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and Nova School of Business and Economics**

SUPPLIERS' EVALUATION MAP AS A SUSTAINABILITY PRACTICE

Pharmaceutical Sourcing in a Portuguese Hospital

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Abstract

The healthcare sector's role in climate change and the complexity of the pharmaceutical supply chain present challenges for the future. This work project attempts to develop a framework addressing these issues through improved pharmaceutical suppliers' evaluation. Its main contribution is the introduction of a sustainability evaluation map. The proposed tool is applied to a Portuguese hospital group, and was built using a qualitative method. Relevant criteria were identified and weighted based on interviews. The results identify 22 criteria summarized in five topics: Mobility, Packaging, Production, Waste Management and Social Sustainability. An example of application is provided.

Keywords

Sustainability, Sourcing, Evaluation Map, Supply Chain, Pharmaceutical Industry, Criteria, Operations Management.

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1. INTRODUCTION

1.1.Contextualization

The health sector is fundamental to societal well-being, intrinsically connected to the universal right to health, a core principle stated by the World Health Organization (WHO) as a basic human right (2017).

This sector also represents a very important part of the global economy, illustrated by the large size of the health care workforce in Europe. In 2019, the Organization for Economic Cooperation and Development (OECD) reported that one in every ten jobs in their state members was in care. Furthermore, healthcare expenditures constitute a major portion of the Gross Domestic Products (GDP) across European countries. In 2022, it averaged 9.2% of the GDP (OECD 2023).

Moreover, the health sector sets itself apart from the global industrial landscape due to its profound impact on human life, coupled with the unpredictability of health outcomes and the weight of ethical considerations. Therefore, rigorous regulations and policies are implemented to ensure the quality and accessibility of care, underscoring the sector's vital role in society (Barros 2024).

1.2.Health and Environment

Healthcare and environment mutually impact each other. On one hand, the sector is potentially very affected by the consequences of climate change, as extreme weather events directly impacts health. These events can cause immediate physical injuries and illnesses, also impacting mental health (Ebi et al. 2021).

On the other hand, due to its size and specific operations, healthcare is one of the most polluting sectors, being an important consumer of water and energy resources, and a significant generator of emissions and waste, with associated direct and indirect environmental impacts (WHO

2017). Globally, about 4.4% of greenhouse gases are attributed to health care, with hospitals being particularly energy intensive (Manyari 2024). Given the direct impact of climate change on public health, it is especially crucial for the sector to lead efforts in reducing its environmental footprint (Choi 2022).

1.3.The Pharmaceutical Industry

The pharmaceutical industry significantly contributes to the environmental impact of the healthcare sector. It is recognized as one of the most polluting industries due to its high levels of waste and energy consumption. Consequently, the industry faces the challenge of innovating its manufacturing processes to balance product safety with environmental sustainability (Lakerveld 2018).

Moreover, the pharmaceutical supply chain is very complex which complicates even more the sustainable journey of the industry. The production process is long and suffers from yield variability (Sarkis et al. 2021). Furthermore, the perishability of drugs is a critical factor; although they may be in perfect condition, once past their expiry date, they are no longer viable. This necessitates meticulous stock control to prevent waste and ensure safety (Coelho and Laporte 2014). Additionally, the seasonality of the drug demand, with a typical peak in the winter, often poses a risk of shortage which can have life-threatening consequences in this industry (Mazer-Amirshahi et al. 2020). The challenge lies in balancing inventory levels against the risk of drugs becoming outdated, requiring advanced forecasting and stock management techniques (Chung and Kwon 2016).

1.4.Hospital's Role as a Company

Hospital groups, as big firms, need to take actions to align with the European Green Deal's goals. This initiative seeks to cut net greenhouse gas emissions by at least 55% by 2030 relative

to 1990 levels (European Commission 2021). By working on reducing their own environmental footprint, hospitals can achieve the “Green Hospital” certification (Interview 3).

However, the scope of responsibility extends beyond the firms' immediate operations to include Scope 3 emissions¹, that encompass the entire supply chain, and that is often the largest share of an organization's carbon footprint (Shrimali 2022).

To address this, assessing suppliers by including green procurement criteria is a crucial step. This evaluation should include checks for certifications, as well as reviews of the suppliers' production cycles and water management practices (WHO 2015).

1.5. Research Question Statement

This work was carried out in collaboration with a hospital group based in Portugal, involving contacts with their Sustainability, Procurement, and Pharmacy teams.

In Portugal, main hospital groups are all defining ambitious climate goals for the future (CUF, Luz Saúde and Grupo HPA Saúde 2024). Still, none of them mentions initiatives regarding sourcing, and in discussion with the Sustainability Team, it is clear that there is currently no established system to select suppliers based on their sustainability impact within the pharmacy's supply chain.

Considering this gap, this research paper will address the following question: **"What Contributions Can a Suppliers' Evaluation Map Make to Sustainability Practices in the Pharmaceutical Sourcing of a Hospital in Portugal?"**. The proposed tool has the objective to help the hospital ranking its suppliers effectively, thereby facilitating the most informed decision-making regarding their selection. However, its implementation faces some challenges.

¹ Emissions originate from activities linked to a company but outside its direct control, occurring throughout its supply chain. (GHG Protocol)

2. LITERATURE REVIEW

2.1. The Critical Role of Supplier Selection in Procurement and SCM

2.1.1. Procurement Definition

Supply Chain Management (SCM) is associated with “the flow of goods and services from the supplier of raw material to the final consumer” (Forghani, Sadjadi and Moghadam 2018).

At the heart of any succesful supply chains, procurement departments have responsibilities related to suppliers selection, evaluation and negociation. Their efforts in managing these relationships bring significant savings and added value to the organization (Hatami-Marbini, Hekmat and Agrell 2020).

The supplier selection process usually begins with identifying needs, followed by establishing criteria, which are then used to score each supplier and select the most appropriate one (Zimmer, Fröhling and Schultmann 2015).

Nevertheless, in some cases, a single supplier cannot fulfill all the needs of a company, necessitating a strategy known as dual or multiple sourcing. While single sourcing can minimize costs and lead times, relying on multiple suppliers can enhance reliability by mitigating the risks associated with unstable suppliers. However, this approach complicates the supplier selection process (Hatami-Marbini, Hekmat and Agrell 2020).

2.1.2. Importance of Sourcing

Globalization and rising economic competition have made purchasing departments more important in supply chain performance, highlighting sourcing as a crucial strategic issue (Debnath et al. 2023). This increased focus is driven by the need to meet the ever-evolving preferences of customers and the significant role of material costs, which can constitute up to

70% of finished product expenses. Effective supplier selection is thus essential to reduce costs, minimize risks, and enhance product quality (Forghani, Sadjadi, and Moghadam 2018).

Additionally, the rise in outsourcing activities has heightened the importance of integrating all members of the upstream supply chain, with focal companies being held accountable for ensuring this integration (Zimmer, Fröhling, and Schultmann 2015).

As a result, the purchasing function has become increasingly vital, often contributing over 80% of the final product's value added. This shift highlights the critical role of supply chains and suppliers in a company's success, emphasizing the strategic importance of sourcing (Hatami-Marbini, Hekmat, and Agrell 2020).

2.1.3. Complexity of Sourcing

However, in today's competitive environment, supplier selection represents an important challenge for supply chain managers (Debnath et al. 2023). The rapid restructuring of the supplier landscape, driven by hyper-connectivity, reduce entry barriers and expands the options for sourcing globally. This expansion increases the number of potential suppliers to assess and select (Hatami-Marbini, Hekmat, and Agrell 2020).

Moreover, the selection process is complicated by the necessity to define criteria accurately. Irrelevant criteria can lead to poor procurement decisions, especially in an era where uncertainty and complexity of data are prevalent. Many sourcing departments still operate without a robust quantitative software, which often has a limited scope and fails to cover all aspects of decision-making (Hatami-Marbini, Hekmat, and Agrell 2020).

Additionally, sourcing must be resilient enough to handle unexpected disruptions, particularly in the healthcare sector, where the supply chain's stability is crucial for patient care (Debnath et al. 2023).

2.2.Sustainable Supply Chain

2.2.1. Definition

Sustainable SCM (SSCM) has become a priority for many businesses due to its impact on a company's long-term viability and competitiveness (Zimmer, Fröhling and Schultmann 2015). It includes the coordination of activities across the supply chain and the management of the flow of materials, information, and capital, while aiming to meet the objectives of the Triple Bottom Line (TBL) sustainability framework's three pillars (Debnath et al. 2023).

The TBL framework, developed by John Elkington, considers social, environmental, and economic dimensions within corporate operations. This approach can be used for evaluating suppliers' sustainability capabilities, enhancing corporate reputation, customer satisfaction, and investor relations (Lou, You, and Xu 2024).

A supply chain is considered sustainable if it encourages smaller order quantities, reduces emissions from transportation and processing, optimizes resource use, and minimizes the environmental impact of various logistical activities (Debnath et al. 2023).

2.2.2. Regulation

SSCM is driven by a global trend toward enhanced Environmental, Social, and Governance (ESG) disclosure, reflecting an increasing regulatory emphasis on sustainability. There is a need for transparency in how listed companies manage ESG challenges (Lou, You and Xu 2024).

In Europe, the Corporate Sustainability Reporting Directive (CSRD) and the Corporate Sustainability Due Diligence Directive (CSDD) form the core of sustainability regulations. The CSRD establishes a framework for companies to comprehensively report on sustainability initiatives and performance (Mazar 2021). In contrast, the CSDD mandates companies to

proactively address and mitigate their operations' adverse impacts on people and the environment (Adcock, Bains, and Crowe 2023).

These directives underscore the importance of integrating sustainability into business strategies. Over the past two decades, increasing regulatory pressures and stakeholder expectations have compelled companies to enhance their practices (Zimmer, Fröhling and Schultmann 2015).

2.3.Sustainable Procurement

The responsibility of healthcare systems extends beyond their immediate operations, with a significant part of their environmental footprint originating from the goods and services they procure (WHO 2017).

In this light, Sustainable Procurement, also called Sustainable Suppliers Selection (SSS) becomes a critical action point. As defined by the Global Green and Health Hospital (GGHH) network (2020), it aims to minimize the health and environmental impacts of procured goods and services to support community health, in alignment with the Sustainable Development Goal 12² (Global Goals 2024). SSS integrates the three pillars of sustainability, as defined by the TBL: Environmentally, it focuses on reducing the ecological footprint, highlighting energy efficiency, renewable resources, and sustainable packaging. Socially, it underscores the importance of Corporate Social Responsibility (CSR), ensuring fair labor practices defined by the International Labor Organization (ILO) and supporting community development. Economically, it examines the costs and long-term benefits of sustainable practices, balancing immediate costs with potential first-mover competitive advantages and enhanced reputation. An example is Germany's Supply Chain Due Diligence Act (SCDDA), which holds companies accountable for the environmental and social impacts within their supply chains (Rünz 2023).

² Goal 12: Responsible Consumption and Production

2.4.Sustainable Evaluation of the Suppliers

Among other actions to encourage sustainable procurement, the WHO (2013) mentions “the assessment of the environmental impact of products and services and where appropriated, substituting or innovating with alternative products materials or approaches that are more sustainable”. This aligns with the purpose of a suppliers’ sustainability evaluation map.

2.4.1. Main Criteria Found

Research on supplier evaluation has evolved significantly. Initially, studies like those conducted by Weber Charles et al. in 1991 highlighted quality, cost, and delivery time as key metrics (Hosseini, Flapper, and Pirayesh 2022). However, the traditional focus on financial metrics has shifted to include sustainability, with recent research by Fong et al. (2017) emphasizing "Green" competencies, environmental efficiency, green image, and net life cycle cost, alongside secondary factors like pollution output, resource consumption, and green practices in product design, management, warehousing, transportation and technology (Lou, You, and Xu 2024). This illustrates the natural shift in sourcing practices due to stricter regulations and increasing environmental awareness (Lee et al. 2009).

2.4.2. Multi-Criteria Decision-Making Techniques Used

To select the optimal supplier, Multi-Criteria Decision-Making (MCDM) techniques are used to identify the best solution, considering the various conflicting criteria in SSS. More precisely, the evaluation of suppliers corresponds to a Multi-Attribute Decision-Making (MADM) (Karakoç, Memiş, and Şennaroğlu 2023).

Many techniques have been described in the literature to proceed to the supplier’s evaluation. Hatami-Marbini, Hekmat, and Agrell (2020) are using the Principal Component Analysis-Data Envelopment Analysis (PCA-DEA) approach. Forghani, Sadjadi, and Moghadam (2018) use a PCA-Z-TOPSIS followed by a Mixed-Integer Linear-Programming (MILP). Hosseini, Flapper,

and Pirayesh (2022), for their part, implement a Best Worst Method-Evidential Reasoning (BWM-ER) method.

2.5.Literature Gaps Identification

Despite existing papers on supplier selection in the pharmaceutical industry and on sustainability, there remains a gap in the research that combines these two areas. Research on pharmaceutical supplier selection often overlook the crucial integration of sustainability criteria. Similarly, while sustainability is studied within the broader context of supply chain operations, its specific application to pharmaceutical suppliers is not thoroughly explored.

This gap is particularly significant given the importance of pharmaceutical industry's environmental footprint and climate change's impact on global health. This work project will therefore focus on developing supplier evaluation models that incorporate sustainability criteria to drive the pharmaceutical industry towards more responsible sourcing practices.

3. METHODOLOGY

The project's main goal is to develop a new supplier selection mechanism to enhance the sustainability of the hospital pharmaceutical supply chain. The intended outcome is an updated supplier evaluation map that incorporates sustainability criteria in the choice of the suppliers.

To achieve this goal, the methodology employed is a qualitative analysis through interviews, made with internal and external stakeholders of the partner hospital, including a site visit. To identify the most suitable interview candidates, an initial list of relevant profiles, based on the literature review, is developed. Each interview is then examined for gaps in expertise, and additional candidates are selected whose skills more precisely address the specific areas of interest.

In the context of this study, six individuals were interviewed, each bringing a different perspective to the research. To maintain the confidentiality of the experts involved, their identities have been withheld. All of them hold professional affiliations within the healthcare sector.

During Interview 1, discussions were held with the head of the Procurement Team of the hospital, who is responsible for negotiations with suppliers. Interview 2 featured a site visit to the pharmaceutical department of the hospital. In Interview 3, the quality manager of a Portuguese pharmaceutical firm was engaged. Interview 4 involved a Sustainable Operations teacher. Interview 5 provided an opportunity to speak with a member of the Portuguese Council for Health and Environment (CPSA). Finally, Interview 6 introduced a member of the National Association of Pharmacists (ANF). The interviews lasted a total of six hours, with an additional three hours per interview required for the preparation of the interview guide and the transcription, bringing the estimation of the total time commitment to 25 hours.

When all interviews have been completed, a classification of the information obtained has been made, first by interviewee (Appendix 2), and then by topic (Appendix 3).

Based on this classification, an evaluation framework is established, completing the current evaluation map used by the hospital by indicators assessing the sustainability practices of the pharmaceutical suppliers. This grid is organised by global topics: mobility, packaging, production, waste management and social sustainability. Weights are assigned, based on the importance of their impact on the company's sustainability.

To illustrate the functionality of the proposed evaluation map, the project concludes with an illustration simulating the outcomes of the updated evaluation map. The focus will be on demonstrating how the new framework operates and on generating a theoretical ranking of suppliers.

4. RESULTS

After conducting the interviews, an overview of the current supplier's evaluation of the hospital group is obtained, as detailed in the section below. Building on this understanding, the sustainability evaluation map is developed.

4.1. Current Suppliers Evaluation

The Procurement Team must conduct two types of evaluation, corresponding to different situations. In the first case, the group faces a new drug need and therefore launches a request for proposal to the market (Interview 1). The initial step in the process involves identifying all the potential suppliers, excluding those without an INFARMED³ license (Interview 1). Then, the list is narrowed based on global regulatory requirements (Interview 4). Once potential suppliers meet these criteria, and only after clinical validation by the pharmacists and the quality team, negotiations can be conducted with the selected suppliers (Interview 1).

In practical terms, potential suppliers are cataloged in an Excel spreadsheet, each column representing a criterion (Interview 1). The evaluation process uses a 10-point scale, known as the Likert Scale⁴, to quantify Central Negotiation and Pharmacy teams opinions on each criterion, thereby turning subjective assessments into measurable data (Emerson 2017).

The decision process is mainly based on a cost-benefit analysis. The evaluation considers equally weighted criteria being level of service, trust, easy communication, relationship duration, price stability and growth potential, while local suppliers are favorized. These factors contribute to operational efficiency and the development of long-term relationships with suppliers, which are essential for establishing sustainable practices (Interview 1).

³ National Authority of Medicines and Health products in Portugal, in charge of the evaluation and authorization of medicines (INFARMED 2024).

⁴ A survey tool that measures opinions by asking respondents to indicate their level of agreement with a series of statements.

The second evaluation relates to ongoing suppliers, with whom the hospital group has been collaborating for several years already. They must be evaluated on a continuous basis to encourage and support their increased efforts towards sustainability (Interview 1).

For both scenarios, the hospital is not taking any sustainable criteria into account at the moment. The year 2023 marks the first time the carbon footprint impact is factored into decision-making (Interview 4).

4.2. Construction of the Sustainability Evaluation Map

The sustainability evaluation framework includes two dimensions: environmental and social. For simplicity, the governance aspect of ESG is excluded, and economic factors are used as benchmarks. The environmental dimension is divided into specific categories: mobility, production, packaging, and waste management. Within each general topic, when possible, subcriteria are ranked by importance order according to the Waste Hierarchy Principle, as endorsed by the European Parliament (2008). This principle prioritizes prevention first, reusing materials as a secondary measure, and considers disposal as the least favored option. The detailed evaluation table can be founded in Appendix 4.

4.2.1. Mobility

In this area, the first priority is the *reduction of deliveries* (1.1.), a change driven by safety needs during the COVID-19 pandemic that has persisted due to its feasibility. However, hospitals must agree to this change as it decreases their flexibility (Interview 2), and suppliers fear losing a key competitive advantage (Interview 6). Additionally, legislative hurdles exist; INFARMED mandates that pharmacies need to have drugs available within 24 hours, preventing reductions in delivery frequency. This requirement contrasts with practices in other countries, where fewer deliveries are common (Interview 6).

The next aspect to reconsider is the optimization of the itineraries (1.2.). Suppliers should invest in an optimization software providing optimized planning and inventory management, which requires data accuracy and an important investment (Interview 1). Specifically, suppliers can form partnerships to combine deliveries, thereby reducing both their carbon footprint and transport costs (Interview 6).

Then, the transport mean needs to be considered. For domestic and shorter distances, land transport, including road and rail, is the priority (1.3.) due to its ability to reach precise locations (Interview 5). Using a fleet of electric trucks (1.3.1.) could further reduce emissions, but it complicates itinerary planning due to the necessary charging time, and current electric battery limitations make this unfeasible for now (Interview 3).

When distances are longer and land transport is not reasonable, shipping is preferred over air transport due to its cost-effectiveness and lower environmental impact (1.4.). However, for urgent or refrigerated deliveries to Portuguese islands, air transport is necessary due to the lengthy shipping times, which becomes an issue for the perishability of medications. In such cases, it is crucial to optimize logistics by utilizing space in already-scheduled cargo flights, rather than dedicating flights solely for pharmaceutical deliveries (Interview 3).

A final key consideration for mobility is the use of active cold chains (1.5.) for shipping. Previously, single use validated cold chain boxes, which are highly polluting, were employed. However, for transporting cold products to the islands, active cold chains are currently impractical due to their limited lifespan, necessitating air transport (Interview 3).

4.2.2. Production

The effort to source raw materials in the supplier's surroundings (2.1.) needs to be a priority regarding production processes. Indeed, hospital's proximity to a supplier does not guarantee the local origin of raw material. Conducting a lifecycle analysis to understand the impact of ingredients (their composition, source, and the production's consequences) is relevant

(Interview 4). Such an approach strengthens the local economy, aligning with hospital's values. Moreover, the supply chain is then less vulnerable to global disruptions, avoiding shortages (Interview 1).

A critical focus has also been placed on reducing energy and water consumption (2.2.). Regarding energy, it involves optimizing equipment, harnessing renewable energy sources, and employing monitoring systems to manage smartly energy demand. Concurrently, water conservation is achieved by implementing closed-loop systems that recycle water and treat wastewater. This approach is also economically beneficial, reducing the company's operational costs (Interview 3).

The production of drugs requires the usage of very toxic ingredients. After adhering to the ICH⁵ guidelines (Interview 3), it is also feasible to identify less toxic alternative ingredients (2.3.), and therefore proceed to the modification of the drug formulation. A pertinent example is the case of the halogenated anesthetics, Desflurane and Sevoflurane. Sevoflurane has been identified as an eco-friendlier alternative to Desflurane due to its lower Global Warming Potential (GWP). However, the shift to Sevoflurane is practically challenging as it has a longer recovery time for the patient. The transition is further complicated by the preferences of medical professionals that may be reluctant in switching (Interviews 1 and 2).

4.2.3. Packaging

Regarding packaging, the first thing to implement is quantity reduction (3.1.). This can be done by working with bulk production, increasing the batch size (Interview 2). However, this approach presents a significant trade-off: enlarging packaging sizes can reduce the overall amount of waste, but larger batches may compromise drug shelf life, as containers remain open

⁵ International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use

longer. This can paradoxically lead to increased waste if the drugs expire before use (Interview 3).

One concrete idea is to replace the notice inside the box by a QR code (3.2.). Notices represent a huge amount of paper, often not used by the patient (Interview 3). One significant challenge is that not all individuals possess smartphones, marginalizing some demographic groups, such as the elderly and disadvantaged people (Interview 6).

After reduction, the supplier can implement circular economy through the introduction of reusable packaging (3.3.). This shift, while logistically complex, involves setting up collection and transportation networks, while ensuring the hospital's collaboration. It also requires measures to ensure the packaging remains clean and still meets all safety standards. We also need to keep in mind that this is not adapted to all kind of drugs. However, with planning and by providing incentives (similarly to the successful bottle deposit system), this approach can be viable (Interview 2).

When it is not possible to reduce or reuse, the supplier can implement a shift to more sustainable material (3.4.). To mention some examples, it could be to go from bubble paper to reused cardboard from the warehouse, or to switch from aluminum to plastic polymers (Interview 3). Changing packaging materials in the pharmaceutical industry is complex and requires extensive testing to ensure the stability of the drugs, which can be a lengthy process (Interview 3). When reevaluating packaging options, it is also crucial to consider the rigorous storage requirements of drugs (Interview 2). Additionally, practical challenges arise for pharmacists when switching materials; for instance, cardboard, while less durable than plastic, absorbs humidity and increases the risk of damage (Interview 2).

The pharmaceutical industry's reliance on plastic, particularly for single-use medical consumables that ensure hygiene and safety, is substantial. Therefore, it is crucial to promote

the use of recycled plastic (3.5.). Effective waste separation plays a key role in this effort (Interview 5).

Additionally, individual labeling (3.6.) of each distributed pill with the necessary safety features is mandated⁶. This requirement is implemented to ensure that, in the event of a problem, the drug can be tracked. If pills are not pre-labeled by the pharmaceutical firms, hospital pharmacists must use specialized machines to apply labels, a process that is not only time-consuming but also generates excessive packaging waste (Interview 2).

4.2.4. Waste Management

Adopting a return-friendly policy (4.1.) is fundamental because, as perishable goods, drugs have expiry dates. Legally, returns need to be accepted by the firm six months before the expiry date of the product, but firms can decide to put an extra effort by accepting the return for longer. Returning the drug represent a fiscal advantage for the hospital, which is economically sustainable (Interview 3).

Nevertheless, if the return is not accepted, hospitals must incinerate hazardous drug waste⁷. They outsource the destruction, and debris are transported to dump sites (Interview 2). This process, particularly when improperly handling hormonal medications, can be harmful to the environment by disrupting local biodiversity and altering wildlife behavior (Interview 5). A return-friendly policy is also a favorable indication to the implementation of criteria 3.3.

An innovative solution involves the recycling of the resulting fly ash (4.2.), classified as 'Class C,' from the incineration of toxic drugs. This ash can be repurposed in the production of Portland cement, used to create building blocks (Interview 3).

Aligning medication packaging with typical treatment guidelines, such as the number of pills per package (4.3.), could reduce drug waste by ensuring patients use the entire pack. However,

⁶ The Falsified Medicines Directive (EU Commission 2015).

⁷ Dispatch No. 242/96, Portuguese Ministry of Health (1996)

the primary challenge seems to be the population's lack of adherence to treatment protocols, indicating that improving compliance is key to effectively reducing waste. Additionally, adapting packaging sizes for both private use and hospital supply (in bigger batches) requires multiple production lines, which could complicate the supply chain (Interview 6).

Moreover, extending drug expiry dates through *stability time studies* (4.4.), costly initially due to significant R&D investments, could be beneficial in the long-term. The success of extended stability for COVID-19 vaccines suggests that current conservative expiry dating in the pharmaceutical industry may offer opportunities for safely prolonging shelf lives. This adjustment could allow more oncology treatments, as currently, an open flask's use for multiple patients is severely time-restricted and involve unnecessary waste (Interview 2).

Drug packaging can serve as a tool to improve waste management. Two possible ways have been identified. First, working in partnership with Valormed⁸, *highlighting its initiative on the drug box* (4.5.). While many people are already aware of the network, as evidenced by the volume of medications returned, there is potential for further engagement (Interview 6). Adding the Valormed logo on the packaging could significantly encourage the population to return their unused drugs. Interviews 3 and 5 point out that while the initiative is already mentioned in the notice, this is not sufficient as most patients will not read it.

Secondly, *providing guidance on selecting toxic waste categories* (4.6) on drug packaging for pharmacists would be very helpful. This would clarify disposal requirements and appropriate categories for disposal. Waste selection must consider four levels of hazardous waste, with level IV being the most toxic and requiring incineration. New pharmacists receive training upon joining, followed by annual refreshers. Despite this, the process remains time-consuming, so clear packaging indications would streamline waste selection (Interview 2).

⁸ Portuguese organization dedicated to the collection and proper disposal of expired medications (Valormed 2024)

4.2.5. Social Sustainability

First, the idea of redistributing drugs (5.1) close to their expiration date to disadvantaged people, rather than destroying them, is a way to work on social sustainability. While they may not be as efficient, many medications remain safe past their expiry date and could provide a better alternative to having no treatment at all (Interview 5). This can be implemented by partnerships. Specifically, instead of returning drugs that are nearing expiration and are going to be destroyed, the hospital can collaborate with associations that can organize distribution to those in need (Interview 2). This approach ensures that medications are used effectively and not wasted, but it raises ethical concerns regarding equal access to healthcare. Another issue is that drugs could only be collected from hospital settings, and not from individuals, to guarantee the storage conditions (Interview 6).

Secondly, it is imperative that the hospital conducts an assessment of the certifications (5.2.) of its suppliers. Pursuing relationships with suppliers that have earned certifications such as B Corp or Fair Trade is a testament to a company's dedication to social responsibility. They serve as a framework for assessing social parameters within the supply chain and help determine the presence of a gender pay gap, evaluate inequalities, and ensure inclusivity, including the employment of older individuals. Furthermore, they aid in scrutinizing practices related to child labor, the support of local suppliers, anti-corruption measures, and parental leave policies (Interview 1).

4.3.Computation of Criteria's Weights

Appropriately weight the evaluation criteria is essential, as they do not equally impact the sustainability of the hospital (Interview 4). For assigning weights, we use the Analytic Hierarchy Process (AHP) decision-making method. It involves a systematic comparison of each criterion against all others to assess their relative importance. Through this process, we calculate weights ensuring that the most critical factors are prioritized (Darko et al. 2018).

The pairwise comparisons step typically involves domain experts who perform comparisons of elements based on their relative importance. This is done using a nine-point scale, with 1 being “Equally Important” and 9 “Extremely More Important”. Reciprocals are used for inverse comparisons (Darko et al. 2018).

Ideally, weights should be assigned regarding the impact they have on carbon footprint, following the GHG protocol procedures; however, this requires significant computation. This task is challenging because some impacts are difficult to measure, and the effects can vary, occurring both in the short and long term (Interview 1). In this work, to simplify the process, weights will be assigned only at the level of the five general topics⁹ based on insights gathered during interviews.

To determine the weights for each category, the following comparison matrix is employed, which, upon normalization, yields the respective weights of the categories:

Criteria	Mobility	Production	Packaging	Waste	Social Sustainability	Weight
Mobility	1	2	9	6	5	46.14%
Production	1/2	1	7	6	3	30.40%
Packaging	1/9	1/7	1	1/4	1/3	3.69%
Waste Management	1/6	1/6	4	1	2	10.92%
Social Sustainability	1/5	1/3	3	1/2	1	8.84%

Table 1: Computation of the Weights

Hospital’s values must also influence the weighting of the criteria. For instance, a hospital might choose to emphasize social responsibilities over environmental factors, depending on its core values.

⁹ Mobility, Packaging, Production, Waste Management and Social Sustainability.

4.4. Illustration of the Use of the Sustainability Evaluation Map

This section will provide a practical example of how the framework needs to be applied by the Procurement team when selecting their suppliers. Due to a lack of available data, simulated data were created to demonstrate the application of the evaluation map and the computation of the scores, using the weights established in the previous section.

To calculate the scores, we will use the 10-point Likert Scale as it is currently done by the hospital. It is important to note that some criteria are binary. In this case, a binary score of 0 corresponds to the lowest possible value on the scale, while a score of 1 is equivalent to the highest value, which is 10, while continuous criteria can have a value in between.

First, for each supplier, a total score is calculated for each criterion by summing the scores of all sub-criteria within that main criterion (see Appendix 5). We are then able to compute the total scores for both global aspects (Strategy and Sustainability), summarized in the following table:

	Strategy & Cost	Sustainability					
	Total Score	Mobility	Production	Packaging	Waste Management	Social Sustainability	Total score
Supplier 1	4,84	6	5	4	6,5	4	5,18
Supplier 2	7	6,8	6	5,5	5,34	3	5,83
Supplier 3	6	3	8,67	5,17	5,84	3	4,13

Table 2: Global Evaluation of the Suppliers

The total score of each supplier is computed using the following equation:

$$\alpha_1 \times \text{ScoreStrategy} + \alpha_2 \times \text{ScoreSustainability} = \text{Total Score}$$

Here, α_1 and α_2 represent the importance given by the company to Strategy and Sustainability.

With $\alpha_1 = \alpha_2$, the Strategy and the Sustainability evaluations have the same significance, which may not reflect the actual importance given by the hospital to sustainability in their decision-making, impacting the ranking of suppliers.

For instance, in our case, considering only the strategy score ($\alpha_1 = 1$), the ranking is supplier 2, then 3, then 1. However, when looking only at sustainability ($\alpha_2 = 1$), the order changes to supplier 2, then 1, then 3. The final decision of which supplier to choose will depend on the weights (α_1 and α_2).

Nevertheless, in practice, the process can be more complex. First, the general idea on how to give a score to each criterion is to compare last year's levels with this year's, but for some sustainability criteria¹⁰, this is not that easy to assess. Secondly, hospitals often need to mitigate risks by sourcing from multiple suppliers, adding an extra layer of complexity to the evaluation process. This scenario is known as the dual sourcing problem, when hospitals must balance quality, cost, and supply chain reliability across two or more suppliers (Interview 4).

5. DISCUSSION

The results of the interviews analysis identify 22 criteria classified in five categories, on which the company can base its sustainability evaluation of the suppliers. The criteria are summarized in the table presented in Appendix 6.

5.1. Internal and External Validity

The need for a sustainability evaluation map has been internally confirmed by the requirements of the Procurement and Sustainability teams of the hospital group. Founded in 2018, the Sustainability team was created because the hospital felt it was time to address this agenda with more dedicated time and resources (Interview 1), confirmed by interviews with stakeholders of the hospital group.

¹⁰ Criteria 2.1., 2.3., 3.3., 3.4., 3.5., 4.1., 4.4. are identified as the most complex ones to evaluate.

Externally, the sustainability evaluation map aligns with the global shift towards sustainability trends that is largely driven by consumer demand, although upcoming European regulations mandating sustainability transitions for companies also play a significant role (Interviews 1 and 4), but competitors are starting to address those issues in the last years only (Interview 1). Although some criteria are specifically tailored to the pharmaceutical industry¹¹, this framework is adaptable to other industries and countries, not only to Pharmacy and Portugal.

5.2.Challenges

Implementing sustainability in this context is very complex. The healthcare sector, directly affected by the consequences of climate change, should be even more concerned with sustainability. But it is also a sector where safety is particularly important. Some waste cannot be avoid without lowering the safety of the patient, and many safety related issues run actually against sustainability. As illustration, each unit of a hospital requires a crash cart, containing only emergency drugs, that will most of the time never be used (Interview 2).

The tension between sustainability and safety in the pharmaceutical industry necessitates innovative solutions. However, due to strict safety regulations, implementing changes often takes considerable time (Interview 3). While legislative changes can benefit commercial and financial aspects, they may require compromises in service levels, leading to negative perceptions from the population (Interview 6). Additionally, legal mandates, such as INFARMED's requirement for pharmacies to stock drugs within 24 hours, restrict operational flexibility (Interview 6).

Technological challenges further complicate the adoption of greener practices. Issues like the low autonomy of electric batteries and the short lifespan of active cold chains demand substantial investment in R&D to be solved (Interview 3).

¹¹ criteria 1.5., 2.3., 3.2., 3.6., 4.1., 4.2., 4.4., 4.5. and 5.1

Implementing the evaluation map in the hospital's practices has also some practical impacts. Compared to the previous evaluation map, subjective opinions are not sufficient anymore to assess sustainability. Reporting process and data collection are essential for understanding supplier's behavior regarding sustainability (Interview 1). This often requires significant investments of time and resources, potentially necessitating an expansion of the workforce, that will need to be trained, to ensure accurate data collection and analysis. This could also change the dynamic in the relationship with the suppliers (Interview 3).

Finally, the transition is more than only about reporting, it is also about how to implement change among suppliers. The hospital group needs to help them structuring their sustainability journeys, which can also be done with the help of organizations like GRACE (Interview 6). This support helps them identify existing measures and determine what further actions are necessary (Interview 1).

5.3.Limitations

First, the sample size of the interviews needs to be considered, limiting the breadth of perspectives represented. The initial interviews were useful to build the first evaluation map. A second round, with more interviews or with a survey regarding adjustments, can be conducted using the first version to improve it. Additionally, diversifying the interviews by exploring needs across different contexts and geographical areas will enrich the data, especially by incorporating insights from the NHS¹² on sustainability (Interview 5).

Then, to enhance objectivity in setting criteria weights, a more robust approach would involve collecting diverse expert opinions to reach a consensus. Additionally, alternative methods should be explored like the Best Worst Method (Hosseini, Flapper and Pirayesh 2022).

¹² National Health Service in the UK

Moreover, introducing a quantitative aspect alongside the interviews, such as using the GHG Protocol for carbon footprint computation, would be an improvement.

Finally, the lack of available data necessitated the creation of simulated data to illustrate the use of our evaluation model. While this approach demonstrates its applicability, working with actual supplier data would have provided more precise insights and a more robust validation of our framework.

5.4. Research Prospects

In future research, it would first be beneficial to expand the criteria used in the evaluation map to include a more comprehensive focus on social and governance aspects, aligning closer with the ESG framework. This approach would enhance the current one, which primarily employs the TBL model.

Secondly, the illustration used in section 4.4. is very simplified and the ranking of suppliers is way more complex in the reality, illustrated by the need of MCDM techniques. To simplify the process, more exclusion criteria could be added to make a first screening phase, directly excluding firms that do not meet some standards important for the company, like child labour, for example (Interview 1). A second simplification step would be to adopt a sequential assessment approach, that would prioritize the most critical sustainability criteria. Currently, the sustainability evaluation framework assesses all criteria simultaneously.

Eventually, the process of evaluation being costly and time-consuming, the hospital group should also consider to outsource it, which can be done by sustainability rating agencies giving an ESG score to their suppliers. The hospital group needs to decide on a score benchmark under which they require an action plan from their suppliers (EcoVadis 2024).

6. CONCLUSION

This Work Project explored sustainability within the pharmaceutical sourcing practices of a hospital in Portugal, aiming to define a supplier evaluation grid incorporating sustainability metrics effectively.

The research is motivated by the important trade-off between the impact of climate change on health and the important environmental footprint of the sector, making the study of sustainability in the context of healthcare highly relevant.

After reviewing the literature, gaps were identified in existing research. Despite numerous papers on supplier selection in the pharmaceutical industry and on sustainability, there remains a significant gap in research that combines these two areas.

To build the map, a qualitative analysis methodology was conducted through interviews with key field experts. This approach facilitated the understanding of current practices and the identification of criteria to implement sustainable evaluation. The Sustainability Evaluation Map, as outcome, provides a structured way for hospitals to assess suppliers against 22 sustainability criteria, regarding environmental and social aspects. Weights were given regarding their relative impact on the environment, and the use of the map was illustrated in an example.

To conclude, healthcare institutions hold a significant procurement power. By incorporating sustainability criteria into their purchasing decisions, hospital groups can encourage suppliers to adopt more responsible practice, for them to stay competitive (Interviews 1 and 5). Despite significant challenges, integrating sustainability efforts yields long-term benefits, like cost savings and an enhanced reputation (Interview 1). In the context of the current climate crisis, it is crucial for hospitals to implement changes in pharmaceutical sourcing. By doing so, they can play a pivotal role in driving environmental progress.

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8. APPENDICES

8.1. Appendix 1: List of Abbreviations

ANF – National Association of Pharmacists

BMW-ER - Best Worst Method-Evidential Reasoning

CPSA – Portuguese Council for Health and Environment

CSR – Corporate Social Responsibility

CSDD - Corporate Sustainability Due Diligence Directive

CSRD - Corporate Sustainability Reporting Directive

ESG – Environment, Social and Governance

GDP - Gross Domestic Product

GGHH – Global Green and Healthy Hospitals

GHG – Green House Gas

GWP – Global Warming Potential

ICH - International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use

ILO – International Labour Organization

MADM – Multiple Attribute Decision Making

MCDM – Multiple Criteria Decision Making

MILP – Mixed-Integer Linear-Programming

OECD – Organization for Economic Cooperation and Development

PCA – Principal Component Analysis

R&D – Research & Development

SCDDA - Supply Chain Due Diligence Act

SCM – Supply Chain Management

SDG – Sustainable Development Goal

SSCM – Sustainable Supply Chain Management

SSS – Sustainable Supplier Selection

TBL – Triple Bottom Line

WHO – World Health Organization

8.2. Appendix 2: Interviews Analysis by interviewee

Interview 1 Role: Head of Procurement, responsible of the negotiation.	• The work of procurement's head is to do an evaluation of the suppliers, but only after the clinical decision (done by pharmacists and quality team). • The current evaluation is based on subjective opinions and those are the current criteria used: level of service, trust, easy communication, relationship duration, price stability, growth potential • Sustainability has three aspects: economical, social and environmental. (Triple Bottom Line) and implement it is good for the brand's image. • The three scopes of the GHG protocol need to be taken into account, this year is the first year that scope three is integrated. To evaluate it, we need data from the suppliers. • They are still wondering if the scope of the sustainability should focus on the product or also on the firm in a more global aspect. • By preference, they choose geographically close suppliers, but Portugal is not a big pharmaceutical producer. • A way to diversify the risk is by supplying from more than one supplier. This complicates the decision-process. • Before definitely implementing a new supplier, the hospital first do a trial with low risk drugs to see if it is working well. • Due diligence EU directive (also includes social aspects). • The Sustainability team of the group was founded in 2018. It started because we felt it was time to address this agenda with more time and resources dedicated on it. The competitors are starting to address those issues now, in the last year. • EU is asking for more reporting on sustainability information, so every company will be forced to do it. The hospital group has been doing it voluntarily. Starting next year, it will be mandatory for us as well.
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	- Initially, before it became a hospital, the hospital group wanted a hospital for their employees and their families, which can be recognized as a CSR initiative. - In the Sustainability Team, one person will be dedicated to the management of the optimization of itineraries. Some softwares are builded to manage this but we are still looking for the best one. - We are conducting a project on the aluminium bottles of the anesthesia gas. We are collecting them to give them to the waste managers for them to melt it and to create a new aluminium bottle. So the necessity for new material is reduced. - Most of the material that come to the hospital is wrapped in what we call “blue wrap” to sterilize it. We are collecting it instead of it going to incineration and send to social organizations. The idea is to produce items that could go back to the hospital group circled project. For example, we are trying to upcycle it into surgical gowns, and hats. - The biggest challenge is to obtain objective data. We are trying to have more and more suppliers sending us information on their sustainability practices. Next year, we will ask our top 40 suppliers for further reporting on their practices and strategies. They are not obliged to do it but if they don’t, they are out of competition. We want to inspire our suppliers to join this sustainability path. - The hospital group helps its suppliers to structure their sustainable journeys, to understand what do they already have and what they need to do more. It is more than only about reporting, it is also about how to implement change. - If a supplier refuses to report, we will not stop working with them. But we need to define exclusion criteria, for example if we discover that a supplier is using child labor.
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	- Concerning social sustainability, we will have to work with gender, ethnicities, age, corruption issues. - We are looking at different kind of evaluation. In the first case, a request for proposal is launched to the market if the hospital group has a new need. Let's say that the hospital group will receive around 100 proposals, and all of them will be evaluated. The ones that do not respect the exclusion criteria are excluded, which narrows the number of possible suppliers. Only the remaining ones will be evaluated with the new evaluation map. - The second case is about the ongoing suppliers, with whom the hospital group is working already for a few years. They also need to be evaluated on a continuous annual basis, to be able to help them doing more efforts regarding sustainability.
Interview 2 Role: Pharmacists, in charge of the distribution of the drugs in the pharmacy department of a hospital. (Site Visit)	- Description of the medical personal working in the pharmacy: there is a receptionist, pharmaceutical auxiliaries and pharmacists (divided between distribution or oncology). - The management of the stock is done with the use of Kanban cards (Kaizen philosophy) which contain reorder point and the optimal quantity to order (adapted with the experience). - The inventory method used is FIFO, meaning that the oldest drug is stored in front of the shelf, except for drugs with very high turnover. They use signs to signal that a drug will perish soon. - The drug demand is seasonal, meaning that having winter and summer stocks would be useful to optimize the orders. - Because of current global disruptions, hospitals sometimes face stockout problems. It also happens that pharmaceutical firms stop the production. An idea to solve the issue is to establish collaboration between hospitals. - In the case of diagnosis drugs, the stockout problem is even more important and doctors need to prioritize the patients that will receive it, they wait for a very long time.

	• Concerning their storage, some drugs have very specific conservation criteria like sun exposition, temperature, photosensitivity. • Effort of some firms to pack in bigger batches to reduce the packaging, some turn to cardboard packaging, but it is not always practical for the pharmacists in practice. • Halogenated anesthetics are very toxic. Sevoflurane is an eco-friendly version of Desflurane with a lower GWP, so it is less toxic. However, when using the alternative, the patient takes more time to wake up after the surgery. Desflurane is advised for kids because you wake up faster. Some doctors are used to the polluting version of the product and do not want to change. • Some suppliers make the effort to reduce the number of deliveries a month to a maximum number, but then the hospital need to adapt because it gives less flexibility. • Oncology products are very expensive products. So when a flask is open, it can be reuse for another patient (in a very limited amount of time). It requires a good planning and potential increase of the lifetime of the product which is very short at the moment. • Waste Management: level 4 contains all the top dangerous drugs, very toxic that cannot be recycle but goes directly to incineration; some clinical consumables are not recycled even if they are not in contact with the toxic drug (which is more time consuming and sometimes time is missing); some packagings could be avoided but keeping in mind that it is sometimes needed for sterilization. • To labelize the drugs sended to the patient, pharmacists use a machine to label it individually to make sure each single drug contain the required info (number of batches expiry data, type of drug, ...). A suggestion to solve this issue would be to produce two types of packaging.
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	• The health sector is very regulated and has a lot of law requirements. Many medical documents require verification and therefore must be signed, necessitating that they be printed. • The planning of the drugs distribution is made on paper every 24h, readapted in the middle of the day. • Each unit of the hospital requires an emergency car. It contains medication that is not demanded by patients but only available in case of problem, which generates a lot of waste. • The hospital is first working internally to avoid reaching expiry date (collaboration with other hospitals), then, when it is too late, drugs are putted in quarantine waiting for the decision of the company if they accept to return it or not. It is economically sustainable for the hospital to return the drug. • Summary of potential sustainability evaluation criteria discussed: information about proper way to throw the drug away through packaging, reformulation of the formula with more sustainable ingredients, shift from plastic to cardboard, providing distinct packagings for private/hospital usage, clear return policy, increase of the stability of the oncology products.
Interview 3 Role: Quality Assurance Head working for a pharmaceutical company	• The firm is taking sustainable initiatives on several levels: internally (reduction of the energy, materials, paper and water consumption), transport (shift from validated shipping boxes to active cold chains) and packaging (shift from bubble paper to reused cardboard from the warehouse). • They are developing ideas for the future, for example replace the notice in the packaging by a QR code on the box. They are also inspired from other countries, for example in the LATAM countries, debris of the toxic drug incineration is used to make cement for building blocs. Another possible initiative is to buy land to replant pine trees in South America.

	• The pharmaceutical industry faces a lot of constraints. Due to the industry regulation, things need to be printed, going to electric vehicles is not feasible at the moment because of the current autonomy that is too low, shipping cold products to the islands is not yet possible because the lifetime of the validated boxes is too short, changing a packaging material requires a lot of tests (which are very long). In general, every change requires more time in the pharmaceutical industry than in others. • The distribution on the continent is only done by truck. For the portuguese islands is done by boat (best option regarding costs and sustainability) or plane (for emergencies or cold products, using commodity planes). • Suppliers reduced the number of deliveries a day in the Lisbon area during COVID-19 pandemic and did not change afterwards, it is possible to reduce but it needs acceptance from the hospitals and an improved planning. • 95% of their raw material deliveries come from Europe and the 5% remaining from Turkey. • By 2025, the company has targets about its own operations but by 2030, the targets are also for its whole supply chain. • Return policy: the pharma company accepts return till three months after the expiry date. There is a legal requirement to destroy the expired product by incineration because it contains toxic chemicals. They outsource this destruction and then the debris go to a dump site. Returning the drug represents a fiscal advantage for the hospital. • Packing in blisters instead of big bottles is a better option to respect the shelf life of the product; switch from aluminum to plastic polymer aluminium (which has a smaller footprint). • Creating distinct packaging for community and hospital use would increase the number of production lines and complicate the manufacturing process and planning.
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	• Valormed initiative is already mentioned on the notice, but not highlighted, it would be a good idea to reinforce the message. • ICH defines guidelines that specify the correct amount of toxicity to respect in the drug production, and the company needs to revise its formulation of drugs to comply the update. • Hospitals do not require reporting, but the company do report internally to its global headquarters.
Interview 4 Role: Operations Management Teacher (university level)	• The first thing to do when selecting the suppliers is to understand who can be the potential ones, and narrow the list for example considering regulations, different in EU/UK/USA. • Most of the time, the hospital faces a dual sourcing problem, meaning that it works with two or more suppliers for a given drug, which complexifies the decision process. This needs to be optimized. • Some drugs have a seasonal demand, like influenza drugs. The demand is higher in the winter, which could complexify the planning. • Sustainable operations are about how to align economical, social and environmental aspects. A solution that is environmentally sustainable but that is not economically viable cannot be sustainable, and opposite. Economical sustainability needs to be used as a constraint in the computation of the solutions. • The first-mover advantage needs to be taken into account, the initial investment is huge but is then compensated in the long run. First thing to do is to improve environmental and social aspects, then argue that it does not hurt too badly the economical side. • The important sourcing decisions are the used transport mean (ships, trucks, trains, or aircrafts) and the choice of the routes (optimization to minimize distances).

	• The supply chain is complex. Indeed, it suffers of yield variability: when you launch a production, you do not know the exact amount of drugs you will obtain at the end. The storage conditions are also complex as drugs are perishable goods, needs to respect some conditions like the temperature. The production process is long. • As the supply chain is more complex, then implementation of sustainability is also more complicate. • Transport represents the biggest challenge, but this is common to all the industries (except the fact that for drugs it sometimes requires cold transport which is even more polluting). • The ideal would be to have reusable packaging (circular economy). Still, improving the packaging is not the most impactful change in this industry. • A lifecycle analysis is needed to understand the impact of the ingredients: what are they made of, from where are they sourced. • A possible way to assess suppliers is by their certifications: fair trade, ISO, ... • It is important to weight the criterias by their carbon footprint, they don't have all the same impact. • The shift to sustainability is demand-driven. Of course, regulation has an impact but mostly it is a natural change, the society drives the change.
Interview 5 Role: president of the Portuguese Council for Health and Environment	• The Portuguese Council for Health and Environment was created because doctors should be the advocates of the people. Environmental factors are responsible for ¼ of death and doctors are the most trustable profession, so they should be the example of the population. The objectives are to increase awareness, put together everyone related to those topics, and reduce the ecological footprint of the healthcare sector that currently represents 4.4% of global emissions.

	• A law from 1996 says that we cannot recycle the plastic used in surgical boxes even if they are sterile, following the law they need to go to the contaminated trash. • The organization of care can also be revised to improve sustainability, by introducing integrated care and telemedicine. Having all the services at one place, or even online, is a way to reduce the itineraries of the patients. • The “Green Hospital” is a certification that proofs the sustainability efforts concerning the hospital building itself. • Doctors have an impact by the choice they make (example of the halogenated anesthetics gases). • The healthcare sector is a huge producer of plastic. A partnership has been established between the hospital and a plastic factory that wants to reach 30% of its production recycled. This requires the separation of toxic and non-toxic plastic to recycle what is possible. • Patients keep a lot of unused medication at home and hospitals throw away because there is a lack of awareness, drugs could be redistributed, destruction of drugs can be problematic if it is not properly done, studies show that the river biodiversity is disturbed because of hormones. • Expiry drugs could be redistributed to poor people. For many drugs, it is not dangerous to take it after the expiry date, and even if the drug is not as efficient, it is better than having nothing. • There is not enough awareness in the population regarding Valormed, pharmaceutical companies have a role to play by highlighting the existence of this initiative on their packaging. • The scope three has the biggest environmental impact. • In the transport part, the areas of improvement are a shift from thermic to electric cars, reduction of the amount of deliveries, and optimization of itineraries.
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	• Suppliers depend on the hospital. So if the hospital says that it only buys from companies that have sustainability objectives, at one point they will need to follow (example of the National service in UK). • Integrating sustainability efforts reduces the cost on a long term perspective. It is a huge investment at the beginning, but then, it will represent a huge reduction of spendings in the future (example of the LED lamps). • On the political level, climate change is not a priority, which represents a transition barrier. UK is an example on this level.
Interview 6 Role: president of the ANF, representing community pharmacies	• The biggest role of the ANF is the interaction with the government, opposition if they do not agree with the law, they protect pharmacists. It is mainly a legal support. The APFH is the association representing hospital pharmacists. • Community VS hospital pharmacy: direct interaction with the final patient. • Purchasing groups: some pharmacies work together to obtain the best prices during the negotiation (gain of negotiation power) only for generics, not for prescribed drugs. • The choice of suppliers is mainly based on strategic aspect, meaning that they take into account if the firm invest more in pharmacies than in parapharmacies/supermarket channels, and cost-benefit aspect. • Pharmacies select their suppliers by diversifying their options to avoid dependency on a single source, ensuring they have alternative plans in place. • The number of deliveries decreased compared to the past, now it is about two deliveries a day. Portugal has a large amount of deliveries compared to other european countries. In fact, wholesalers are afraid to go down to one delivery a day because they would lose competitive advantage compared to their competitors.

	• Portugal faces cultural and political differences. Pharmacies are very accustomed to provide the best service as possible to their customers and a portuguese law says that a pharmacy should have the drug available in the next 24 hours, so it is impossible to decrease a lot the deliveries according to law. Only looking at the theory, it would be possible with a good algorithm and inventory, but barriers are faced in the practice. • Legislation change concerning availability of the product is possible, but then you go in the direction of a lower service which is not ideal, even if it would be better commercially and financially. • In the contexte of a pilot partnership project, two wholesalers work together to combine their deliveries. This is beneficial because it reduces their carbon footprints, but also because it reduces costs. • In the production, it is important to be careful about what materials are used (example of the anesthesia gases). • ADIFA did some work to compute the carbon emissions of suppliers • GRACE is an association helping companies in their sustainability transition. • Hospital pharmacies are ahead regarding sustainability. For community pharmacies, the budget management is more difficult, as they are more worried about short-term issues than big groups. • It is possible to increase the stability time of drugs with further studies, the COVID-19 vaccines being a good example. • The idea of distinct packagings is good (for hospitals and community pharmacies) but regarding production, it should increase the cost because you have now two lines of production.
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	• The drug information on each packaging follows the falsified medicines directive which is an EU legislation. • The firms usually adapt the size of the box (in other words, the amount of pills in one package) to the common directives for the treatment. The waste seems to come from the lack of adherence from the population to the treatment, we should promote adherence: the problem is in the use not in the supply. • Most of the population is aware of Valormed because many medications are returned using their boxes. However, there is still potential for increased awareness, and promoting it on the packaging could be beneficial. • We have been too conservative regarding expiry dates. With further stability studies, it could be improved. • It is impossible to redistribute expired drugs coming from individuals because we do not know how it was stored. The only option would be to redistribute soon-to-be expired drugs coming from hospitals, where we know the storage conditions are respected. • An ethical problem to redistribute lower quality drugs to poor people raises.
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8.3. Appendix 3: Interviews Analysis by topic

Health & Environment	• Interview 5: The Portuguese Council for Health and Environment was created because doctors should be the advocates of the people. Environmental factors are responsible for ¼ of death and doctors are the most trustable profession, so they should be the example of the population. The objectives are to increase awareness, put together everyone related to those topics, and reduce the ecological footprint of the healthcare sector that currently represents 4.4% of global emissions. • Interview 5: Doctors have an impact by the choice they make (example of the halogenated anesthetics gases). • Interview 5: Doctors are trusted by the population, so they should be an example regarding environmental behavior.
Supply Chain Management	• Interview 2: Description of the medical personal working in the pharmacy: there is a receptionist, pharmaceutical auxiliaries and pharmacists (divided between distribution or oncology). • Interview 2: The management of the stock is done with the use of Kanban cards (Kaizen philosophy) which contain reorder point and the optimal quantity to order (adapted with the experience). The inventory method used is FIFO, meaning that the oldest drug is stored in front of the shelf, except for drugs with very high turnover. They use signs to signal that a drug will perish soon. • Interview 2: The drug demand is seasonal, meaning that having winter and summer stocks would be useful to optimize the orders. • Interview 4: Some drugs have a seasonal demand, like influenza drugs. The demand is higher in the winter, which could complexify the planning.

	• Interview 2: Because of current global disruptions, hospitals sometimes face stockout problems. It also happens that pharmaceutical firms stop the production. An idea to solve the issue is to establish collaboration between hospitals. • Interview 2: Concerning their storage, some drugs have very specific conservation criteria like sun exposition, temperature, photosensitivity. • Interview 2: The planning of the distribution is made on paper every 24 hours, readapted in the middle of the day. • Interview 4: The pharmaceutical supply chain is complex. Indeed, it suffers of yield variability: when you launch a production, you do not know the exact amount of drugs you will obtain at the end. The storage conditions are also complex as drugs are perishable goods, needs to respect some conditions like the temperature. The production process is long.
Supplier selection	• Interview 1: The work of the procurement's head is to do an evaluation of the suppliers, but only after the clinical decision (done by pharmacists and quality team). • Interview 1: We are looking at different kind of evaluation. In the first case, a request for proposal is launched to the market if the hospital group has a new need. Let's say that the hospital group will receive around 100 proposals, and all of them will be evaluated. The ones that do not respect the exclusion criteria are excluded, which narrows the number of possible suppliers. Only the remaining ones will be evaluated with the new evaluation map. • Interview 1: The second case is about the ongoing suppliers, with whom the hospital group is working already for a few years. They also need to be evaluated on a continuous annual basis, to be able to help them doing more efforts regarding sustainability.

	• Interview 1: The current evaluation is based on subjective opinions and those are the current criteria used: level of service, trust, easy communication, relationship duration, price stability, growth potential. • Interview 1: By preference, geographically close suppliers are chosen, but Portugal is not a big pharmaceutical producer. • Interview 3: By 2025, the company has targets about its own operations but by 2030, the targets are also for its whole supply chain. • Interview 4 : The first thing to do when selecting the suppliers is to understand who can be the potential ones, and narrow the list for example considering regulations, different in EU/UK/USA. • Interview 4: A possible way to assess suppliers is by their certifications: fair trade, ISO, ... • Interview 4: It is important to weight the criterias, they don't have all the same impact. • Interview 5: Suppliers depend on the hospital, so if the hospital says that it only buys from companies that have sustainability objectives, at one point they will need to follow (example of the National service in UK). • Interview 6: The choice of suppliers is mainly based on strategic aspect, meaning that they take into account if the firm invest more in pharmacies than in parapharmacies/supermarket channels, and cost-benefit aspect. • Interview 6: community pharmacies work with purchasing groups: some pharmacies work together to obtain the best prices during the negotiation (gain of negotiation power) only for generics, not for prescribed drugs.
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Sustainability	• Interview 1: The Sustainability team of the group was founded in 2018. It started because we felt it was time to address this agenda with more time and ressources dedicated on it. The competitors are starting to address those issues now, in the last year. • Interview 1: Initially, before it became a hospital group, it wanted a hospital to provide healthcare for their employees and families, which can be recognized as a CSR initiative. • Interview 1: Sustainability has three aspects: economical, social and environmental (Triple Bottom Line). Implement it is good for the brand's image. Economical sustainability needs to be used as a constraint in the computation of the solutions • Interview 1: The hospital group is still wondering if the scope of the sustainability should focus on the product or also on the firm in a more global aspect. • Interview 1: The three scopes of the GHG protocol need to be taken into account, this year is the first year that scope three is integrated. To evaluate it, we need data from the suppliers. • Interview 1: Concerning social sustainability, we will have to work with gender, ethnicities, age and corruption issues. • Interview 4: We need to take the first-mover advantage into account (big investment that will be compensated in the long run). First improve environmental and social, then argue that it does not hurt too badly the economical side. • Interview 4: The shift to sustainability is demand-driven. Of course, regulation has an impact but mostly it is a natural change, the society drives the change. • Interview 5: Integrating sustainability efforts reduces the cost on a long term perspective. It is a huge investment at
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	the beginning, but then, it will represent a huge reduction of spendings in the future (example of the LED lamps).
Sustainable initiatives	• Interview 1: The hospital group helps its suppliers to structure their sustainable journeys, to understand what do they already have and what they need to do more. It is more than only reporting, it is also about how to implement change. • The hospital group is conducting a project on the aluminium bottles of the anesthesia gas. We are collecting them to give them to the waste managers for them to melt it and to create a new aluminium bottle. So the necessity for new material is reduced. • Interview 3: The firm is taking internal sustainable initiatives on several levels: internally (reduction of the energy, materials, paper and water consumption), transport (shift from validated shipping boxes to active cold chains) and packaging (shift from bubble paper to reused cardboard from the warehouse). • Interview 3: They are developing ideas for the future, for example replace the notice in the packaging by a QR code on the box. They are also inspired from other countries, for example in the LATAM countries, debris of the toxic drug incineration is used to make cement for building blocs. Another possible initiative is to buy land to replant pine trees in South America. • Interview 5: The organization of care can also be revised to improve sustainability, by introducing integrated care and telemedecine. Having all the services at one place, or even online, is a way to reduce the itineraries of the patients. • Interview 5: The “Green Hospital” certification proofs the sustainability efforts concerning the hospital building itself.

	• Interview 5: Doctors have an impact by the choice they make (example of the halogenated anesthetics gases). • Interview 6: GRACE is an association helping companies in their sustainability transition.
Mobility	• Interview 3: The pharmaceutical firm proceeded to a shift from validated shipping boxes to active cold chains, with a lower environmental impact. • Interview 3: Going to electric vehicles is not feasible at the moment because of the current autonomy that is too low. • Interview 3: The distribution on the continent is only done by truck. For the portuguese islands, it is done by boat (best option regarding costs and sustainability) or by plane (for emergencies or cold products, using commodity planes). • Interview 3: Shipping cold products to the islands is not yet possible because the lifetime of the validated boxes is too short, it needs to be done by plane. • Interview 4: The most important sourcing decisions are the used transport mean (ships, trucks, trains, or aircrafts) and the choice of the routes (optimization to minimize distances). • Interview 4: Transport represent the biggest challenge, which is common to all industries (except the fact that in the case of drugs, it sometimes requires cold transport which is even more polluting). • Interview 5: In the transport part, the areas of improvement are a shift from thermic to electric cars, reduction of the amount of deliveries, and optimization of itineraries.
Deliveries	• Interview 1: In the Sustainability Team, one person will soon be dedicated to the management of the optimization

	of itineraries. Some softwares are builded to manage this but we are still looking for the best one. • Interview 2: Some suppliers make the effort to reduce the number of deliveries a month to a maximum number, but then the hospital need to adapt because it gives less flexibility. • Interview 3: Suppliers reduced the number of deliveries a day in the Lisbon area during COVID-19 pandemic and did not change afterwards, it is possible to reduce but it needs acceptance from the hospitals and an improved planning. • Interview 6: The number of deliveries decreased compared to the past, now it is about two deliveries a day. Portugal has a large amount of deliveries compared to other european countries. In fact, wholesalers are afraid to go down to one delivery a day because they would lose competitive advantage compared to their competitors. • Interview 6: In the context of a pilot partnership project, two wholesalers work together to combine their deliveries. This is beneficial because it reduces their carbon footprints, but also because it reduces costs.
Packaging	• Interview 2: Some packagings could be avoided but keeping in mind that it is sometimes needed for sterilization. • Interview 2: Effort of some firms to pack in bigger batches to reduce the packaging, some turn to cardboard packaging, but it is not always practical for the pharmacists in practice. • Interview 2: To individually labelize the drugs sended to the patient, pharmacists use a machine to make sure each single drug contain the required info (number of batches expiry data, type of drug, ...). A suggestion to solve this

	issue would be to produce two types of packaging (for hospital and community pharmacies). • Interview 3: They are developing ideas for the future, for example replace the notice in the packaging by a QR code on the box. Something that is already implemented is the shift from bubble paper to reused cardboard coming from the warehouse. • Interview 3: In general, every change requires more time in the pharmaceutical industry than in others. Changing a packaging material requires a lot of tests (which are very long). • Interview 3: Packing in blisters instead of big bottles is a better option to respect the shelf life of the product; switch from aluminum to plastic polymer aluminium (which has a smaller footprint). • Interview 3: Creating distinct packaging for community and hospital use would increase the number of production lines and complicate the manufacturing process and planning. • Interview 4: The ideal would be to have reusable packaging (circular economy). Still, improving the packaging is not the most impactful change in this industry. • Interview 5: The healthcare sector is a huge producer of plastic. A partnership has been established between the hospital and a plastic factory that wants to reach 30% of its production recycled. This requires the separation of toxic and non-toxic plastic to recycle what is possible. • Interview 6: The idea of distinct packagings (for hospitals and community pharmacies) is good but regarding production, it should increase the cost because you have now two lines of production.
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	• Interview 6: The drug information on each packaging follows the falsified medicines directive which is an EU legislation.
Return policy/Waste Management	• Interview 1: Most of the material that come to the hospital is wrapped in what we call “blue wrap” to sterilize it. We are collecting it instead of it going to incineration and send to social organizations. The idea is to produce items that could go back to the hospital group circled project. For example, we are trying to upcycle it into surgical gowns, and hats. • Interview 1: The hospital group is conducting a project on the aluminium bottles of the anesthesia gas. We are collecting them to give them to the waste managers for them to melt it and to create a new aluminium bottle. So the necessity for new material is reduced. • Interview 2: Level 4 contains all the top dangerous drugs, very toxic that cannot be recycled but goes directly to incineration; some clinical consumables are not recycled even if they are not in contact with the toxic drug (which is more time consuming and sometimes time is missing). • Interview 2: Each unit of the hospital requires crash cart. It contains medication that is not demanded by patients but only available in case of problem, which generates a lot of waste. • Interview 2: The hospital is first working internally to avoid reaching expiry date (collaboration with other hospitals), then, when it is too late, drugs are putted in quarantine waiting for the decision of the company if they accept to return it or not. It is economically sustainable for the hospital to return the drug. • Interview 3: They are also inspired from other countries, for example in the LATAM countries, debris of the toxic

	drug incineration is used to make cement for building blocs • Interview 3: The pharmaceutical company accepts return till three months after the expiry date. There is a legal requirement to destroy the expired product by incineration because it contains toxic chemicals. They outsource this destruction and then the debris go to a dump sit. Returning the drug represent a fiscal advantage for the hospital. • Interview 5: a law from 1996 says that we cannot recycle the plastic used in surgical boxes even if they are sterile, following the law they need to go in the contaminated trash. • Interview 5: Patients keep a lot of unused medication at home and hospitals throw away because there is a lack of awareness, drugs could be redistributed, destruction of drugs can be problematic if it is not properly done, studies show that the river biodiversity is disturbed because of hormones. • Interview 6: The firms usually adapt the size of the box (in other words, the amount of pills in one package) to the common directives for the treatment. The waste seems to come from the lack of adherence from the population to the treatment, we should promote adherence: the problem is in the use, not in the supply.
Valormed	• Interview 3: The Valormed initiative is already mentionned on the notice, but not highlighted, it would be a good idea to reinforce the message. • Interview 5: There is not enough awareness in the population regarding Valormed, pharmaceutical companies have a role to play by highlighting the existence of this initiative on their packaging. • Interview 6: Most of the population is aware of Valormed because many medications are returned using their boxes.

	However, there is still potential for increased awareness, and promoting it on the packaging could be beneficial.
Production	• Interview 2: Halogenated anesthetics are very toxic. Sevoflurane is an eco-friendly version of Desflurane with a lower GWP, so it is less toxic. However, when using the alternative, the patient takes more time to wake up after the surgery. Desflurane is advised for kids because you wake up faster. Some doctors are used to the polluting version of the product and do not want to change. • Interview 3: Raw material: 95% of their deliveries come from Europe and the 5% remaining from Turkey. • Interview 3: ICH defines guidelines that specify the correct amount of toxicity to respect in the drug production, and the company needs to revise its formulation of drugs to comply the update. • Interview 4: A lifecycle analysis is needed to understand the impact of the ingredients: what are they made of, from where are they sourced. • Interview 6: In the production, it is important to be careful about what materials are used (example of the anesthesia gases).
Reporting	• Interview 1: EU is asking for more reporting on sustainability information, so every company will be forced to do it. The hospital group has been doing it voluntarily. Starting next year, it will be mandatory for everyone. • Interview 1: The biggest challenge is to obtain objective data. We are trying to have more and more suppliers sending us information on their sustainability practices. Next year, we will ask our top 40 suppliers for further reporting on their practices and strategies. They are not obliged to do it but if they don't, they are out of

	competition. We want to inspire our suppliers to join this sustainability path. • Interview 1: If a supplier refuses to report, we will not stop working with them. But we need to define exclusion criteria, for example if we discover that a supplier is using child labor. • Interview 3: Hospitals do not require reporting yet, but the company do report internally to its global headquarters.
Expiry date	• Interview 2: Oncology products are very expensive. So when a flask is open, it can be reuse for another patient (in a very limited amount of time). It requires a good planning and potential increase of the lifetime of the product which is very short at the moment. • Interview 5: Expiry drugs (or soon-to-be) could be redistributed to poor people. For many drugs, it is not dangerous to take it after the expiry date, and even if the drug is not as efficient, it is better than having nothing. • Interview 6: It is possible to increase the stability time of drugs with further studies, the COVID-19 vaccines being a good example. We have been too conservative regarding expiry dates. With further stability studies, it could be improved. • Interview 6: It is impossible to redistribute expired drugs coming from individuals because we do not know how it was stored. The only option would be to redistribute soon-to-be expired drugs coming from hospitals, where we know the storage conditions are respected.
Dual sourcing	• Interview 1: Diversification of the risk by supplying from more than one supplier • Interview 4: Most of the time, the hospital faces a dual sourcing problem, meaning that it works with two or more suppliers for a given drug, which complexifies the decision process. This needs to be optimized.

	• Interview 6: they choose based on having different suppliers to avoid relying on only one source, to have a plan B.
Regulation	• Interview 2: The health sector is very regulated and has a lot of law requirements. Many medical documents require verification and therefore must be signed, necessitating that they need to be printed. • Interview 3: Many processes still require physical documentation and signatures, which cannot be completely replaced by digital methods. Therefore, it's necessary to maintain printed proofs.
Challenges	• Interview 1: The current evaluation is based on subjective opinions. • Interview 1: The biggest challenge is to obtain objective data. We are trying to have more and more suppliers sending us information on their sustainability practices. Next year, we will ask our top 40 suppliers for further reporting on their practices and strategies. They are not obliged to do it but if they don't, they are out of competition. We want to inspire our suppliers to join this sustainability path. • Interview 2: The health sector is very regulated and has a lot of law requirements. Many medical documents require verification and therefore must be signed, necessitating that they be printed. • Interview 3: The pharmaceutical industry faces a lot of constraints. Due to the industry regulation, things need to be printed, going to electric vehicles is not feasible at the moment because of the current autonomy that is too low, shipping cold products to the islands is not yet possible because the lifetime of the validated boxes is too short, changing a packaging material requires a lot of tests (which are very long).

	• Interview 3: In general, every change requires more time in the pharmaceutical industry than in others. • Interview 4: The supply chain is complex. Indeed, it suffers of yield variability: when you launch a production, you do not know the exact amount of drugs you will obtain at the end. The storage conditions are also complex as drugs are perishable goods, needs to respect some conditions like the temperature. The production process is long. Because of this complexity, the implementation of sustainability is also more complicate. • Interview 5: On the political level, climate change is not a priority. UK is a good example on this level. • Interview 6: Portugal faces cultural and political differences. Pharmacies are very accustomed to provide the best service as possible to their customers and a portuguese law says that a pharmacy should have the drug available in the next 24 hours, so it is impossible to decrease a lot the deliveries according to law. • Interview 6: Legislation change concerning availability of the product is possible, but then you go in the direction of a lower service which is not ideal, even if it would be better commercially and financially. • Interview 6: Hospital pharmacies are ahead regarding sustainability. For community pharmacies, the budget management is more difficult, as they are more worried about short-term issues than big groups.
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8.4. Appendix 4: Current Evaluation Map & Sustainability Evaluation Map Proposal

Criteria	Level of Service	Trust	Easy Communication	Relationship Duration	Price Stability	Growth Potential
Explanation	Supplier's ability to meet needs in terms of quality, delivery timeliness, and support.	Supplier's reliability. A trusted supplier fulfills promises, and maintains confidentiality. It is critical because it reduces the need for auditing, which save time and resources.	Can quickly resolve issues, implement changes, and provide updates. This leads to smoother operations and can contribute to better mutual understanding and problem-solving.	Indicates the stability of the partnership. Long-term relationships can lead to better terms and understanding of the requirements. It is also a way to reduce risk.	Important for budgeting and financial planning. It avoids sudden cost increases that could impact profit margins. It also signifies a degree of predictability in the cost of goods sold.	Important for companies planning to expand. Suppliers with growth potential can adapt to increasing demand.

General Topic	Specific Criteria	Comments & Sustainability Impact	Challenges to implement
1. <u>Mobility</u> Weight: 46.14%	<u>1.1.Reduction of deliveries</u>	6: The number of deliveries decreased compared to the past, now it is two a day. 6: Portugal has a large amount of deliveries compared to other european countries. 6: In the theory, it would be possible to reduce it even more by optimizing it with a good algorithm and inventory management.	2: it gives less flexibility to the hospital. 3: Possible to reduce it but it needs acceptance from the hospitals. 6: Wholesalers are afraid to decrease the number of deliveries because it represents a competitive advantage. 6: INFARMED mandates that a pharmacy should have the drug available in the next 24h. 6: Cultural difference compared to other countries.
	<u>1.2.Optimization of the itineraries</u>	6: Pilot partnership project: wholesalers collaborate to consolidate their deliveries. This strategy enhances sustainability and reduces costs by optimizing logistics.	1: Requires data accuracy and investment in optimization software
	<u>1.3.Having an electric trucks fleet</u>	Reduction of emission	3: Going to electric vehicles is not feasible at the moment because of the current autonomy that is too low

			3: The planning needs to take into account the charging time
	<u>1.4.Prioritize transport by ship rather than by plane</u>	4: When comparing emissions, the land transport is the best option followed by shipping and air transport. However, transport by plane is the fastest option.	3: Distribution to Portuguese islands: boat (best option regarding costs and sustainability) or plane (for emergency or cold products).
	<u>1.5.Shipping by active cold chains</u>	3: Initially, single use validated cold chain boxes were used.	3: Shipping cold products to the islands with active cold chain is not yet possible because the lifetime of the active cold chains is too short.
2. <u>Production</u> Weight: 30.40%	<u>2.1.Local sourcing of raw material for the drugs production</u>	1: As the hospital prioritize local suppliers, it is important to stay coherent and making sure they also prioritize locally sourced raw material. It supports local economy, in parallel with the hospital values. 1: The Supply Chain is then less vulnerable to global disruptions.	4: Conducting a lifecycle analysis is needed to understand the impact of the ingredients, what are they made of, where are they sourced.
	<u>2.2.Effort to reduce energy and water consumption in the production processes</u>	3: Minimizes consumption and emissions, which decreases the carbon footprint.	3: It involves optimizing equipment, harnessing renewable energy sources, and employing monitoring systems.

			3: implementation of closed-loop systems that recycle water and the treatment and reuse of wasted water.
	<u>2.3.Effort to go for less toxic materials in the drugs production</u>	3: Respect ICH guidelines about toxicity, (protecting patient safety by ensuring that drugs do not contain harmful levels of toxic substances). 2 & 6: Sevoflurane and Desflurane (halogenated anesthetics): Sevoflurane is an eco-friendly version of Desflurane with a lower GWP, so it is less toxic. However, when using the alternative, the patient takes more time to wake up after the surgery. Desflurane is advised for kids because you wake up faster.	2: Requires a period of adjustment from the medical team, as the effect of the drug can be different and the medical personnel can be reticent to adopt it. High investment: suppliers must invest in new products that are compliant.
3. Packaging Weight: 3.69%	<u>3.1.Quantity Reduction</u>	2: By increasing the batch size and bulk production. 2: By rethinking the way drugs are packed, keeping in mind that for example, packaging is sometimes needed for sterilization.	3: In some drug cases, it is better to pack in smaller blisters instead of big bottles to respect the product shelf life of the product. It is a trade off between waste and expiry date.

	<u>3.2.Replace the notice by a QR code</u>	3: Represent a huge amount of paper that is often not used by the patient.	3: Not everyone has access to a smartphone, perhaps excluding a certain segment of the population (elderly and disadvantaged)
	<u>3.3.Introduction of reusable packaging</u>	2: never seen implemented but very good idea to introduce circular economy, because the best way to recycle is to reuse.	2: Implementing a system for returning empty drug packaging to firms would be logistically challenging. It involves establishing collection and transportation networks, ensuring cleanliness, and maintaining safety standards. 2: However, streamlining the process, integrating it into existing operations, and offering incentives (like the bottle deposit system) could make it feasible. With careful planning, reusable drug packaging could be a viable and eco-friendly initiative.
	<u>3.4.Shift to more sustainable material</u>	Examples: 3: going from bubble paper to reused cardboard from the warehouse.	3: Changing a packaging material requires a lot of tests to make sure it doesn't disturb the stability of the drug (so it is very long to change).

		3: switch from aluminum to plastic polymer aluminium	2: It is not always practical for the pharmacists in practice to work with another material (for example, cardboard is less robust than plastic, picks up humidity and means you end up breaking more things which means more waste). 2: Given that packaging materials come into direct contact with drugs, it's crucial to ensure they don't compromise the sterility and quality of the product.
	<u>3.5. Use of recycled plastic</u>	5: The health care industry is a huge producer of plastic. Indeed, many consumables are single-use in order to guarantee patient hygiene, safety and health. 5: Partnership between the hospital and a plastic factory that wants to reach 30% of their production recycled: separation of toxic and non toxic plastic to recycle what it is possible.	5: Ensure the feasibility for all types of products because of safety concerns.
	<u>3.6. Individual labelling of the pills with the required information</u>	2: Pharmacists need to use a specific machine to label individually each pill to make sure	3: Mainly against doing distinct packaging because it increases the number of lines of

	<u>by the EU legislation (falsified medicines directive)</u>	each they all contain the required info (number of batches expiry data, type of drug, ...). The fact that it is not labelled individually yet produces a lot of unnecessary packages and is very time consuming for the pharmacists.	production, it complicates the production planning, it means more registration numbers. 6: It should increase the cost because you have now two lines of production (if you produce two different products and not only one)
4. <u>Waste Management</u> Weight: 10.92%	<u>4.1. Adopting a return-friendly policy</u>	3: The pharma company accept return till three months after the expiry date, legally it needs to be accepted by the firm six months before the expiry date, so the pharma company is putting an extra effort. 3: There is a legal requirement to destroy by incineration the product because it contains toxic chemicals. The destruction is outsourced and then the debris are going to a dump sit. Returning the drug represent a fiscal advantage for the hospital, it is economically sustainable.	5: Destruction of drugs can be problematic if it is not properly done, studies show that the river biodiversity is disturbed because of the hormones in the drug. 2: If a firm refuses to accept our expired drugs, we dispose of them at the hospital according to established regulations through an external company.
	<u>4.2. Recycling of the drug incineration debris</u>	2: Nonetheless, drug waste deemed hazardous undergoes mandatory	3: Incineration can lead to air pollution but also to the spreading of toxic substances if not

		incineration, as regulated by Dispatch No. 242/96 of the Ministry of Health. 3: possible to use the debris of the toxic drug incineration, so the fly ash (class C), to make Portland cement for building blocs.	carried out properly. It requires important regulation. Alternatives to incineration should be considered.
	<u>4.3.Adapting the format of the package (number of pills) to the common directives of the treatment</u>	As the patient is supposed to use the whole pack, it should have as impact to reduce the amount of waste.	Problems 6: Waste comes from the lack of adherence from the population to the treatment, we should promote adherence (the problem is in the use not in the supply). 6: It would require several production lines if we want to send big batches to hospitals.
	<u>4.4.Conduct further stability time studies to extend the expiry date of the drug</u>	6: It is possible to increase the stability time with further studies, example of the COVID-19 vaccines. 6: The industry has been too conservative on expiry dates.	2: Expensive on the short term, requires huge Research and Development investment.
	<u>4.5.Highlight the existence of the Valormed network on the packaging</u>	3 & 5: Already mentionned on the notice that it is possible to return medication to the Valormed network, but not putted in evidence, it would be a good idea to reinforce	3: Requires the collaboration of the pharmaceutical firms with Valormed. 6: Most of the people already knows about it because we receive a lot of medication in the

		the message because there is a lack of awareness in the population, pharma companies have a role to play by highlighting the existence of this initiative on their packaging.	return boxes. But there is still room for improvement so it could be good to promote it on the packaging; a few years ago, they started separating what is recyclable from what is not.
	<u>4.6. Guide the hospital pharmacies concerning the selection of the toxic waste through the packaging</u>	2: Level 4 contains all the top dangerous drugs, very toxic, that cannot be recycled but goes directly to incineration. Waste Management classifies waste according to the four levels of hazardous materials. This classification includes: Group I – Waste Equivalent to Urban Waste Group II – Non-Hazardous Hospital Waste Group III – Biological Hazard Hospital Waste Group IV – Specific Hazard Hospital Waste (includes rejected pharmaceuticals), such as expired medications or those not administered in their entirety, and cytostatics along with materials used in their preparation and administration.	2: Some clinical consumables are not recycled even if they are not in contact with the toxic drug (level 4). The cause is that the selection is more time consuming and sometimes time is missing in the management of the pharmacy, would requires to put some efforts. 5: A law from 1996 says that we cannot recycle the plastic used in surgical boxes even if they are sterile, following the law they need to go in the contaminated trash. 2: The pharmacy staff undergo mandatory training in the field of waste management on an annual basis.

5. <u>Social Sustainability</u> Weight: 8.84%	<u>5.1.Redistribution of soon-to-be expired drugs instead of destruction</u>	5: Redistribution to disadvantaged people. For many drugs, it is not dangerous to take it after the expiry date, and it is better than having nothing. 2: Good idea to redistribute instead of destroying. Partnering with associations could make a big difference. It's a great way to improve access to healthcare for those in need.	6: Impossible to redistribute almost expired drugs coming from individuals because we cannot assure the correct storage conditions; ethical problem to redistribute lower quality drugs to poor people; the only possible option would be to redistribute soon-to-be expired drugs coming from hospitals, where we known that the storage conditions are respected. 2: We would need to ensure only safe medications are included and establish clear protocols for distribution.
	<u>5.2.Certifications Assessment: B Corp, SA 8000, Fair Trade, ISO, ...</u>	2: Certifications help determine the presence of a gender pay gap, evaluate inequalities, and ensure inclusivity, including the employment of older individuals. Furthermore, they aid in scrutinizing practices related to child labor, the support of local suppliers, anti-corruption measures, and parental leave policies.	2: Requires regular audit, initial costs of obtaining certifications can be prohibitive for smaller suppliers.

8.5. Appendix 5: Computation of the Scores ¹³

1. Strategic/Cost aspect (initial evaluation map)

	Service Level	Trust	Communication	Relationship Duration	Price Stability	Growth Potential	Total score
Supplier 1	6	4	2	3	9	5	4,84
Supplier 2	7	6	8	8	6	7	7
Supplier 3	5	8	3	5	8	7	6

2. Sustainability aspect

Mobility (46.14%)

	Reduction of deliveries	Optimization	Priority to land transport	Ship over Plane	<i>Active cold chain*</i>	Total score
Supplier 1	6	5	1	9	0	6
Supplier 2	9	7	0	8	1	6,8
Supplier 3	4	5	0	6	0	3

Production (30.40%)

	Local Sourcing	Energy/water consumption reduction	Less toxic material	Total score
Supplier 1	7	6	2	5
Supplier 2	3	6	9	6
Supplier 3	9	8	9	8,67

¹³ Binary Criteria are identified by an asterisk.

Packaging (3.69%)

	Quantity reduction	<i>Notice in a QR code*</i>	Reusable packaging	Sustainable material	Recycled plastic	<i>Labelling*</i>	Total score
Supplier 1	7	0	4	5	8	0	4
Supplier 2	8	0	4	5	6	1	5,5
Supplier 3	9	1	3	5	4	0	5,17

Waste management (10.92%)

	<i>Return-friendly policy*</i>	Recycling incineration debris	<i># Pills adapted to treatment*</i>	Conduct stability time studies	<i>Valormed highlight*</i>	<i>Guidance on toxic disposal*</i>	Total score
Supplier 1	1	5	1	4	1	0	6,5
Supplier 2	1	6	1	6	0	0	5,34
Supplier 3	1	8	1	7	0	0	5,84

Social Sustainability (8.84%)

	Redistribution of soon-to-be expired drugs	<i>Certifications assessment*</i>	Total score
Supplier 1	7	1	4
Supplier 2	6	0	3
Supplier 3	5	1	3

8.6. Appendix 6: Summary of the Sustainability Criteria

Category	Criteria
1. Mobility	1. Reduction of deliveries 2. Optimization of the itineraries 3. Short distances priority: land transport 3.1 Having an electric trucks fleet 4. Long distances priority: transport by ship over air 5. Shipping by active cold chains
2. Production	1. Local sourcing of raw material 2. Effort to reduce energy/water consumption 3. Effort to use less toxic materials
3. Packaging	1. Quantity reduction 2. Replacing the notice by a QR code 3. Introduction of reusable packaging 4. Shift to more sustainable material 5. Use of recycled plastic 6. Individual labeling of the pills
4. Waste Management	1. Adopting a return-friendly policy 2. Recycling of the drug incineration debris 3. Adapting pill count per pack to treatment protocol 4. Conducting stability time studies 5. Highlight of the Valormed network 6. Guidance on toxic waste selection
5. Social Sustainability	1. Redistribution of soon-to-be expired drugs 2. Certifications assessment

