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Optimizing Material Flow by Applying Lean methodology

Exploring Information Flow Barriers Among Stakeholders in Pharmaceutical Materials Management

Bachelor's thesis in Industrial and Materials Science

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PREFACE

This thesis work, consisting of 15 credits, was conducted at the Department of Industrial and Materials Sciences at Chalmers University of Technology, in collaboration with AstraZeneca.

First and foremost, I would like to express my deepest gratitude to AstraZeneca for entrusting me with this work opportunity but also their hospitality for providing me with an office during my time there.

A special thank you to Jonas Malmqvist, my manager and Masuduzzaman Mohammed my supervisor at AstraZeneca. Whose guidance, support and willingness to share knowledge truly helped me elevate my work. Likewise, the staff at Material Management have also been helpful and kind, especially with their participation in interviews and helping me understand my Gemba walks, thank you.

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Key words: Lean, Clinical Supply Chain, KPI, Qualitative Interview, Industry 4.0

WORDLIST

LLMs: Large Language Models
FAQ: Frequently Asked Questions
SOP: Standard Operating Procedure
IIoT: Industrial Internet of Things
Buffer: Temporary stockpile of materials or components

ABSTRACT

This study examines how a stringent regulatory industry like the pharmaceutical industry could adopt modern operational practices like Industry 4.0 and Lean principles. This thesis presents a case study at AstraZeneca's Material Management in Gothenburg, aiming to identify bottlenecks within lean principles and propose data driven improvements. Using methods like methodological triangulation by combining different methods such as Gemba walks, semi-structured interviews, and datasets.

The research identifies multiple issues such as information flow as the primary bottleneck. Research hits communication issues between departments by providing incorrect documentation, creating waste, and defect wastes that cascade into secondary inefficiencies. The department also lacks Key Performance Indicators and cross-departmental transparency, resulting in a "black box effect".

The data also reveals a growing trend in reported issues year-over-year, suggesting that organizational growth introduces new operational challenge that current processes are not equipped to handle

This study attempts to suggest possible solutions on KPI implementation, a visual process interface with checkpoints, standardized checklists, new communication channels, and an AI chatbot for inquiries attempting to replace static communication methods such as frequently asked questions.

SAMMANFATTNING

Denna studie undersöker hur en bransch med stränga regleringar, såsom läkemedelsindustrin, skulle kunna införa moderna arbetsmetoder som Industri 4.0 och Lean-principer. Uppsatsen presenterar en fallstudie från AstraZenecas materialhanteringsavdelning i Göteborg, med målet att identifiera flaskhalsar inom Lean-principerna och föreslå datadrivna förbättringar. Metoder som metodologisk triangulering används genom att kombinera olika metoder, såsom Gemba-rundor, semistrukturerade intervjuer och datamängder.

Forskningen identifierar flera problem, såsom informationsflödet som den främsta flaskhalsen. Forskningen belyser kommunikationsproblem mellan avdelningarna genom att tillhandahålla felaktig dokumentation, vilket skapar "waste" inom Lean och defekter som leder till sekundära ineffektiviteter. Avdelningen saknar också KPI och avdelningsöverskridande transparens, vilket resulterar i en ”black box-effekt”.

Data visar också en växande trend i rapporterade problem från år till år, vilket tyder på att organisationens tillväxt medför nya operativa utmaningar som de nuvarande processerna inte är rustade att hantera.

Denna studie försöker föreslå möjliga lösningar för implementering av KPI:er, ett visuellt processgränssnitt med kontrollpunkter, standardiserade checklistor, nya kommunikationskanaler och en AI-chattbot för förfrågningar som försöker ersätta statiska kommunikationsmetoder såsom vanliga frågor.

CONTENT PAGES

1. INTRODUCTION

The worldwide Pharmaceuticals Industry has experienced an incredible growth in revenue in the past two decades. In 2024, the total revenue was 1.7 trillion dollars [1]. By 2035, the industry is expected to grow over 3 trillion dollars [2]. Post-approval R&D cost is estimated at 2.8 billion dollars (2013 dollars), with an annual growth of 8,5% [4]. In a world where a company is becoming more efficient as the norm, the whole pharmaceutical industry has yet to fully transition into industry 3.0 while other industries have achieved 3.0 and some have implemented industry 4.0 [5]. The companies that implemented Lean 4.0 improved their quality assurance reliability by 50% and decreased their inventory waste by 57%. [25]. Today the pharmaceutical industry tends to waste around 70% of all the drugs produced, this wastefulness cost the top 10 companies an estimated hundreds of million [7]. The reason pharmaceutical industry has a great difficulty reaching industry 3.0 or the lack of innovation towards industry 4.0 is the stringent regulations that the pharmaceutical companies work with [8]. The pharmaceutical industry is one of the most regulated sectors globally. American FDA (Food and Drug Administration), WHO (World Health Organizations, EMA (European Medicines Agency) all have a significant role in ensuring that pharmacy companies go through rigorous testing and validation to provide qualitative medicines as it affects public health and safety [9]. Pharmaceutical companies have shown interest in lean and six sigma methodologies, not only in manufacturing but also in R&D [10]. This shows that lean is possible within pharmaceuticals and has even netted some interesting results already, one spokesperson for Bristol-Myers Squibb has mentioned that “It’s quite amazing when you start to apply this criteria (lean) to how we do drug discovery. You essentially see how inefficiently we do it” [10].

1.1 Problem Description

SAP is the main goal of Axial 2030. SAP is an electronically centralizing data management system [11] that will improve the pharmaceutical industry, because SAP is used to give different departments easy access to real time information across the company [12]. This change will make it easier to plan and act reliably with minimum conversation between departments, because of the cross-department information access. But implementing SAP does not mean that AstraZeneca will become a Lean company overnight, or that SAP will be a magic tool that will solve every problem.

KPI and other measurement metrics will be crucial for a smooth transition from old technology into 21st century digitalization. Today information flow between different departments internally and externally can be hard to streamline. This issue will be attempted to solve using SAP, but the building blocks need to be placed right now using lean principles to remove waste, streamline material and information flow and tracking our process using KPI to ease the transformation into Axial 2030s digitalization era.

1.2 Goal and Purpose

The primary goal of this research is to identify and analyze an unspecified bottleneck withing the Material Management team. The department responsible for inbound orders/material acknowledges the existence of an inefficiency; no scientific research has been performed to identify the root cause. Therefore, the aim is to perform a comprehensive case study to locate inefficiencies and provide a data-driven basis for future improvements. By mapping the process and analyzing the workflow using lean methodologies. These goals have been summarized into bullet points for more manageable understanding:

- How is the current material flow in MM&D defined and measured?
- What does a comprehensive analysis using Lean principles reveal about the existing processes?
- What improvement solutions can be designed to optimize material flow?

1.3 Delimitations

The case study will only focus on Management and not for other departments or AstraZeneca as a whole.

This study is also a thesis bachelor of 15 HP and consists of 20 weeks in total, which limits the scope of this study to only one product family within the department and not for every product family

This study will also not present any experimental results due to time limitations and will adhere to future actionable suggestions.

1.4 Tools During writing procedure

AstraZeneca, like many other companies, has strict regulations and rules regarding information sharing and use of AI tools on public sites and servers. Therefore, some parts of thesis have utilized AstraZeneca's own AI called AZ ChatGPT to meet these strict rules for data protection. The reason for the usage of AI is to enhance writing, ensure that the reader has quality reading material through improved grammar, sentence clarity, and structure.

2. Theoretical background

This chapter will describe the theoretical framework that will be used in this thesis to help create a baseline for understanding during other chapters, including methodology, results, and discussion.

2.1 Lean Principles

In the late 1900s, as mass production and scientific management techniques were questioned, a new method was discovered in Japanese manufacturing companies. These companies demonstrated that the idea of "Just in time" was a more effective approach to manufacturing. As a result, during the 1980s the European and American companies began to adopt these methods, which lead to a major paradigm shift across many industries [13]. These methods later came to be known as Lean principles. Although they originally developed within industrial factory logistics, they were later adopted in sectors such as the military, construction, automotive and service industries, just to name a few.

Lean is a philosophy and for companies it is not always an easy implementation because these Lean principles are not only just a technical matter but something that also affects cultural and methodological aspects [14]. Successful lean adoption requires organizations to rethink how people work, collaborate, and approach problems daily.

The philosophical aspect of lean is called the 4Ps [15]. Those four Ps are:

Philosophy: every decision starts from the board. Lean can only happen if there is a long-term commitment to the cause; else there cannot be desired results.

When first implementing Lean, Companies might experience a short-term economic stagnation [16]. The reason behind this is because the implementation of Lean requires fundamental rethinking of their business strategy, operational processes, and organizational culture [17]. Lean requires a long-term commitment strategy for long term planning to take place because Lean brings new ideas, methods, and responsibilities. Ultimately, it initially disturbs the business short term.

A significant challenge during the adaptability phase is the resistance of individuals, particularly at the management level. Managers might expect results comparable to pre-Lean performances, which in turn puts immense pressure on the workers, to maintain previous output levels with much less experience in a new working environment. This pressure can undermine Lean principles, as workers will be attempting to revert to familiar methods, viewing Lean as a temporary initiative rather than a fundamental shift in the organization's philosophy. This short-term thinking may sacrifice long term strategic gains to satisfy immediate performance expectations. Such an approach fundamentally contradicts Lean philosophy, which requires patience, and commitment for continuous improvement over extended timeframes.

Process: In Lean philosophy, processes are not static but rather dynamic. Processes should constantly improve through experiments and learning from prior processes. Toyota Production Systems utilize many types of processes. Arguably, the most important one is value stream mapping (VSM). It identifies every activity necessary from the moment material is delivered to the factory until it leaves the factory. It does not necessarily have to be a product, it could also be a service. Value stream mapping helps distinguish value adding practices from non-value adding activities [18]. Thus, creating the possibility to systematically eliminate the 7 wastes of lean [20].

Lean has a huge emphasis on continuous flow, where products and services move through operations with no interruption, and where customers set the tempo with their demands rather than forecasts. Kanban is a system built on this idea and utilizes a visual signal to regulate workflow and prevent overproduction.

People: Respect for people is a core foundation in Lean philosophy, enabling genuine empowerment and development [15]. Organizations must invest in employees through training and providing opportunities for skill development. Creating an environment where people can express their ideas and challenge existing practices is essential for continuous improvement [21]. Investment in workers also enhances job security. Layoffs should not be an option for cost reduction, rather the investments in personnel will naturally reduce cost by eliminating waste [15].

Respect in Lean extends beyond the organization's boundaries. Lean emphasizes the development of long-term partnerships with suppliers based on shared objectives [21]. Rather than focusing on short term partnership by picking the most cost-effective partner, Lean organizations work with long term partners, by working closely with suppliers with ambitions for long term partnership, this collaboration will lead to improved quality, reduced lead times, and elimination of waste through extended value streams. This requires supplier development programs, transparent communication, and commitment to mutual prosperity.

Problem Solving: Problem solving is usually executed by putting Band-Aids on processes, most commonly reoccurring problems. This approach never truly lets the organization get a higher level of performance. In Lean, reaching the root cause of an issue is often seen as a better long-term solution [15]. One of the methods of finding the root cause is called the 5 Whys, a technique where the personnel need to repeatedly ask “why”, which will make the problem go from a surface symptom to its underlying causes [20].

PDCA is another method. PDCA stands for Plan-Do-Check-Act. The way this method is approached is to first plan on potential improvements based on existing data, then implementing those changes on a small scale, checking the results, and comparing them to the expectations. Then try to standardize successful changes and adjust the unsuccessful ones. PDCA creates an experimentation culture to constantly strive for implementation through curiosity and data analysis.

2.1.1 Waste of Lean

The main idea of lean principles is to eliminate waste [17]. In lean terminology, waste is considered as "Something that does not add value to the customers product or the process to produce that product". There are 8 wastes in total [22]. These 8 wastes are:

Overproduction occurs when the output of a product exceeds the demand of the customers; it could also be that the manufacturer has produced the order prior to the set date. Overproduction also tends to create other types of waste like inventory and transportation, because of the surplus that must be stored. Overproduction also carries a significant financial risk as goods produced without demand may never find a customer, resulting in financial losses for the company.

Transportation is a type of waste that refers to unnecessary movement of materials, parts, or information between processes which does not add value to the final product. Movement is seen as a cost to the final product due to the unnecessary processing time and resources it takes, which does not actually improve the functionality of the final product. Excessive transportation also complicates the overall workflow which often hints on another underlying issue or type of inefficiency. Like over capacity of inventory, which tends to create a need to temporarily move other products around to create inventory storage.

Inventory waste occurs when the company does not have knowledge of their inventory capacity, does not adhere to the capacity level, or in worst case scenario is trying to over promise, all of which cause more issues than expected. Trying to hold more material than customer demand carries a huge risk, because future demand is not promised and might lead to higher inventory cost. Some companies do not see excessive inventories as an issue because they use excessive as a "buffer". The reason behind this is to mask even deeper failure. For example, the factory might be very inefficient as it uses the buffer to mask that inefficiency; some of these inefficiencies could be poor quality control or unreliable suppliers.

Waiting describes the idle time. This could be when workers are forced to wait because they cannot complete their work task due to previous steps that have not been completed yet or if the previous step is faulty and will not suffice to complete future tasks. This type of waste could also be a bureaucracy issue because documents need to be signed or must go through careful control. Another issue could be communication channels where a company might still use outdated communication methods or that communication and information is tied to specific humans which create longer lead times.

Defects are tied to the quality of the product. If the product does not meet the required quality standards, it must undergo rework, repair, or worst case must be disposed of as scrap. This type of waste is particularly damaging because even if all other processes are executed perfectly, defects will still negatively impact overall performance. When production occurs according to demand, but products must be scraped, it creates

waiting waste, costs money and time, requires last-minute transportation, and results in overproducing just to meet demand.

Motion waste is unnecessary movement for personnel; it could be something small like having to move from your work cubicle to another room just to find a scissor that you might need and then must return it. Or it could be even worse, like having to move from one side of the factory to another to complete a work task. All of this leads to physical fatigue for the workers, which might lead to frustration, mental and physical fatigue, or even higher risk of workplace injuries. All these risks do not add any value to the final product.

Overprocessing can be seen as "Gold Plating". It occurs when manufacturers add unnecessary steps to their processes or/and products, such as detailing the products when the customers have not requested it, or performing activities beyond the scope of what is being paid for.

Skills are the failure to leverage knowledge and work experience of workers. When a manufacturing process is too rigid and the workers do not have the opportunity to engage in "kaizen", it hinders their ability to apply their skills, and the ideas workers had ultimately become a form of waste. Companies should listen to the ideas and insights of workers to gather information about the process before any changes are made. There should be opportunities to empower workers, as low morale may develop otherwise, and changes implemented without the workers involvement may lead to a stagnant workflow.

Companies should actively evaluate their manufacturing processes through the frameworks of the eight wastes of lean. Without systematic assessment, it can be difficult to identify specific sources of inefficiency within the company. By applying appropriate measurement techniques, organizations may find that financial difficulties are not necessarily inherent to the business model, but rather the result from identifiable and potentially addressable forms of waste.

2.1.2 Gemba Walk

Gemba is an important part of Lean philosophy. Gemba is the Japanese word for "The Actual Place". The idea behind Gemba is to see the process for yourself, instill discipline, get a chance to talk with employees to hear what problems are not getting solved, a chance to monitor quality and safety, connect team goals with organizations strategy.

Gemba is often associated with PDCA (Act, Plan, Check, and Do). It is commonly linked to DMAIC, a problem-solving framework used in Lean and Six Sigma. DMAIC is an acronym for Define, Measure, Analyze, Improve and Control. Because PDCA and DMAIC both support process observation, problem identification and continuous improvement, DMAIC often gets applied within a Gemba based improvement approach. [23].

The initial phase of conducting a Gemba walk is to plan. Planning has two parts, Scope and Relevance. The Scope ensures that the designated area in which the gemba will take place is manageable in terms of size and complexity, enabling focused and systematic examination.

Relevance ensures that the place of research directly aligns with the overarching objectives of the Gemba walk, guaranteeing that the observation remain anchored to the preparation phase, which will in turn yield meaningful insights that closely aligns with the research questions.

During the preparation phase, it is essential to establish clear and well-defined objectives for the specific purpose of this Gemba walk. The researcher must identify the particular issue or phenomenon to be observed in the "real place". For instance, is the research goal to eliminate bottlenecks, improve safety or enhance productivity? By having clear objectives before the walk begins, the researcher maintains focus on the predetermined phenomena under investigation, therefore reducing the risk that unexpected discoveries will divert attention from the primary research objectives.

The second phase of Gemba is the actual walk. During this phase, it is of most importance to remember that Gemba is not just an observational activity but also an interactive process in which the researcher can ask open-ended questions to gain a deeper understanding of the process. All questions posed and responses received should be systematically documented. This documentation helps the post walk analysis, and there might be information that could be shared so having it all documented makes it easier.

There are also several tools and techniques that can enhance the effectiveness of Gemba walks and yield more meaningful results. Process maps or floor plans serve as guides during observation, allowing researchers to help write what happened in different parts of the map to remember later but also to note that not every issue happens everywhere in the process, some are specific issues.

Checklists are a valuable form of aid, specifically listing things you have intended to observe from the preparation phase. This will help the participant to actively look and search for the issues and will minimize the risk of getting overwhelmed. Process maps can serve dual purpose beyond navigation, the map could also be used to write down which type of Lean waste is occurring in different machines, or departments or areas.

Video recordings provide an opportunity to review the gemba walk retrospectively. The researcher may wish to revisit the recorded observation after completion to identify details or issues that may not have been apparent during the initial visit. This can be particularly valuable when the walk involves a large amount of information and may be overwhelming during the initial observation.

2.2 Industry 4.0

Industry 4.0, or as it is often called, the fourth industrial revolution, is the digital transformation that is reshaping the foundation of work. Industry 4.0 has gained significant attention in the 21st century because it has a substantial impact on sustainability, economics, and social development. Arguably, the most widely discussed concept of industry 4.0 is IIoT. Industrial reports show that the application of industry 4.0 technologies such as IIoT, cloud service and data analytics has been associated with number of economic sustainability opportunities through methods such as material flow optimization, better time to market of products and reduction of waste, just to name a few [26].

Industrial Internet of Things is defined as the “technology dealing with the interconnection of physical devices along with inter-relation of data via internet without requirement of human to machine, human to human interaction.” [27]. By feeding information from a physical factory, the data could be stored in data centers, which the data then could be analyzed using artificial intelligence. This method has proven to deliver greater efficiency [27].

2.3 Lean and Industry 4.0

Industry 4.0 technologies have a strong synergy with Lean principles, they often complement each other. Industry 4.0 is used to solve the implementation challenges related to Lean [28]. Kaizen is an important part of lean principles and smart products from industry 4.0 can collect and use data to analyze the information about repeating actions from their sensors. By using the information provided by IIoT, companies can more easily focus on continuous improvement [29].

2.4 Black Box Effect

Logistic executives at Procter & Gamble noticed that their customers consumed diapers at a steady rate, but the demand order had a variety in the supply chain. This variety was also amplified as they moved up the supply chain. This phenomenon is called the bullwhip effect [30]. Bullwhip effects occur when suppliers and departments try to forecast production, these forecasts create more demand that is necessary, when companies don't have proper communication, it becomes hard to understand market trends thus leading to overproduction. There are solutions presented to counteract these bullwhip effects, namely:

Information sharing is when demand is shared from downstream departments and transmitted upstream departments in a timely manner [30].

Channel alignment is the coordination of pricing, transportation, inventory planning, and ownership between different departments within the supply chain [30].

Operational efficiency refers to activities that improve performance such as reduced costs and lead time [30].

One of the solutions is to make data available for every department, leading to both sides being able to update their forecast with the same raw data [30].

One way suppliers tend to work through contracts, by having formal agreements, transparency is established, which leads to better teamwork across departments [31].

2.5 KPI

Key Performance Indicators are methods used to assess organizational performance and goals. However, KPIs should not be used to validate an organization's success. Instead, they should be used as a guiding mechanism that helps align activities across the organization, KPIs provide a clear picture which encourages everyone in the company to share the same goals, the KPI is used to manage performance and make sure that everything that is accomplished in the company is done so to meet and exceed those KPIs [32].

3. METHOD

This chapter presents the methodological approach used in this thesis. The methodology of the work will be a weekly sprint structure derived from Agile Project Management [24].

3.1 Study Structure

This research employed an iterative, Agile-inspired approach to account for the uncertainty and exploratory nature of the Study. At the end of each week, the researcher, supervisor and sometimes the manager meet and conduct a review of the weekly process, to evaluate whether the weekly goal was achieved and how close that week has gotten the team to the goal of the project, and what could be done in the following iteration based on previous results and urgency to meet demand of the core goals.

This iterative methodology is suitable in highly uncertain settings [24]. The appropriateness of this study stems from two key factors. Firstly, this study will take place in an R&D setting, which entails significantly more volatility than commercial material flow. Secondly, this thesis itself is volatile in the sense of what to expect because a study like this has not been done prior to this one. Hence, a rigid methodology like waterfall has not been chosen because of lack of flexibility which this study requires.

The research method employed to conduct this research study is Methodological Triangulation, defined as “The combination of methodologies in the study of the same phenomenon” by Denzin (1978:291). Triangulation enhances research validity and reliability by compensating for the limitation risks of only one method.

The reasoning behind the utilization of methodological triangulation is to minimize the risk of flawed or misleading data from relying on a single data collection method. By using multiple methods, the root cause becomes clearer to the researcher, especially when the researcher can how the root cause affects different people and methods, which also helps with cross validation of the findings to better understand complex root causes.

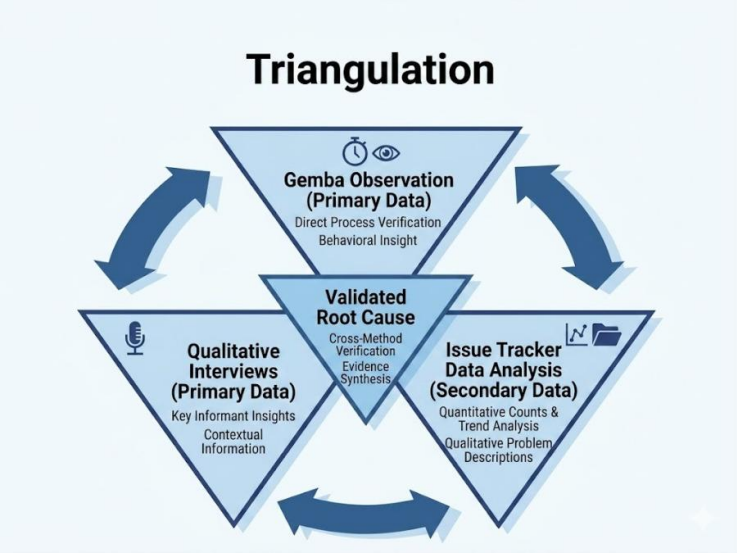

Figure 1. AI generated image showing triangulation method

Three different research methods have been used for this study; they could be categorized as qualitative and quantitative.

Qualitative Gemba walk: Instant workplace observation to understand actual work processes and identify visible waste, work standards and how workers perform their tasks

Qualitative Interviews: Conversations with personnel to understand root causes and worker perspectives on various work-related topics.

Quantitative company dataset data: Analysis of historical problem records to identify patterns and trends.

3.2 Literature Review

The first step was to gain an extensive understanding of the scope of this thesis by reading existing literature; a comprehensive foundation was set up. This literature reviewing process could be divided into two key segments: Theoretical foundations and methodological approaches, such as existing theoretical papers on lean-principles, six-sigma, and process mapping. These papers help understand fundamentals in the pharmaceutical industry as well as other industries with the ability to understand how lean principles affects different industries and how applicable it becomes very appealing for industries that are lagging. Analyzing leading industries while working in a lagging industry is common and often referred to as cross-industry analysis [13]. Because the second part consists of interview methodologies and methodology for writing a scientific paper but also analyzing scientific research. Learning to analyze and quickly understand which papers are relevant to this work significantly helps the study from a time perspective as well as credibility. After reading about theoretical research papers about lean and six sigma the next step was to read more niche papers about

these theories in pharmaceutical industry or Sweden. To see how different industries and regions work with lean and six sigma. If the same theories have different outcomes, implementation barriers, or success rates depending on the cultural and regulatory frameworks.

3.3 Data Collection

To gather quantitative data, AstraZeneca provided two different datasets for analysis. Both consist of problem logs spanning multiple years, from 2024 to 2026. However, this thesis will focus on data from 2024 and 2025. The reason for this decision is to compare two full years, 2026 is too early and therefore there would not be sufficient data enough to examine that data.

The data handling process began by assigning different categories to each log entry. This made it easier to identify correlations, divide the data into segments, and thus draw conclusions.

For the categories, the logs had predetermined labels such as Date, Category, Title, Description, Department, Issue root cause, Responsible. While all of these categories are relevant, many of them require reevaluation or additional verification for better results within the context of this research.

For this reason, the case study will not be strictly qualitative or quantitative, the aim is to have both. Qualitative through phenomenological interviews, Gemba walks and quantitative through existing data.

The categories selected were “Category”, which refers to the type of category the product is. “Issue” explains what kind of issue occurred to the product. “Responsible” is used to pinpoint if the issue is originated internally, externally or from suppliers. “Responsible” was determined using “Description” and “Title”. By reading the description it was made clear who was responsible for the issue. This data can be misleading, therefore there is a need to validate this data. This is why the research consists of two parts, Qualitative and Quantitative.

3.4 Gemba walk

Gemba walks were utilized to capture the actual work practices of the inbound logistics process. The method used during these Gemba walks was observation and continuous questions to understand the line of work.

3.4.1 Gemba Data Collection

As this work was limited to Material Management , the first step was to map all the workers and their experience in general. The actual workplace is divided into two parts:

one physical and one digital. This department is seen more like a service and checkpoint department. Most of the work happens through information sharing. The rest happens in another building compared to the information workplace. Therefore, the researcher focused on both.

Before conducting a Gemba walk, there had been a lot of planning done, namely information analysis. It is important to know what to look for. The initial Gemba was done after data collection based on historical issues in the department.

The Gemba walks were structured around these four questions:
1. Which of the 8 wastes of Lean could be identified?
2. Could any of the data collected be seen in the real place?
3. How does the process look like?
4. Where is the material coming from and where will it go after?

The reasoning behind these questions was to understand whether the data is accurate or if there is a consistent pattern between what the data suggests and what is happening in the department. By understanding the data, the goal was to validate the claims of the company's datasets. This method is called methodological triangulation, where different research methods, both quantitative and qualitative methods, are integrated to cross validate findings. Then the goal was to understand where exactly the issue was, because the work could be divided into external and internal sections. Internal being the goods area where the material is and the external part being only about information about the material either prior to arrival or after arrival but the information being inconsistent enough to halt the process, the goal was to understand where the optimization had to take place, that is why question 3 and 4 was important.

Five Gemba walks were conducted, the dates ranging from 10th of February 2026 to 27th of March 2026, each with specific observational objectives that were built on previous data, such as gemba walks, interviews, and company dataset.

First Gemba took place on the10th of February 2026.
Objective: To observe and understand the process for the first time, an overall view of the goods area, what system is being used, what type of issues the workers say that they have.

Second Gemba took place on the12th of February 2026
Objective: To observe workers performing their actual work and then stop and ask them questions regarding what they did and why they do it in that way.

Third Gemba took place on the23rd of February 2026
Objective: Prior to the Gemba walk, there was an issue with one of the orders, which helped gain a deeper understanding of how workers react to certain issues.

Fourth Gemba took place on the 6th of March 2026
Objective: To see how workers work on different orders, something that had not been previously observed

Fifth Gemba took place on the 27th of March 2026
Objective: To return to the real place after gaining so much more knowledge and try to understand the process from an engineering standpoint and assess what had changed compared to the first Gemba walk

3.5 Study Interview

Interviews were pivotal for this research, serving to validate but also explain findings from previous methods. Interviews provided opportunities to gain a better understanding of the processes from experienced workers, but also to validate patterns from prior methods. Therefore, interviews have become the most important method for research. Additionally, interviews captured information that the quantitative method did not show or could not be interpreted.

Interviews were conducted with two different groups based on their relationship with Material Management. First, the personnel within Material Management who directly worked with the daily operations.

The second group was the external stakeholder from other departments who regularly interacted with Material Management through information and material requisition. The need for an interview with external stakeholders became necessary after the first interview which revealed that external stakeholders had a big influence on Material Management work processes.

Due to the complexity of the information that needed to be explored during these interviews, to gain as much data as possible but also to be used to get answers for other method questions. Interviews had to be conducted instead of questionnaires. Both methods were evaluated, and interviews were preferable for one reason: open-ended questions. Due to how complex and volatile the questions were, it would be a waste of opportunity not to interview each person.

A questionnaire was initially prepared as a potential alternative or a complementary method for the interviews. The researcher decided to not publish the questionnaires before conducting the interviews to assess the complexity of the interviews. Ultimately the researcher decided against a questionnaire, because it would be inadequate due to the lack of follow up questioning, real time clarification and conversational flexibility that proved essential for exploring the context dependent processes under investigation.

Qualitative research was the type of method used for these interviews. Because qualitative research is predominantly used when the research has to “Focus on individual experiences or group norms” [33]. But also, for “Conceptualizing data and identifying patterns and relationships” [33]. This type of research works with the overarching goal of this segment of the research because of the need for flexibility and understanding the workers who have much more knowledge of the processes.

The interview structure was decided on Semi-Structured Interviews [34]. These questions made sure every participant got the same questions and had follow up probes to further dictate the conversation, while if something interesting arose, the option to ask questions outside of the questions and probes were possible.

3.5.1 Interview analysis process

The interview analysis was based on a concept called phenomenological method, a concept widely used in qualitative research [41]. In this case study, Colaizzi's seven step process was selected because it provides a rigorous framework for data analysis [36].

The first step for this method is to become familiar with the dataset by reading the material thoroughly several times. The second step is to identify all statements that are relevant to the research goal.

The third step is to formulate the meanings from the identified statements. In this study, however, the researcher does not formulate these meanings and findings based on interpretation but instead uses raw interview data to validate the research goals with the interviewer's own words. The next step is to create themes based on the different statements formed by all the interviewers.

The research then creates descriptions of these themes as step five suggests. In the sixth step, the researcher condenses the description part, to isolate the essential meanings that directly answer the research goals. The last step is to validate the findings by returning to the raw data and analyzing whether the conclusion captures the true experience of the interviewer. If it does not, then the researcher starts over until it does [36].

3.5.2 Interview process within Material Management

The Material Management team consists of four employees, all of whom are AstraZeneca staff with substantial experience and knowledge of the relevant processes. All the interviews were conducted on site in a face-to-face format, as both interviewer and participants worked in the same facility. Although online interviews were a solid option, they tend to be underreported [37].

Prior to the interviews, the researcher prepared questions, studied the process in advance through Gemba walks, and developed material to present during the interview. The questions used during the interview are presented in Appendix G & H. Appendix B & K was also used during the interview as a subtle way to evaluate the prior work of the researcher but more importantly a way for the researcher to instantly see a complex work process seen on a piece of paper.

Before each interview, the interviewer provided the interviewees with a consent letter. This document assured the interviewee that their answers would be used solely for research purposes and would not be shared with management or used for performance evaluation. It also stated that the interviewee's identity would not be known to anyone and strictly kept confidential and would not be disclosed to anyone other than the researcher. This helped create an environment in which the participants could share information more openly, including issues that might otherwise have created hesitation due to anxiety or stress. Participants were also informed of their right to withdraw from the study at any time.

Participants were not provided with interview questions or any preparatory material in advance. This decision was intentional and aimed at encouraging spontaneous conversation rather than exchanging rehearsed responses. The main goal was to obtain spontaneous, rich, specific, and relevant answers from the interviewee, with actual experiences. Kvale (1996) states that the aim of an interviewer is to create “self-communicating”, where participants' responses are clear and meaningful without requiring extensive interpretation. [38]

The interview questions were designed to serve three purposes. First, they were used to assess historical practices and working methods identified through Gemba walks and company dataset analysis, and to compare those findings with the experience of the workers. Secondly, the interviews explored issues and topics that were not observable through those previous methods, such as information flow problems, decision making processes and communication breakdowns withing the digital systems. Thirdly, the questions examined where the workers thought the root cause was located, why they held those views, and how those causes might be investigated further. All interviews were also sound recorded to let the interviewer have the option to revisit the material for better value extracting.

The first interview question was designed to allow the workers to explain if Appendix B accurately presented the process or whether any elements needed to be added. A follow-up probe was then used to encourage them to explain the process with the support of this visual representation in Appendix B. This enabled the researcher to assess whether the findings from previous methods were consistent with the accounts given by experienced workers. Another probe was used with the help of appendix K, which presented the eight wastes of lean visually. The purpose of this was to help workers identify which forms of waste had the greatest impact on different parts of the processes shown in appendix B. This also bade it easier for each participant to refer to specific types of waste, even if they did not immediately remember all eight categories.

Interview dates:
26th of February 2026 – Pilot Interview
2nd of March 2026 – First Interview
5th of March 2026 – Second Interview
5th of March 2026 – Third Interview

3.5.3 Interview process: Stakeholders

To identify eligible stakeholders for the stakeholder interview, the researcher decided to interview the most recent stakeholders that worked with Material Management. Most recent 48 orders spanning from 17th of March 2026 to 15th of July 2025. This timeframe was selected to capture current working relationships and recent process experiences.

Following the interview with Material Management, several questions emerged that required stakeholder perspectives to address them fully. Therefore, the goal of the research was to create interview questions that would directly answer the questions of the workers that were closely in line with the research questions of this study.

There were many reoccurring stakeholders responsible for the orders sent to Material Management. What initially appeared as 48 orders essentially consisted of 20 stakeholders. The researcher only found the contact information of 13 people out of those 20. Out of those 13, 5 people agreed to take part in the interview.

The interviews took place in the following dates:
23rd of March – Pilot interview
24th of March – First interview
24th of March – Second interview
24th of March – Third interview
24th of March – Fourth interview

Almost all stakeholder interviews took place online through Microsoft teams expect one; the reasoning behind this decision was attributed to distance. Most of the participants lived in England, one in Poland and one in Sweden. The interview with the Swedish participant took place at site like previous interviewees. The remaining interviews were conducted via a video call. Interview types do not create a significant difference in results [39]. The participants were highly engaged and wanted to improve AstraZeneca just as much as any other person.

3.5.4 Pilot Interview

The objective of a pilot interview is to conduct a small-scale version of a planned interview. Pilot interviews are very useful to assess readiness, ability, and commitment. Pilot interviews allow researchers to practice and then analyze the results based on planned data collection, thus allowing the researcher to improve the effectiveness of the interview prior to the large scale-study. When conducting a pilot interview, it is important to have a reason as to why the interview is taking place [39].

In this case study, two interviews took place, one interview with Material Management and one for the stakeholder interview.

During the interview for Material Management, the researcher realized that the interviewee had limited familiarity with Lean and could not recall the 8 wastes of Lean, thus the first improvement was to print out pictures of the 8 waste of lean as shown in appendix K so the interviewees could take their time and read through them each time to give a better answer. Another improvement was to have a better introduction before the interview to give each participant more confidence, and these words of encouragement later proved to be an effective approach as they became more open to answering questions. The last improvement was to stop using a cover letter as it was deemed too serious and not necessary because all the interviewees were AstraZeneca workers, and it was part of their job to take the interviews.

The pilot interview for the stakeholder interviews was considerably more successful than the interview with Material Management, because at that point the first pilot interview already resolved many of the issues that could have appeared in the stakeholder one. There still were improvements, for example it was clear that the stakeholder interview needed considerably more contextual information about the study, who the researcher was, what their role was in the study, and why we picked those people in particular. All of this was apparent in the pilot interview as the interviewee felt hesitant at first and before answering, the interviewee requested additional information beyond what had initially been provided.

Before the interview there were designated Interview goals. These goals served as benchmarks for the pilot interview, and the researcher used them to assess the interview methodology and whether the questions were reasonable. For example, did the questions need further explanation, and when they answered, were the responses sufficiently detailed or was there more information needed. All these questions helped improve the larger scale interviews before they took place, thanks to the pilot interview.

4. Results

This chapter will present the finding from the methodology part of the research. There will also be an attempt to answer the research questions provided from the organization:

- How is the current material flow in MM&D defined and measured?
- What does a comprehensive analysis using Lean principles reveal about the existing processes?
- What improvement solutions can be designed to optimize material flow?

4.1 Company Dataset Results

The company dataset presented several interesting results. The purpose of the document was to record every issue that occurred at the department. From this dataset, the researcher was able to explore several important questions, such as which product type needs most optimization, how significant the issue was, whether the problems followed a trend, and where these issues originated.

The first chart was used to compare the total amount of issues in the dataset on a year-over-year basis, shown in figure 2. Appendix L shows the total number of orders created year over year. In 2024, a total of 578 orders were created, and 7.8% of those orders had issues. In 2025 that number grew to 16.95%.

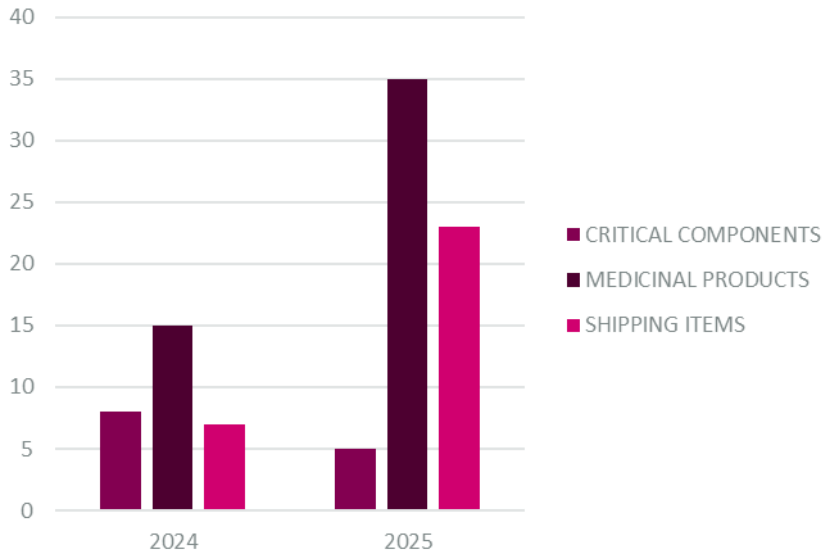

Figure 2. Total amount of issues Year-Over-Year

One of the research limitations was the fact that the research would be limited to one product family. Therefore, the company dataset was utilized to find the product family which needed the most optimization. By analyzing the company dataset, the result

turned out to be medicinal products, with a total amount of issue of 54 in the year 2025 shown in figure 3.

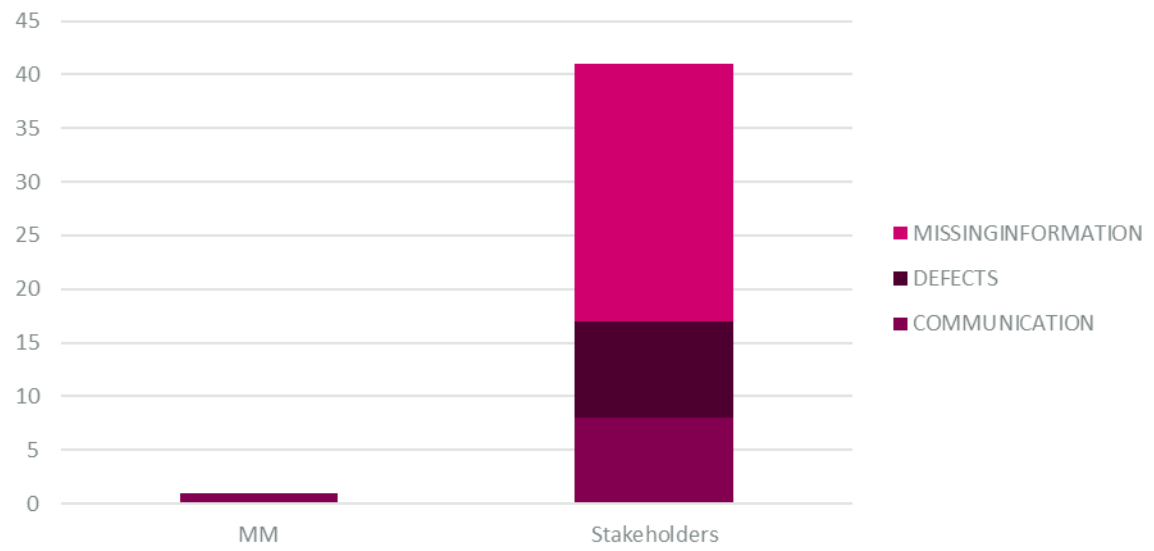

Figure 3. Total amount of issues for Material Management

The logical next step was to attempt to gather more information regarding medicinal products, more specifically what types of issues impact medicinal products. The results showed that, the issues were generally always a form of Missing information, defects and communication, and that the issues always stemmed from the stakeholders.

To summarize the company dataset, the results show that the total number of issues quickly grows from the two full years of available data. Within those issues, medicinal products are the most prominent issue and therefore the research became limited to medicinal products only. According to the data, stakeholders are responsible for these types of issues, and that information flow is the issue that is created by the stakeholders.

4.2 Gemba Walk Results

Each Gemba walk was conducted at a different point in time and was used to validate findings from other methods as previously mentioned. Each Gemba walk had distinct objectives, and in this chapter the result of each of those objectives will be presented.

First Gemba took place during 10th of February 2026.
Objective: To observe and understand the process for the first time, an overall view of the goods area, what system is being used, what type of issues the workers say that they have.

Observation Result:
Worker explained that they partake in meetings, handle information in an office setting while actual order handling happens in a goods area within the same building but approximately 100-200 meters from the office. The researcher then asked the worker if this constant motion from office to goods area was an issue. The workers answered that they do not see it as a problem because they usually have a laptop, which makes it possible to work without having to go back to the office.

The worker then showed the goods area and explained each part of the area and that materials arrived here, and that it was Material Management who sorts the products out by checking if the material is the right amount and that the product identity is identical to the order identity by the stakeholders. The worker then showed checklists that are being used by Material Management as a form of standardization. The workers explained that medicinal products were the issues and talked about medicinal products in their example. The researcher did not accept the suggestion and claimed no conclusion could be drawn at this point. The worker also mentioned that the stakeholders do not adhere to these checklists and that the reason was unclear to them as of why the stakeholders did not work accordingly and constantly made mistakes.

Second Gemba took place during 12th of February 2026
Objective: To observe workers performing their actual work and then stop and ask them questions regarding what they did and why they do it in that way.

Observation Result: The second Gemba was just two days after the initial one, therefore the researcher tried to not disturb and only observed the workers. By this time the research had still not been limited to one product family at that time, thus the researcher could only analyze the overall work. When analyzing the goods area, it was apparent that the company had implemented 5S standards to the goods area, but the overall inventory space was too small. The researcher asked the workers about the size of the goods area and the response was that it did get crowded sometimes but that it was not a significant issue for the workers.

The researcher also learned more about the digital system that AstraZeneca had implemented decentralized digitalization to monitor orders and inventories. This means that the current is limited compared to other supply chain applications. To compensate for the department has created a sophisticated lean visual management system, that is also digital. This system is only as good as the information that is being documented in the system. Therefore, the current system is highly dependent on the workers.

Third Gemba took place during 23rd of February 2026
Objective: Prior to the Gemba walk, there was an issue with one of the orders, which helped gain a deeper understanding of how workers react to certain issues.

Observation Result: In this case, there had been damages to certain components which halted the order, because the material was already in the system, they had to scan every damaged component and essentially delete it from the system. The components could technically have been used, but the workers decided against it. Showing how important it is to adhere to the very strict regulations of the pharmaceutical industry where even something small could have huge consequences. This also made the researcher realize how important it is to maintain a high success rate when it comes to orders rather than speed and time. The cause of the defect was natural, so it was not something that needed immediate investigation in terms of optimization.

Fourth Gemba took place during 6th of March 2026
Objective: To see how workers work on different orders, something that had not been previously observed

Observation Result: The researcher had an interesting opportunity to observe a worker processing an order that had not been previously observed by the researcher in the previous Gemba Walks. This order had to take place in a colder environment, and the order had monitoring equipment attached to it. The worker explained why the equipment was being used. The researcher then inquired about the frequency of issues arising regarding orders of this nature and the consequences of such issues occurred. The worker indicated that scrapping the entire order would be required, though such occurrences were infrequent. The worker then processed the work.

Fifth Gemba took place during 27th of March 2026
Objective: To return to the real place after gaining considerably greater knowledge and try to understand the process from an engineering standpoint and assess what had changed compared to the first Gemba walk

Observation Result: At this last Gemba walk, the researcher had considerably greater knowledge about the system and activities which the workers performed. This Gemba walk was seen as an audit to compare other method results. In this Gemba walk, it was clear that due to space constraints, material disturbances can have an immediate effect on the workers. Toyota often uses the analogy, trying to navigate through water while lowering the water levels to reveal the rocks. [15], implying that with a reduced safety net, it is easier for the problems to arise as there is no safety net or buffer to hide the issues. If the goods area were larger, there would be considerably more mistakes in a row to overwhelm the area with products. However, it requires much less material to have the same result. In terms of lean this is not a form of waste, because the workers are actively managing the space they are given, but reassured the researcher that putting more pressure on this area was not an option. Another problem is that material stacks up in goods, not every order is in the goods area temporarily moving on, some materials arrive with insufficient information regarding the order, during the time that Material Management tries to get in touch with the stakeholder, the material just takes place in the goods area.

In summary, Material Management does not necessarily suffer from goods of area constraint or the fact that Material Management needs more optimization in that area. This is more of an information flow issue, based on Gemba walks.

During the Gemba walks there was also the creation of a flowchart over the medicinal product process, shown in Appendix B.

4.3 Interview Result

In this chapter, the answers from the Material Management Interview and Stakeholder interview will be presented using Colaizzi's Method of Data Analysis [41].

4.3.1 Material Management Interview Result

Answers from the first Interviewee:

SL.	Collected Data	Meaning unit	Possible CODE	Possible THEME
1	"Most likely the error is in the mailbox, that is where we discover the issue or else it is during OP1 and TEST. When information is wrong in the mailbox, it makes us go back and forth to get the right documents and update the ones with wrong documentation...Same with Test, some documentation errors won't be known until it's time to use them during the actual TEST where we see the values"	Errors in documentation, which typically gets identified at specific workflow stages, requiring rework that delays progress and disrupts the process flow until accurate information is provided.	Information flow issues, documentation error	Workflow inefficiency
2	"Directly I think about information, but I think it is people as well (both external and internal), if you dig a bit deeper it usually is people that are the issue, not always there are some cases that the documents are wrong from the beginning as well. Most cases its wrong documentation and wrong information given..."	Suggesting human errors from stakeholder and Material Management personnel as potential factors for documentation issues	Human error and documentation errors as root cause	Root cause analysis
3	"...waiting (waste) as well because when we discover the problem, time has passed and now, we need to halt the process to get the right information which takes time, waiting is the result of the defect. Non utilized talent I mean it is not on that level but maybe I should see that there is in issue in the mailbox, maybe it is that I don't have enough time and I feel stressed so I don't spend time to find	Halted work processes due to documentation issues creates waste (Lean)	Documentation errors creating waste (lean)	Lean Waste

	the issue, but maybe it is lack of best practice..."			
4	… but if you have an interface, you can move the information from another interface. That is the goal of AXIAL; we are pushing for that. So, once we have registered in smart supply which is registered from scratch then we can start using barcode scanning for the movement but sometimes we do it manually because it is just faster by marking everything, but we still have to do the transaction in smart supply. Electronic documentation was a feature on smart supply, but the project decided to not use it because those questions need configurations which need to be done manually and take too long to do. So, there is no electronic documentation. We move everything in the system manually.	Digital systems exist today but are inefficient, due to time intensive set up requirements, which leads to manual workarounds	Underutilized automation and digital capabilities	Digital transformation barriers and manual process persistence
5	"I would like to add a KPI for efficiency for the mailbox, slippage for OP1 and TEST. Then we can see how many errors we find in the mailbox compared to the total amount. Then, as I said before, there are documents you cannot find in the mailbox until it is too late either at OP1 or TEST. So KPIs measure error rate compared to the total. And if we want to help the entire project, we should have a KPI for the finished goods we send and see how many mistakes we make so we can learn and see if we make any mistakes too. Efficiency is so much about time, but we need to focus on products instead and see the efficiency of the products received and handled."	Need KPIs to measure error rates at different stages in the process, to monitor efficiency, and as a monitoring system for errors delivered by stakeholders.	Development of Key Performance Indicators	Continuous improvement and performance monitoring

Answers from the second Interviewee:

SL.	**Collected Data**	**Meaning unit**	**Possible CODE**	**Possible THEME**

1	The bottleneck is definitely in the mailbox and documentation. So when it comes to site, where sometimes there are defects in the product due to transportation but the things we can't control is the bottleneck that is stopping us so like documentations... maybe it is the operator that has missed something that we will only see on OP1 or TEST	Mailbox is seen as the primary process bottleneck due to documentation, which is not detected, causing more significant delays later in the work process.	Documentation as bottleneck and delayed errors due to work process	Workflow inefficiency
2	I feel like we get information quite late, sometimes we get a very good information like “Hey these are the documents that are on their way and will be arriving in 1 week”. But it is not always like that. Sometimes we even get material with no information at all. It just arrives at the site. It's a mix. We would like to know 2 weeks before material arrival so we can create a plan accordingly.	One week's notice before material arrival is not adequate for workers as it creates planning challenges. Also, some orders have no heads-up time and arrive unexpectedly, preventing proper work preparation.	Inconsistent heads-up time creates planning constraints	Heads up time for orders
3	When we handle commercial products we have a system called ... , where we decommission products and take them off the market. It is not something that actually helps our work and process, it's more that we have to do it. We probably need to become more technological, one wish would be to have every material to have a barcode so we can just scan and have it in the system, that way we wouldn't need manual work. Today most of our work is don't using paper.	Current electronic systems do not enhance workflow efficiency.	Technology and digitalization gap	Digital transformations need
4	We have to cancel meetings during periods like that, and we also need to stop our self-development programs. So, there is stress. Because we always need to priorities the customers first. So, I would say the balance shifts in the team. Everyone has to cancel meetings and sometimes someone really cannot work on the urgent order and that puts even more pressure on someone else that can. So, I would say imbalance and high workload in those moments.	Peak demand periods force cancellation of meetings and professional development activities, creating stress. Due to customer priority	Workload imbalance and development disruption	Work life balance challenges

Answers from the Third Interviewee:

SL.	**Collected Data**	**Meaning unit**	**Possible CODE**	**Possible THEME**

1	I would say it begins here (documentation). There is wrong information, wrong documents or even missing documents. But we first discovered it in our mailbox. We catch most of the issues between “site” and “OP1”. Most of the issues are at mailbox even if we look and see that it looks good, we still see it afterwards at site, like hold on this is the wrong document, but still the bottleneck is at the mailbox we have to go back and forth and talk with the step prior about the wrong/missing documents...	Errors in documentation, which typically gets identified at specific workflow stages, requiring rework that delays progress and disrupts the process flow until accurate information is provided.	Information flow issues, documentation error	Workflow inefficiency
2	I mean the dream case would be to have a heads-up time of 1 week before the material arrives, so we can plan beforehand and then also prioritize urgent orders better. Today we don't have a heads-up time of one week. Sometimes we don't even have a heads-up time material just arrives not as common, but it happens and also, we don't have a clear view of the process, what is happening? We haven't told other departments that we want this information 1 week before material arrival. It is not standardized; it could be a quick fix if you think about it.	One week's notice before material arrival is not adequate for workers as it creates planning challenges. Also, some orders have no heads-up time and arrive unexpectedly, preventing proper work preparation.	Inconsistent heads-up time creates planning constraints	Heads up time for orders
3	That is something that we already have in our company dataset, but we are not good at tracking it. It depends on the details some people are detailed, some are less so. I personally could become better at tracking, I'm not very detailed. To get good data I should do it even if I don't like to do it right now in the moment.	Issue tracking capabilities exist but are inconsistently utilized due to varying levels of individual detail and discipline.	Inconsistent data capture	Highly human depended systems
4	VP board, is our visual planning. I like the VP board but its important that everyone uses it and does it at the best possible way. I mean the VP will only be good if everyone is doing a good job at updating it. I like how easy it is to follow it and see where we are. I like the idea behind the VP board	Visual planning board provides valued transparency and ease of progress tracking but is highly dependent on all team members and the consistency and quality updates that the board needs to remain effective.	Visual management tool dependent on user compliance	Visual management effectiveness

4.3.1.1 Material Management Interview Result findings

The results indicate that the primary issue is an information flow problem. The interviewees raised many points, but the most frequent issue raised is workflow inefficiencies. According to the interviewees, these inefficiencies typically occurred in the mailbox, which serves as an information exchange point between two departments,

These mailbox inefficiencies were identified as a source of several Lean wastes. The interviewees also mention possible solutions such as extending the heads-up time, allowing Material Management more time to prepare for incoming orders.

They also raise important points about the aftermath of these issues such as possible workload problems, where workers are prioritizing customers, which leads to cancellation of meetings and self-improvement programs.

Workers also mention how they are open to digitalization because it would streamline communication. They also noted that current digitalization attempts have been positive, for example, the Visual Planning board, therefore suggested that further digitalization would yield improvements. They also indicated that not all forms of digitalization are beneficial, as there are instances where digital solutions are not utilized because they are time consuming and require manual inputs. The workers also suggested measurement tools need to be introduced to keep track of all the issues. Currently, the situation was described as overwhelming because the extent of the problem remained unclear. There have been attempts to measure the processes, but the workers noted that these should not be based on human input where the workers must write down all the issues, because that leads to inconsistencies and lack of details based on the workers.

4.3.2 Stakeholder Interview Result

SL.	Collected Data	Meaning unit	Possible CODE	Possible THEME
1	... I feel like the process is not clear because there are no strict rules, sometimes there are no planners in an order, I would like the process to be clearer...	Process uncertainties stem from absence of defined rules and inconsistent tole assignment	Process ambiguity and lack of defined structure	Process clarity needs
2	... unclear format; it is not well described, and there is a lack of clarity regarding the sourcing and receipt of ::: packaging materials or drug products. For example, there is a question “What is this product” but the options are not well written, which makes it, so people leave it blank...	Outdated form fields lacking clear descriptions creates information flaws that are inadequate for downstream departments, leading to incomplete data entry	Form design deficiencies causing data gaps	Data collection tool design and usability

3	... In our processes we have a threshold for our orders, we immediately flag orders that have a first-time right level sub-90%...	Performance monitoring is being used to identify and flag problematic orders.	Quality monitoring and exception flagging	Quality control
	...The process in how to handle an order, how to proceed and how to execute the work task is very clear, we are very happy with the work process, the SOP is very clear and does not need any changes...	Order handling procedures and work processes are well defined through clear SOPs	Clear process documentation and clarity	Process standardization
	...Having a longer heads-up time is definitely possible, we did not know that Material Management wanted a longer heads-up time, as they have never requested it or communicated with us regarding the matter, it is possible to have a heads up time of 3-4 weeks in some orders, but I cannot promise that we can always provide an heads-up time for every order...	Possibility to increase heads up time for some orders but not a possibility for all orders. Also highlights lack of communication between departments	Departmental communication gaps and capability constraints.	Unvoiced requirements And variable notification capabilities.
	...I definitely think digitalization is needed and would help everyone, in this process, some sort of functionality where orders, communication and needs are easy to see and follow between departments...	Digital solution is needed to provide cross departmental visibility of orders, communication and requirements, enabling easier tracking and coordination across processes.	Need for digital platform for cross departmental visibility	Digital Transformation and cross functional collaboration tools.
	...The reason we like to work with Material Management is because of their flexibility to handle order, therefore we do not want to lose that flexibility, I like the service side of Material Management they always answer and help other stakeholders with orders, I understand that it might become tiring and they should maybe have an FAQ, but my wish would be to keep the flexibility.	Stakeholders appreciate Material Managements valued flexibility and responsive service orientation, and stakeholders want to preserve these values. Despite recognizing unsustainability	Valued flexibility versus standardization trade-off	Service Quality and operational flexibility balance.

4.3.2.1 Stakeholder Interview Result findings

Stakeholders experience uncertainties due to lack of checklists and ambiguity regarding documentation. Current documents are poorly described, leading to poorly written documentation, incomplete data entry, and consequently downstream departments having to restart communication. There is also an absence of the role “responsible” with the stakeholders at times, which makes the process even more unclear. While stakeholders believe there are no issues with the current work process due to their adherence to KPIs such as first time right, they point to Material Management as the issue due to Material Management's lack of clarity regarding what is needed. Stakeholders saw digitalization as a positive change, because of the benefits of ease of communication, more transparency by being able to follow other departments' orders, and more information regarding orders through checkpoints. Stakeholders also mentioned that an increase in heads up time is possible for orders, although it would be challenging for every order.

Stakeholders also mentioned that they value their working relationship with Material Management due to their flexibility and adaptability to orders, and it is something that they would like for Material Management to maintain. They also noted that it might be challenging to maintain the same level of flexibility, and that an FAQ resource could prove to be beneficial for Material Management.

4.5 Results Based on Lean

After looking at the results from all the methods, figure 6 was created to show how Material Management is being assessed based on the 8 wastes of lean.

AstraZeneca works based on orders and is not based on forecasts, therefore there is no overproduction.

Based on interviews with Material Management, all the interviewees saw waiting as a form of waste. The first interviewee mentioned “Defects (That the given document is wrong, or that the product that arrives is defective but usually wrong with information and documentation). But that will strike us on the waiting as well”

“We have the option but that will affect “motion”. If I park in goods receiving, we have a limited area. Initially I park it there and it gets overcrowded; we can store it in a non-register warehouse. But that Is an unnecessary motion because we need to move the material back and forth. So “motion””

“They are waiting for people that have the information, usually it is a planner that takes care of everything but sometimes that person doesn't have knowledge about some part of the process and they need to forward it to the next person. So yes, the issue is usually people and information “

“I mean we can start here (utilized talent). I mean this is where it has been hard for us in the team to find the time to put our skills to use to improve the processes. We haven't

had it as a priority, at least historically... Waiting is another one of course as we said before (missing documents, wrong information). So, number one for me is waiting, then unutilized talent and then defects."

Based on the Gemba walks performed, there is an identified issue regarding inventory space. However, the issue does not derive from the inventory itself, hence it has been evaluated as "yellow" in figure 5. Green stands for no waste, yellow indicates that there is waste, but the waste derives from other waste, and red means that there is waste which needs immediate action.

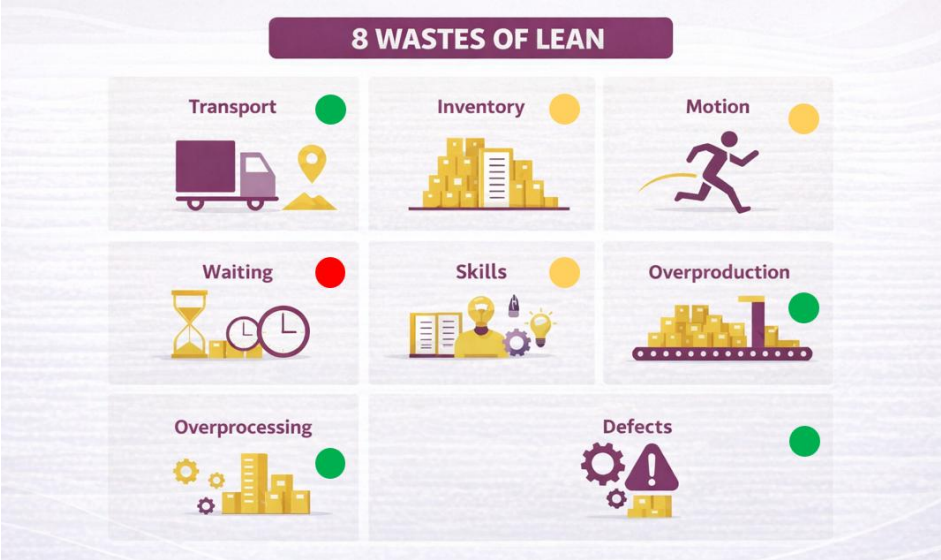

Figure 5. Identified Waste at Material Managements department (AI generated using copilot)

5. Discussion

This chapter will explain future improvement opportunities within Material Management, focusing on utilizing results presented in the previous chapter to help solidify the claims. Issues have been identified, and there are also results. Now a discussion will be held on why these suggestions will improve Material Management, and how they align with the future goals of AstraZeneca in their 2030 Axial project.

5.1 Material Management: In The Present

This flowchart in Appendix B shows how everything starts with Stakeholders sending material information to Material Managements mailbox. When the order notice arrives, the team has around a week before the material arrives, but that estimation is not always clear. Sometimes no notice about material arrival is sent to Material Management. When documentations arrive in the Mailbox, the team manually takes the data and writes them in a Visual Planner card, for the workers to handle the orders in a manner that fulfills 5S standards.

Currently, Material Management does not use any KPIs for their Visual Planner. The only time there is any form of logging of products and orders is when issues arise. When that happens, Material Management tracks that data in a company dataset. This process also happens manually. Based on the interviews, it was established that the logging of issues differs based on the worker, as some workers document with more details while others do not do it on the same level of sophistication.

This shows that while Material Management has tools in their disposal and is actively trying to become Leaner and adopt the values of industry 4.0, the underlying structure needs a redesign. Today workers work very flexibly and get praised for it by other departments, but the same flexibility that the workers feel is making their work tasks easier is a result of inefficiency.

In the stakeholder interview, the interviewees mentioned how the process is very clear for them and their satisfaction with the SOPs. They also mention three interesting things regarding their relationship with Material Management. First, they mention tracking their own issues and promise a first time right of 90%. If the claim is true, it shows that the stakeholders do not have any issues with other processes in their work and the issue derives from Material Management. They also mention that in reality Material Management is a very small part of their actual work; the processes might be clear for every operational area, but the same clarity might not exist between Material Management and stakeholders.

Secondly, some of the stakeholders mentioned that the orders are not created by them, they receive information on what the study contains, then one of the stakeholders creates an order with the received information and when the form is done, they allocate

that work to a department. Now if information is missing, Material Management flags the order and gets in contact with the stakeholder who is responsible for the order, if that person does not have the right information, then that person turns to the person who created the order etc. This created longer lead times and shows why waiting occurs.

Lastly, another interviewee from the stakeholder's interviews validates this claim and mentioned that the person who creates the order has access to many documents, but the person does not know how many of those documents are needed. The solution would be to have clear checklists for every order, now many orders usually have three distinct documents that are always needed for medicinal products. One of these documents has received a lot of scrutiny from one of the stakeholder interviewees. This person argues that no one understands the actual documentation form and encourages one person from every department to explain how this document could be reworked, with new standards and explanations. The interviewee mentions that when people do not know what to write in the document, they leave it blank and hope it does not affect the work.

Therefore, Material Management has often become a service-oriented department, because the processes and checklists are not present, questions arise from stakeholders on how to move forth with an order, Material Management receives a lot of praise for their flexibility and availability to answer these questions and create opportunities to work around problematic orders.

In the interview with Material Management, they did not want to lose their flexibility but also mentioned that they sometimes feel heavy workloads, demonstrating a level of anxiety that introduce more standardized work, will limit their ability to handle orders that require flexibility.

5.1.1 Summary of Present work process

The primary identified wastes are:

Waiting Waste: Due to wrong information in documents

Defect Waste: Wrong documents make it, so the process must be stopped and reworked. Due to these issues, additional wastes occur as consequence, for instance:

Inventory waste: When material is waiting for orders to get the right information, it gets stored in a small goods area, making it harder to store new material.
Motion: When the inventory gets full, Material Management workers must move material to temporary storage, and this leads to workers having to move to other storages and bring old materials and orders.

Another issue is the lack of checklists from the department on what they need to complete an order.

Material Management also lacks performance monitoring, it is important for a company to actively collect data on work processes. This helps workers understand where the issues are located with information such as time.

Finally, there is an issue with the communication and service demands placed in the department. Because Material Management is responding to stakeholder inquiries, this in turn generates further inquiries, creating a recurring cycle of communication that places additional demands on the department.

5.1.2 Mapping out Material Management present issues

This flowchart in figure 6 highlights most of the issues within Material Management work processes, based on results from interviews, Gemba walks, and company dataset.

Mailbox is where communication between the department and stakeholders takes place. When the documentation for materials arrives in the mailbox, workers go through the documentation to find immediate issues that could be addressed before any type of material arrives. If the documents pass the initial check material arrives at site. Then it goes through to OP1, where a worker is comparing the data received with the material at site. OP1, QA and ID-Test all suffer from the same issue. As mentioned in the interview: “Some can slip through the mailbox, and it goes through OP1 and that is when we realize the issue and understand that there is a problem with documentation. Same with Test, some documentation errors won't be known until it's time to use them during the actual test”.

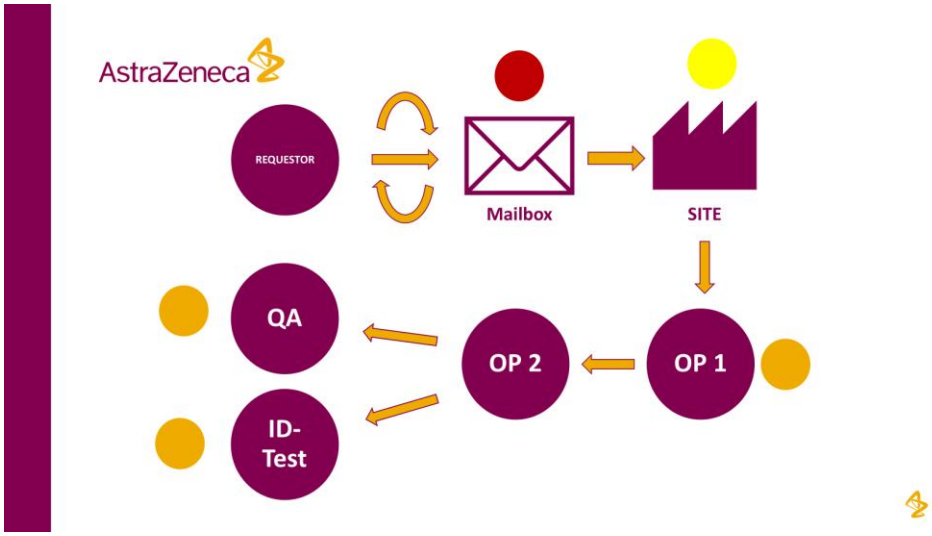

Figure 6. Flowchart over Material Managements work process with lean waste integrated

Not all of the issues could be solved by simply spending more time in the mailbox as some of the workers suggested. Based on the stakeholder interviews, it was evident that

the stakeholders want to know what Material Management required in the form of a checklist, as well as a revision of existing documents to streamline the process.

When these types of wastes occur, it creates more pressure on downstream departments, their estimation for material arrival also gets affected. Downstream departments then get in contact with Material Management to ask about material whereabouts, which means even more activity at the suggested bottleneck.

Therefore, it can be concluded that Material Management has a Black box effect with other departments, requiring Material Management employees to work more flexibly because the upstream department and the downstream department struggles to observe what Material Management is actually doing, and what is required and when it is required.

5.2 Material Management possible roadmap for the future

To eliminate the black box effect and all the waste that is currently occurring as a result, it is therefore necessary to introduce more transparency. Currently, the department uses visual planners, which represents a positive initial step; however, other departments do not have access to them. Furthermore, this could not be resolved by simply granting access to these visual planners, because the system currently in use is still reliant on the workers and their inputs, making it difficult for stakeholders to understand the process.

The proposed suggestion is to adopt a new visual interface. The goal is to retain much of the existing system to avoid abrupt operational disruption, while also creating a new visual interface enabling other departments as well as workers within Material Management to better understand the process. Figure 7 illustrates what such an interface can look like.

In figure 7, there are checkpoints, for example, B1, B2, and B3. This enables stakeholders and workers to identify exactly at what stage of the process the order is, when a downstream department overserves that the order is progressing and is close to completion, they could prepare for the order, rather than requesting estimated arrival times from Material Management. Furthermore, the most significant advantage is that each checkpoint has a dual purpose. Not only does it visually show everyone where an order is, but each time an order has cleared a checkpoint, the data will be stored. For example, when the product first arrived at checkpoint B1 and when it moved to B2, the time in between could be value for future research like creating a Value Stream Mapping.

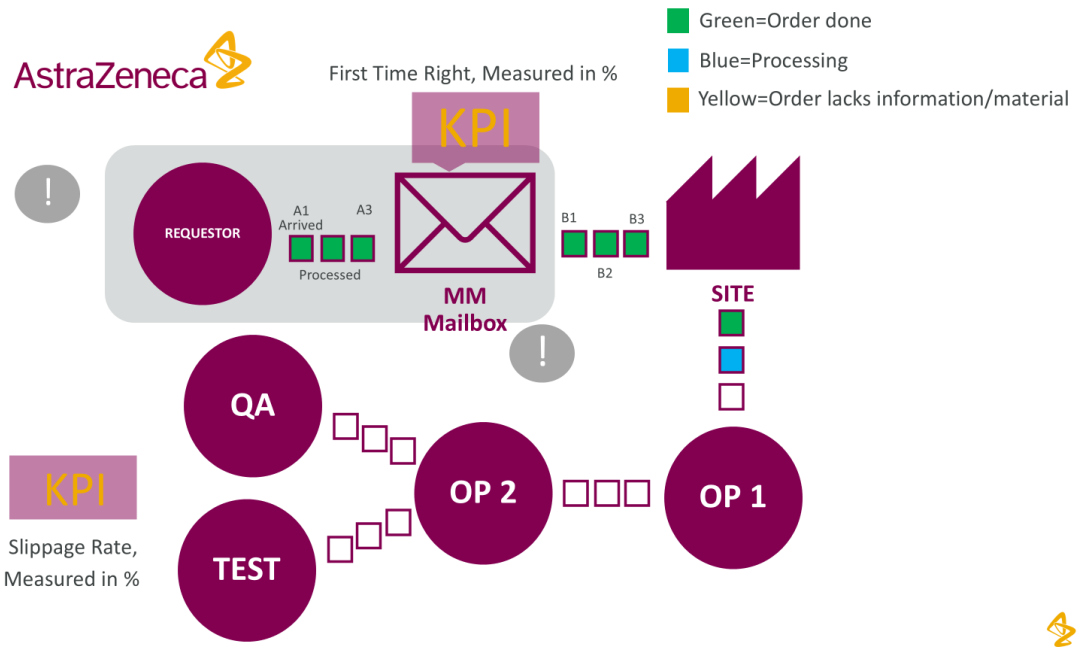

Figure 7. Suggested Interface for Material Management

Another feature is to have something called “Advanced logging”. This is where a summary of every action is saved. While the workers continue working in the existing system, every change will be logged in this advanced tab, which could be used to calculate downtime. Even if “waiting” is a form of waste, the quantitative impact of which remains unmeasured; by using this advanced logging function, it becomes possible to identify that an issue was spotted at OP1 and resolved two days later. Which will further help with bottleneck analysis in the future.

The most important issue is the lack of KPIs, which would have a significant impact on the department. Currently, because there is no baseline data, every change cannot be evaluated based on historical data; therefore, every new change cannot be evaluated. It is therefore proposed to introduce two KPIs:

The first KPI is first time right, measured by how many orders get completed without any major disturbances, such as missing information and missing documents. The reason this KPI is relevant is because the workers indicated that spending more time on the mailbox will resolve most of the issues, the only ones that will not be resolved are those that a worker has to physically check the product and compare it to the given data, which can only be identified at later stages in the process. If this first time the right KPI is established, the department can decide to experiment by giving workers more time to spend in the mailbox and observe the recorded results in the KPI. The KPI will be calculated with the formula: (Number of items completed correctly on first attempt)/ (Total items processed) * 100%
Another KPI is to track the slippage rate. This KPI will track how many orders slip through the mailbox; this one should be seen as a temporary KPI, to evaluate stakeholders' ability to provide sufficient data. It is difficult for workers to reverse the process when there has been a mistake in the documentation that cannot be identified

unless it is tested at a later stage. This is arguably the most significant issue with the current work progress, and the KPI will be used to quantify how significant the problem is. The formula for this KPI is: (Wrong after confirmation in Mailbox) / (Total confirmed items) * 100%

It is also recommended to establish a checklist for Material Management. By having clear checklists and guides explaining why these documents are needed, stakeholders will have to check the requirements before sending documents. The department could also introduce an FAQ, enabling stakeholders to first check whether their query is a common issue before deciding to reach out to Material Management. There could also be an attempt to revise certain documents, where stakeholders and Material Management can create new versions that are clear for everyone.

If Material Management wants to maintain customer satisfaction by maintaining their established reputation for flexibility, a chatbot could be implemented in the team mailbox. This Chatbot could read and analyze all previous conversations between Material Management and stakeholders; by learning and training on existing prompts, the AI could take over the service part of the mailbox, which in turn will lead to the same amount of flexibility without occupying the workers. To limit hallucination, which tends to be an issue with current LLMs [42], the chatbot could include a confirmation button so that the only action required by the workers is confirm and send the message, ensuring customer satisfaction through limited hallucinations.

5.3 Possible Research Areas Within Material Management

There are three distinct opportunities for further research.

If AstraZeneca decides to implement AI chatbots, the future research could be the actual implementation of the chatbot.

Another area for research would be to create a VSM for Material Management Drawing on the proposed data collection system with the help of advanced logging, this would lead to more precise research problems, because the data is less dependent on human interaction, thus enhancing data credibility. A VSM can pinpoint exactly where in the process the bottleneck is and what is creating it, because of the advanced logging feature. Should a VSM be created, it would assist future researchers in addressing the bottlenecks identified through the VSM.

Lastly, there could be a project to analyze existing documents and create new ones or help sort existing documents for each order, thus creating the much-needed checklist for Material Managements.

5.4 Limitations

AstraZeneca was limited in the number of datasets it could provide for this study

The datasets provided were not good enough to be used as a standalone method, because the data were filled by humans, as previously mentioned some employees might write more compared to others.

Time constraints limited the opportunity to conduct a more thorough analysis of the datasets and extract more information.

Some of the datasets had to be reevaluated, though it was done with the assistance of a supervisor at AstraZeneca with considerably greater knowledge. There could still be possible mistakes or inaccuracies.

6. Conclusion

Overall, this research has shown that Material Management experiences information flow discrepancies between different departments, which creates wastes as a bi-product, this research has also proven that most of the issue could be solved by quick fixes, like the fact that the stakeholders had no knowledge that Material Management needed a longer heads up time, which the stakeholders claim is an easy fix. But there are also larger issues at hand, which AstraZeneca is fully aware of, like the Axial 2030 goal of implementing SAP, to increase transparency and communication between stakeholders. My suggestion is more of a steppingstone towards this project to ease the transition into the next era of AstraZeneca.

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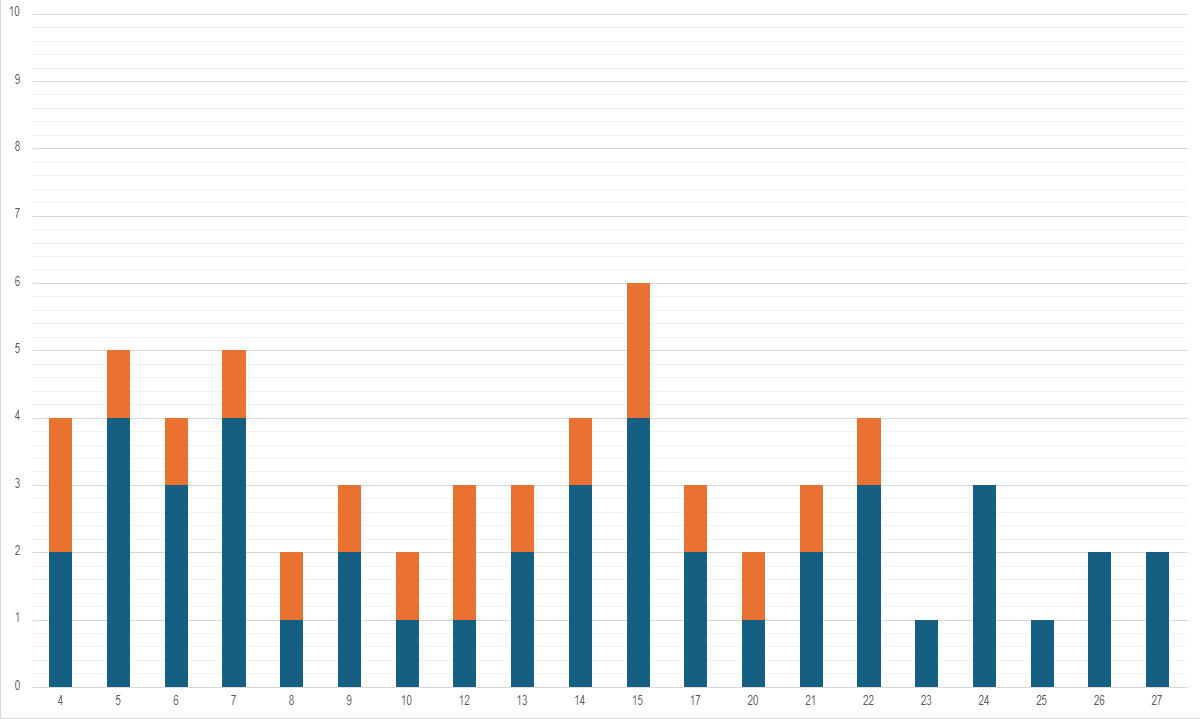
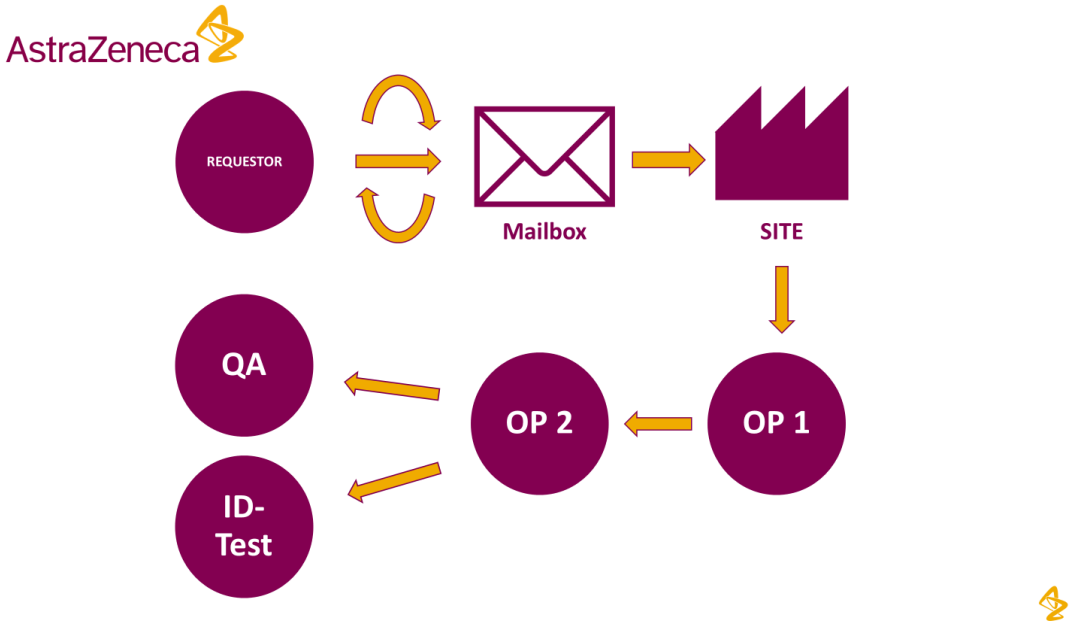
7. APPENDIX

Appendix A- Data Stakeholders, for picking interview, orange staples shows how often they are “Responsible”, while blue shows how often they “created” an order.



Appendix B- Flowchart over the process



Appendix C- Consent Letter

CHALMERS

Consent and information about processing of personal data in student thesis

Research Title	Optimizing Material Flow by Applying Lean Methodology: Exploring Information Flow Barriers Among Stakeholders in Pharmaceutical Material Management
Principal Investigator	Hayrettin Güven - Chalmers University of Technology, Department of Industrial and Material Science.
Contact Email	Guvenh@Chalmers.se hayrettin.guven@astrazeneca.com
Study Duration	Approximately 30–45 minutes per interview
Interview Date	_____

PURPOSE

You are invited to participate in an interview. This interview will be part of a thesis work at Chalmers University of Technology. The consent letter and all the answers that will be provided during the interview will be published to the public. The interview is part of a broader research regarding information flow between stakeholders, and how the given information affects material flow efficiency within AstraZeneca material management processes. This study explores the information flow and process bottlenecks in the pharmaceutical material management process.

The research specifically focuses on:

- How communication gaps between requestors, procurement, quality assurance, logistics, and end-user departments create delays in material availability.
- The impact of non-optimized information channels on both medicinal and non-medicinal incoming material handling.

Your perspective as a professional within a pharmaceutical material management team is invaluable to this research.

Appendix D- Consent Letter

CHALMERS

Voluntary Participation

Participation in this interview is entirely voluntary. You may:

- Decline to answer any question without providing a reason.
- Withdraw from the study at any time before, during, or after the interview, without penalty or consequence to your employment or professional standing.
- Ask for clarification about any aspect of the study at any time.
- The interviewee may withdraw from the study at any time. If a withdrawal occurs, all audio recordings and responses will be deleted immediately. The final date for the withdrawal is 1st of May. After this date, the thesis will be in the final clearance process for publication, and no further changes can be made.

Refusal or withdrawal will have no negative impact on your professional relationship with the researcher or institution.

Confidentiality & Data Protection

All information you provide will be treated with strict confidentiality in accordance with Chalmers and Swedish national data protection legislation GDPR guidelines. Specifically:

- Interview recordings and transcripts will be anonymized; no personal identifiers will appear in any publication or report.
- Your organization's name will be pseudonymized unless you provide explicit written consent for disclosure.
- Data will be stored securely on password-protected, encrypted systems accessible only to the principal investigator and approved co-researchers.
- Findings may be published in academic journals, presented at conferences, or used for educational purposes in anonymized form only.

Potential Risks and Benefits

Risks: There are minimal foreseeable risks associated with participation. You may be asked to reflect on workplace processes or challenges. Should any question cause discomfort, you are free to skip it or end the interview at any time.

Benefits: While there is no direct personal benefit, your contribution may lead to actionable improvements in pharmaceutical supply chain efficiency, ultimately benefiting patient safety, operational performance, and the broader healthcare system. A summary of the research findings will be made available to participants upon request.

Appendix E- Consent Letter

CHALMERS

Audio Recording

With your consent, this interview will be audio-recorded to facilitate accurate transcription and analysis. Recordings will:

- Be accessible only to the principal investigator and approved research assistants.
- Be deleted permanently upon completion of data analysis or after 1st of May 2026, whichever comes first.
- Never be shared with your employer or any third party.

If you do not consent to recording, written notes may be taken instead. Please indicate your preference in the consent declaration below.

Consent Declaration

Please read carefully and initial each statement to indicate your agreement:

1. I have read and understood the information provided in this consent form.

Initials: _____

2. I have had the opportunity to ask questions and have received satisfactory answers.

Initials: _____

3. I understand that my participation is voluntary and that I may withdraw at any time.

Initials: _____

4. I understand that my data will be anonymized and treated with strict confidentiality.

Initials: _____

5. I consent to the interview being audio-recorded.

Initials: _____

6. I agree to participate in this research study.

Initials: _____

Appendix F- Consent Letter

CHALMERS

If you withdraw your consent, we will cease processing personal data we have collected with the support of your consent. Some information may be saved due to Chalmers obligations under Swedish archive legislation.
Chalmers University of Technology, org. No. 556479-5598 is
Personal data controller. You can find Chalmers privacy policy at www.chalmers.se.
As a participant, you have the right to receive information about how your personal data is processed. You have the right to have incorrect information corrected, redundant data deleted, request that processing shall be restricted, and data transferred to another actor. You also have the right to submit a complaint to the Swedish Authority for Privacy Protection (Integritetsskyddsmyndigheten). Do you have any questions about Chalmers's processing of personal data contact Chalmers's data protection officer at dataskydd@chalmers.se.
I agree that Chalmers University of Technology processes personal data about me in accordance with the above.

Participant Name (Print):	**Researcher Name (Print):**
_____	_____
Signature: _____	Signature: _____
Date: _____	Date: _____

Appendix G-Material Management Questions

1st Question

Because we will only focus on Medicinal products, we have created this flowchart for how drug products are being moved. Do you think this flowchart is accurate? If yes, where in this flowchart would you say there is a bottleneck or where in the process is the issue known and where does it derive from?

Follow up:

- Walk me through the process when delays happen there (where he pointed on the map). When delays happen here, are they usually waiting for *people*, *equipment*, or *information*? Describe the impact that wait has on the upstream teams.

- what are the most common issues when this happens based on the 8 wastes of lean

- How does this block affect MMs work overall?

2nd Question.

Prior to material arrival at site, how does MM currently receive and respond to material demand signals from internal customers (e.g., Planner, ProjectLead or ProjectManagement, or/and clinical departments)? Is the heads-up time and the provided information sufficient to perform your work as MM?

Follow up probes.

- If continues urgent orders arrive, how does it affect team planning for MM and how does it affect the workload

3rd Question.

Does MM use digital systems or technology tools (barcode scanning, electronic documentation) that are currently used to manage receipts? In your view, what technological or process changes would significantly reduce waste and improve material flow across MM and its stakeholders?

Follow up probes:

- What metrics or KPIs does MM currently track? Are they sufficient to identify and address material flow inefficiencies?

- If you could redesign one information channel between MM and another stakeholder, which would it be and how would you redesign it?

Appendix H-Material Management Questions

4th Question.

Does MM use 5S tools like visual management in the team to guide material receiving, inspection, storage, and distribution? If not, do you think it can influence the work in a positive way?

Follow-up probes:

- Are there differences in how information is communicated or documented between stakeholders /different supplier types?
- Currently, how do you know without asking someone verbal questions, that the process is healthy? Is there a visual signal? If not, what visual signal is missing that would instantly tell you to realize “we have a problem?”
- Is the visual management process clear in how it should be performed?

5th Question

Is there anything else about your team's material management processes, information challenges, or improvement ideas that you would like to share and that we have not yet covered?

Appendix I- Stakeholder Questions

Question 1

During our research we have noticed a low rate for “Right First Time” regarding documentation and missing information such as delivery notes. Do you think the data is justified? If yes, why do you think this issue arises and how does this affect your work?

Question 2: Material Requirement Awareness and Lead Time

Could you walk me through how you typically become aware of material needs or demands? Specifically, I'm interested in understanding whether these requirements originate from your own planning or from requests by other stakeholders.

Additionally, what is the typical timeframe you have between learning about a material requirement and when that material is needed? How does this lead-time affect your ability to fulfill orders effectively?

Question 3: Documentation Standards and Process Improvement

How do you stay informed about the current documentation formats and standards required for the ordering process?

I'd also like to understand your perspective on the current templates: Are they clear and easy to locate when needed? What challenges, if any, do you encounter when working with these documents?

Finally, what recommendations would you make to improve the order generation process and the materials management receipt procedures?

Question 4: Workflow Challenges and Communication Barriers

From your perspective, what are the primary issues or bottlenecks that most significantly impact your workflow, particularly regarding information flow and communication between stakeholders?

What specific changes or improvements would you suggest addressing these challenges and enhancing collaboration?

Appendix J- Stakeholder Questions

Question 5: Digital Solutions and Efficiency Enhancement

In your opinion, could integrated digital tools, such as SharePoint for document management or Power BI for data visualization, meaningfully reduce lead times and improve operational efficiency in your work area?

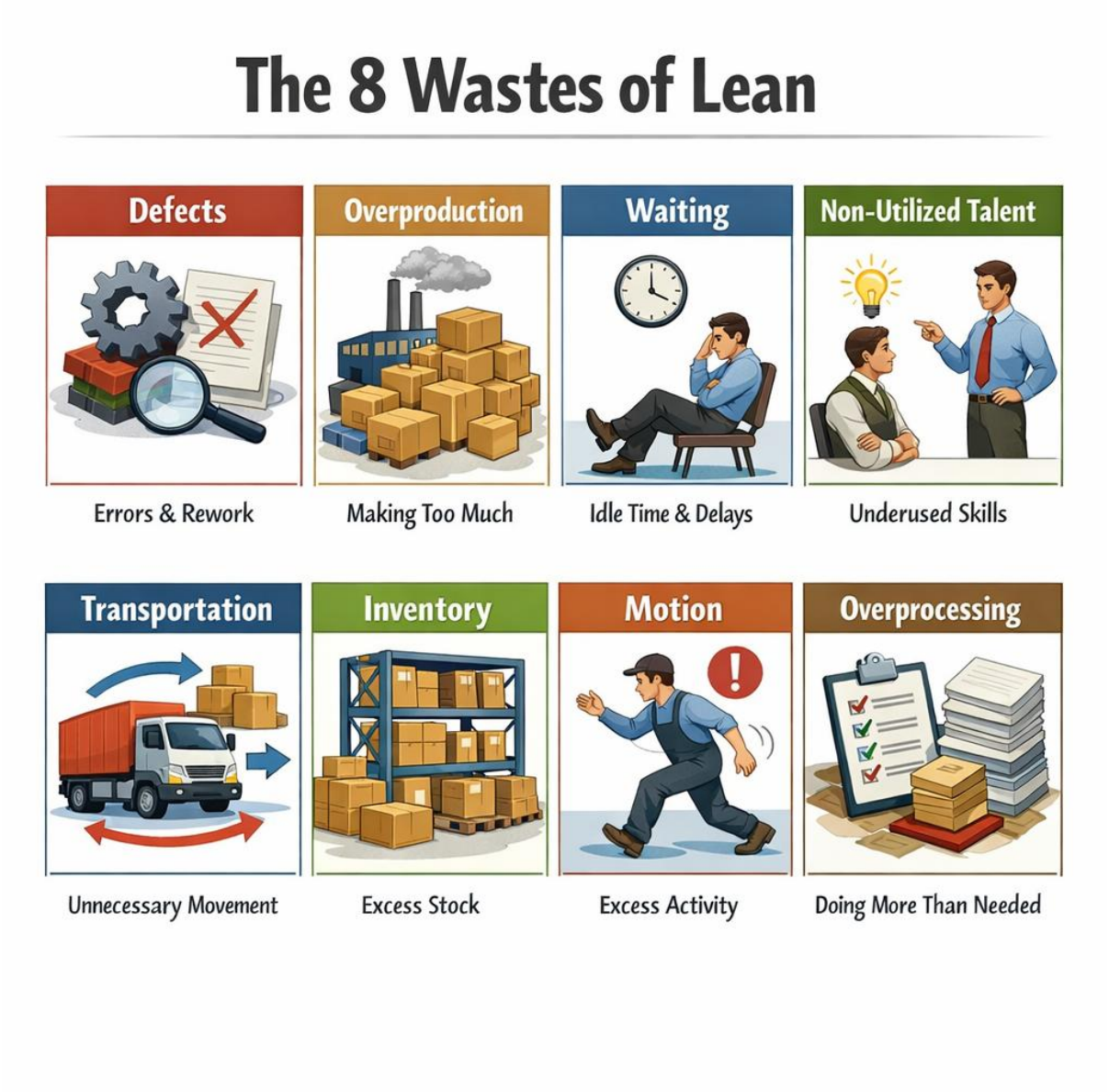
Question 6: Open Discussion

Is there anything else regarding current processes, information management challenges, or potential improvements that you feel is important to discuss but hasn't been covered in our conversation today? I welcome any additional insights or observations you'd like to share.

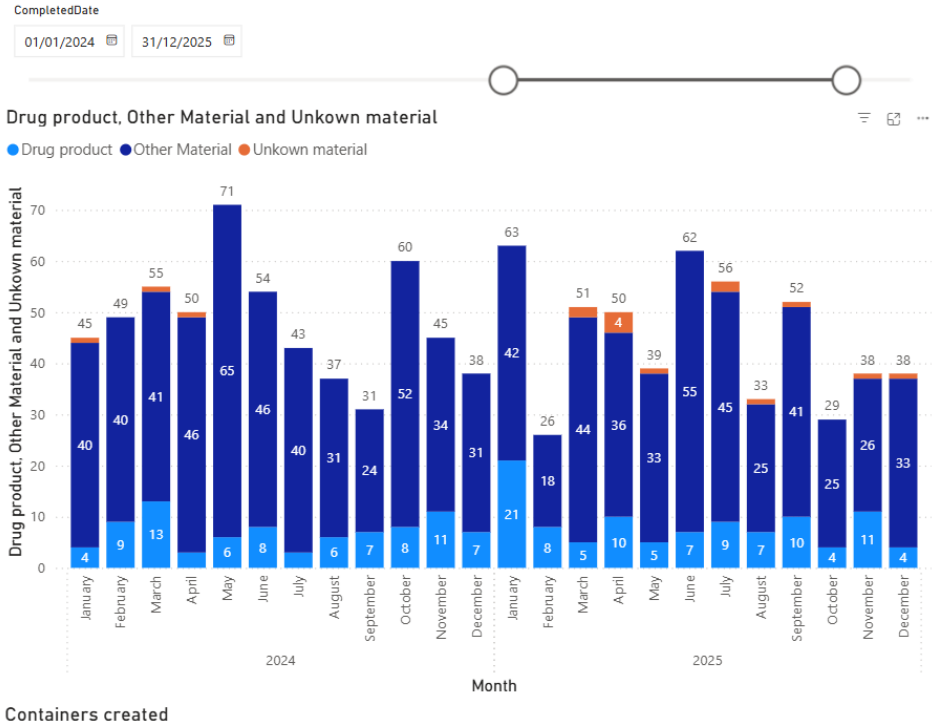
Interview Closing Statement

"Thank you for taking the time to share your valuable insights. Your feedback will contribute significantly to identifying opportunities for process improvement and enhanced operational efficiency. If any additional thoughts occur to you after our discussion, please feel free to reach out."

Appendix k-


The 8 Wastes of Lean
Defects
Errors & Rework
Overproduction
Making Too Much
Waiting
Idle Time & Delays
Non-Utilized Talent
Underused Skills
Transportation
Unnecessary Movement
Inventory
Excess Stock
Motion
Excess Activity
Overprocessing
Doing More Than Needed

Appendix L-



Containers created

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