2100000053	VASELINA - LIQUIDA	L	0	1	5
2100000066	SEDA SAFIL VIOLET REAB. 4/0 DS 19 C1048420	CX	0	5	2

Figure A.18 - Continuous review view

For each one of the supplies showed in the list, a supplier must be placed and the quotations and previous order steps are made.

2. Periodic review

Every month on the day 1, provisioning service will see if there are some materials that needs to be ordered. After clicking in the "Monthly Search – What to order", a list with the supplies that need to be order appears, like the next Figure



PERIODIC REVIEW

Código	Material	Unid	Stock	Target Stock	Quantity Order
1000001180	ROLOS MULTIBANCO 57x45x11 novas medidas 57*30*11	UN	190	15118	14763
1000001191	ARQUIVADORES 31/80	UN	0	816	751
1000001346	AGRAFADOR 24/6	UN	4	3	1
2300000044	TESTE QUIMICO TST BROWNE	CX	0	144	111
2300000057	MANGA MISTA SEM FOLE 20 cm	UN	3	97	72

Figure A.19 - Periodic review view

A similar strategy to the continuous review is followed here; with the supplier search and quotation ask.

3. Search by code

It is also possible to see the main information about a code filling the cell near to "Code" with the code number that the professional needs to look. By clicking in the "Code Search" button, the following information appear:



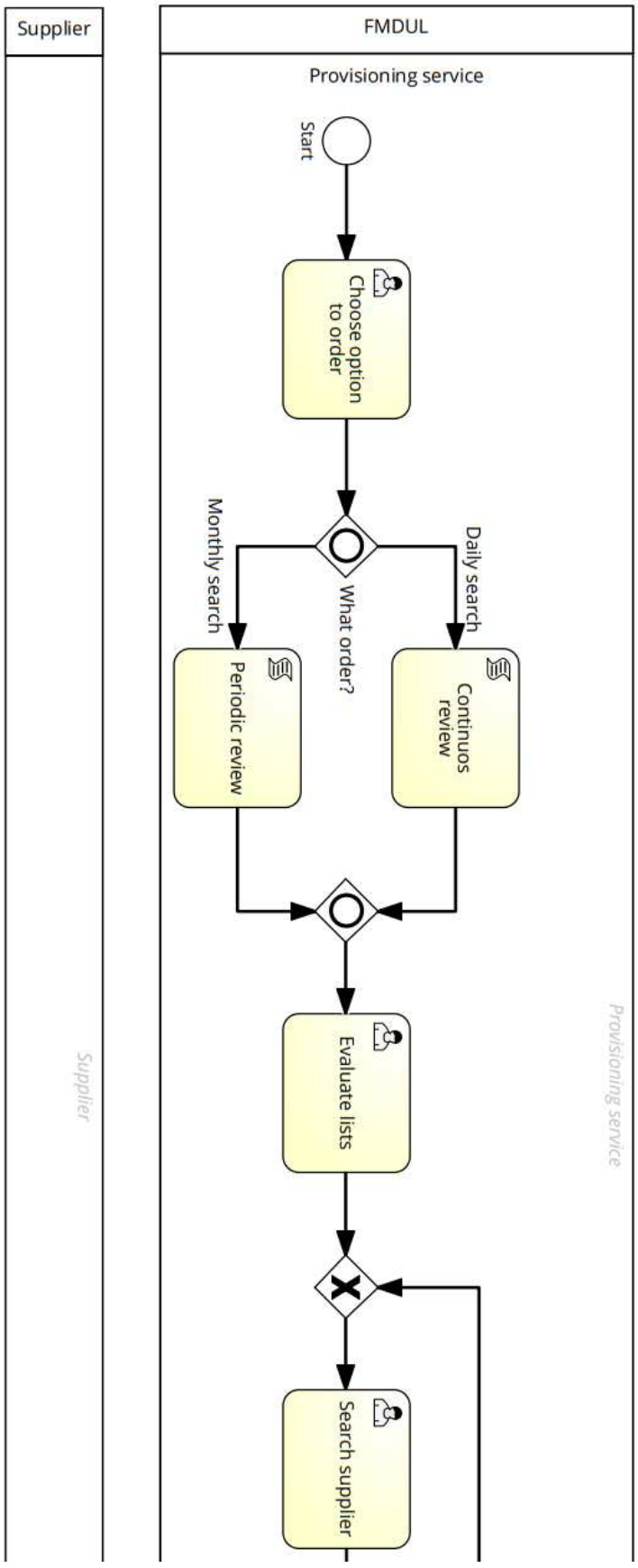
CODE SEARCH

Código	Material	Unid	ABC	Type of Ordering	Stock		Foreca	Reorder Point	EOQ	Order	PEE	
2700000578	AÇO 310 206 679 336 090 GATES N°3	UN	B	Continuous Review	0	0		0	0	NO		0

Figure A.20 - Code search view

The tool is translated to Portuguese for its implementation, once the professionals that use it are all Portuguese.

Annex R - Inventory management and order To-be



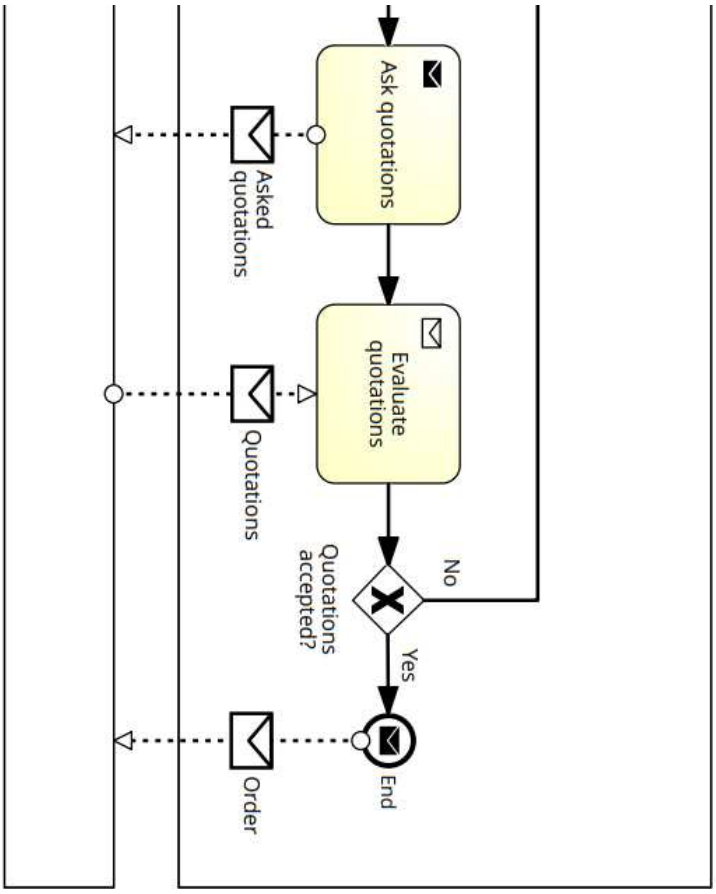


Figure A.21 - Inventory management and order To-be