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Identification of Causes of Medicine Expiration in the Warehouse-A Case of Saudi Medical Company

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Abstract

Effective inventory management is critical for firms to maximize efficiency, minimize waste, and maintain a healthy financial position. This research investigates the causes of medicine expiration in the warehouse setting. Expired medications not only represent a waste of resources but can also pose safety risks if inadvertently distributed. Understanding the root causes of expiration is a crucial step toward improving warehouse operations and inventory control. The research applies several analytical techniques to diagnose the problem. ABC analysis is used to categorize medicines based on their annual usage value, allowing the team to focus on the most critical inventory items. Turnover ratio calculations provide insights into the velocity at which different medicines are sold, highlighting slow-moving stock that is prone to expiration. A fishbone diagram is constructed to systematically explore the potential causes of expiration, covering factors such as forecasting accuracy, storage conditions, packaging, and supplier reliability. Finally, a Pareto chart is leveraged to identify the vital few medicine categories that account for the majority of expiration issues. Through this multifaceted approach, the project team can uncover several key drivers of medicine expiration. Inaccurate demand forecasting emerges as a primary culprit, leading to the procurement of excess inventory that exceeds shelf-life. Suboptimal storage conditions, such as forecasting and sales, also contribute to the accelerated degradation of certain medicines. The findings of this work have broader implications for inventory management practices across various industries.

Keywords
Inventory Management, Expiry, Pharmaceutical Medicine, Shelf Life and Warehouse.

1. Introduction
Warehouse and inventory management are some of the most important resources that many institutions and organizations take into consideration. Therefore, many organizations and institutions form a department concerned with managing stores and warehouses, which ultimately aims to optimize the use of inventory they own. Moreover, due to the importance of inventory management, there are many types of warehouses, and it depends on the type of institution or organization. These warehouses may be owned or rented temporarily. In addition, there are many types of warehouses, such as fuel warehouses, raw materials warehouses, customs warehouses, records warehouses, and

finally, warehouses that specialize in medical facilities. Medical stores and warehouses are among the most important resources that organizations distributing medical items are interested in because they represent resources or frozen money in the form of item stock, which varies including raw materials, medical supplies, and medicines. A pharmaceutical distribution company faces a problem in its product inventory. The pharmaceutical manufacturing company is contracted with. This problem is an established trend in businesses that store products for distribution which is the production plans are overlapping with distribution plans thus causing complications for both companies. The distribution company is failing to move certain products and is distributing others that will eventually be unattainable to the customers, these cases of products are labeled as uncontrollable. The uncontrollable products are instigating expiration or out-of-stock cases.

The research in warehouse and inventory management is crucial for the medical and pharmaceutical sectors because it addresses critical challenges related to product availability, cost control, operational efficiency, compliance, and supply chain resilience. By addressing these key areas, this research can have significant implications for the overall effectiveness, sustainability, and responsiveness of these essential industries, ultimately benefiting patients, healthcare providers, and the broader community. Efficient inventory management in the medical and pharmaceutical sectors can lead to reduced wastage, better resource allocation, and improved access to life-saving drugs and medical supplies, which is especially important during times of crisis or shortages.

1.1 Objectives

The primary objective of this research is to identify the key factors and underlying causes that lead to the expiration of medicines in the warehouse of a Saudi medical company. The purpose of this study is to offer insightful information that will help the pharmaceutical distribution company overcome significant obstacles to efficiently managing its inventory and reducing product waste. To be more precise, the research goals include analyzing the Saudi medical company's present inventory and warehouse management procedures in order to identify problems and obstacles; examining the areas of overlap between the medical company's distribution plan and the manufacturing schedule of the contractual pharmaceutical manufacturer to determine the underlying reasons for the mismatch between supply and demand; examining the distribution company's classification and monitoring systems for "uncontrollable" products, which eventually lead to stock-outs or expiration; assessing the efficiency of the business's inventory replenishment and demand forecasting techniques, as well as the effect they have on the prompt delivery of medications to clients; putting forward data-driven, practical suggestions to enhance the inventory and warehouse management procedures in order to reduce medicine expiration and guarantee consistent product availability.

2. Literature Review

Inventory management is currently one of the main problems supply chain managers face. Many companies understand the benefits of having an effective inventory control system. Effective inventory management makes it easier to handle unpredictable demand while upholding a high standard of customer care. In a complicated supply chain network where inventories are distributed throughout the system as finished commodities or raw materials, an integrated approach to inventory management has become crucial (Tang, & Zhang. 2018). Healthcare businesses must maximize resource utilization, boost output, cut expenses, and deliver top-notch care. The healthcare sector has profited from just-in-time (JIT) methods in three ways: they have improved patient outcomes by cutting down on waste and non-value-adding activities (Balkhi et al. 2022). Demand is typically shifting in B2C scenarios in favor of products with longer residual shelf lives. In these situations, there is a chance that goods that are getting close to expiration may not be picked up by customers, ending their shelf life unsold and needing to be thrown away. Retailers can encourage the sale of products that are about to expire by implementing suitable discount policies, which can help to lessen the severity of this occurrence. This work develops a multi-period discrete-time simulation model with a defined and deterministic shelf life for perishable products. Furthermore, it was discovered that the influence of discount programs is positively impacted by demand fluctuation (Solari et al. 2024).

Investigation on the relationship between perceived quality, risk aversion, brand affect, brand trust, brand equity, and desire to purchase perishable food products with expiration dates. The findings show that perceived quality, brand affect, brand trust, and brand equity are all positively correlated with risk aversion. Additionally, a favorable correlation was discovered between parameters associated to brands. Results also showed that desire to purchase perishable food products with expiration dates based on price is positively impacted by risk aversion and brand-related variables (Konuk 2018). Due to the high cost of pharmaceuticals and the need for proper storage and management, they account for a sizable chunk of the expenses in the healthcare sector. The predicted number of daily refills, the

service quality, and the storage space utilization are the three major performance indicators that are the subject of tactical decision support. analysis of the trade-offs between the amount of labor required for refills, emergencies, and the range of medications provided (referred to as the formulary). The outcome is a decision assistance tool that makes it easier to enhance the current management procedures (Kelle et al. 2012).

To improve hospital logistics, this research proposes a novel approach that respects inventory capacities by synchronizing procurement and distribution operations. Our method placed more emphasis on scheduling decisions than multi-echelon inventory decisions. These decisions included when to purchase a product, when to transport it to each care unit, when each person should report for work what duty he should perform, etc. The development of planned schedules that balance the activities throughout the purchasing cycle is necessary for this potential method (Lapierre & Ruiz 2007). Providing the highest caliber of care for patients is the main goal of the healthcare industry. An efficient healthcare supply chain should be established in order to cut down on some needless expenses, even while healthcare costs continue to rise. This study intends to address this problem by looking at the inventory management procedures used in one public hospital in Indonesia and emphasizing how inventory affects hospital supply chain performance. Three primary concerns pertaining to inventory management practices have been recognized, namely excess inventory, erroneous forecasting methods, and inadequate IT assistance (Rachmania & Basri 2013).

Looking into how demand forecasting and inventory level control affect hospital pharmacies' PSC performance. The study discovered a strong correlation between PSC performance and inventory level control. Likewise, there was a strong and positive correlation between PSC performance and demand forecasts (George & Elrashid 2023). This research aims to create a complete conceptual model that explains how hospital-supplier integration affects healthcare organizations' overall performance. Additionally, it looks into how lean approaches affect hospital performance and supplier integration in a moderating way. The findings show that hospital performance is positively impacted by hospital-supplier integration. When lean methods are used in hospitals, these effects become even more noticeable (YANG et al. 2021). This study found Jordan's drug shortage's root causes. The results show that Jordan's drug shortages are mostly caused by four causes: supply-demand imbalance, human factors, legislation and regulatory processes, and distribution issues. Drug shortages are not substantially correlated with problems linked to manufacturing (Awad et al. 2016). Applications for inventory management have been adopted by the healthcare sector in an effort to improve supply chain effectiveness and efficiency.

Within the healthcare sector, the need for medications and diagnostic tools is expanding quickly. There has been a lot of discussion about the applications of simulation, new technologies for tracking healthcare items, new managerial practices, optimization, and information exchange strategies. As one of the first in-depth studies to address efficiently managing inventory items in healthcare supply chains, this assessment of the literature advances the subject of study (Leaven et al. 2017). In light of the advancements in supply chain management, this study aims to focus on the subject of whether there are any similarities between the industrial sector and healthcare services. Five primary study areas are identified with regard to supply chain management in a health care system, based on a classification of the body of current research. Furthermore, it is stated that in addition to research with a monodisciplinary focus, it appears vital to have an interdisciplinary focus on Supply Chain Management concerns in health services (de Vries & Huijsman 2011). Assessing inventory control in Malaysia's private healthcare industry, concentrating on the flow of medications from a wholesaler to clinics.

There are now problems that need to be fixed with clinic service levels. The wholesaler's availability of stock and urgent orders are the two main issues that the case study company faces, according to the data. A supply chain future state architecture is proposed based on vendor-managed inventories. Obstacles to accomplishing this are also noted, taking into account Malaysia's present supply chain management capacities (Haszlinna Mustaffa & Potter 2009). At all levels of healthcare, there is a pervasive issue with the ineffective and illogical use of medications. Hospitals' limited resources are being unduly stretched by the lack of well-defined policies and processes regarding the management of medications, which is having a negative impact on patient benefits. Hospital supply chain and medication management systems now in place have a number of flaws, most notably a lack of resources and a poorly defined policy framework. In order to close the gaps and fix the flaws in the supply chain system, immediate action is needed to monitor, assess, and evaluate its operation. The recruitment of highly qualified personnel with the necessary training in medication management at all care levels must be given top priority (Iqbal et al. 2017). In hospitals, single inventory policies have been implemented for whole drug classes, despite a variety of distinct drug and demand characteristics. Regular shortages can hurt patients' lives, particularly when they are receiving life-saving medications. This investigation aimed to create a hospital inventory management system that would minimize overall inventory

expenses while upholding the highest standards of patient safety. The study, which was conducted in a sizable public hospital in Thailand, only looks at medications with a high consumption value. Hospital inventory management should be customized to the drug categories and demand features that are exclusive to the healthcare supply chain and not applicable to general manufacturing (Priyan & Ramasamy 2014).

In the health services industry, risk management is evolving into a highly targeted endeavor. Several dangers have been linked to the supply chains of the pharmaceutical sector, specifically because of the intricate structure of its processes. The objective of this research is to evaluate the risks associated with pharmaceutical supply chains (PSCs) through the identification, analysis, and proposal of a decision-making model grounded in the Analytical Hierarchy Process (AHP) methodology. According to the study's conclusions, supply-related risks—such as fluctuations in import arrival patterns, a lack of information sharing, the failure of significant suppliers, and a shortage of supplies—should take precedence over operational, financial, and demand-related risks (Moktadir et al. 2018). Keeping an inventory under control for a pharmacy has two major objectives. The needs of the pharmacy and its clients determine the products that are routinely maintained in stock. Minimizing the cost of prescription drugs is the second objective of inventory management.

Several pharmacies have pricing agreements with specific pharmaceutical companies or have preferred wholesalers they can place orders from in order to reduce the cost of purchasing prescription drugs. Steering clear of profit loss is another facet of minimizing medication expenses. By using prescriptions before they expire and processing returns on a regular manner, good stock management helps lower medication expenses (Dubey et al. 2022). The study on the effects of ordering coordination and information sharing on the performance of a supply chain with numerous retailers and one capacitated supplier under variable demand conditions is presented in this paper. Specifically, a computer model that mimics the decisions made by retailers regarding inventory replenishment and suppliers regarding manufacturing under various demand patterns and capacity constraints is put forth. The performance of the supply chain is found to be greatly impacted by information sharing and ordering coordination in terms of both overall cost and service level. Policies are created to help businesses exchange data and coordinate orders in various scenarios. These recommendations can assist businesses in cutting expenses and raising supply chain customer satisfaction standards (Zhao et al. 2002).

The extremely competitive climate of today is drawing more and more attention to lean management. In this context, the study's goal is to investigate the premise that better financial performance for a company is a result of effective (lean) inventory management. The findings from cross-section linear regressions show that a firm's rate of return decreases with increasing levels of inventory preserved (moving away from lean operations (Koumanakos 2008). An article aims to explore the performance outcomes of vendor-managed inventory (VMI) as seen from the buyer's point of view, as well as the factors that facilitate its effective implementation. The degree of the buyer-supplier relationship, the IT system's quality, and the volume of information sharing all influence the buyer's perceived value of VMI success, but not the actual quality of the information provided. Moreover, three performance outcomes are brought about by VMI: better supply chain control, increased customer service, and, to a lesser degree, lower costs (Claassen et al. 2008).

The novelty of our paper is that it combines different methods and techniques that are used in several geographical locations around the world. By drawing upon a diverse set of approaches from various contexts, our work provides a unique and holistic solution to the current problem at hand. To achieve the stated objectives, we undertook a multi-pronged research methodology. This involved carefully selecting and applying multiple analysis techniques, data collection tools, and software platforms. We conducted an extensive review of the existing literature to identify the most relevant and effective methods employed in similar problem domains globally.

3. Methods

In this study work, the Turnover Ratio (TOV) is employed for data filtration, and a Pareto chart is used for root cause analysis. The turnover ratio—which has an ideal range of 1-3, with 2 being the best ratio—is used to assess how well products performed over the research period. To help spot any anomalies, a preliminary graph is made to show the product rankings together with the associated turnover ratios. After removing outliers, Excel functions are used to categorize the remaining goods as "controllable" (within the 1-3 range) or "uncontrollable" (outside the range). The trustworthiness of the results is increased since this methodical approach guarantees that the study concentrates on the most pertinent and stable products. Next, by arranging the factors according to their percentage contribution, the Pareto chart is utilized to determine which are the primary causes of the issue under investigation. This aids the researcher in

setting priorities for the underlying issues that need to be fixed in order to resolve the issue successfully. These techniques have the advantages of greater validity, rigor, and a data-driven approach to the study, which enables the researcher to focus on the most important areas for development.

3.1 Data filtration using Turnover Ratio (TOV)

Turnover ratio is the total number of times inventories is sold and replaced in a certain amount of time as shown by the ratio of inventory turnover. It is used as a measurement to the products performance during the duration of the study. The optimal range that the company suggest the turnover ratio of the product is between (1~3) and the optimal ratio is 2. The range is a standard set by the company according to their experience in the field. An initial graph was made through the excel program. A line chart is used to display data in the order of the ABC analysis. The x axis shows the ranking of the product, and the y axis shows the turnover ratio of the product. Then the additions of the limits were introduced the lower limit was set to 1 and the upper limit was set 3 and a line that is equal to 2 to show optimality. The initial graph was made to have a clear representation of the graph before the filtration of the data further down the line.

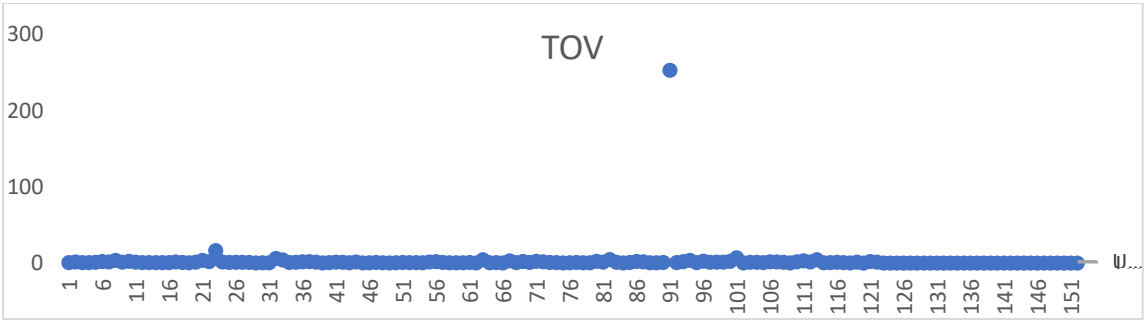
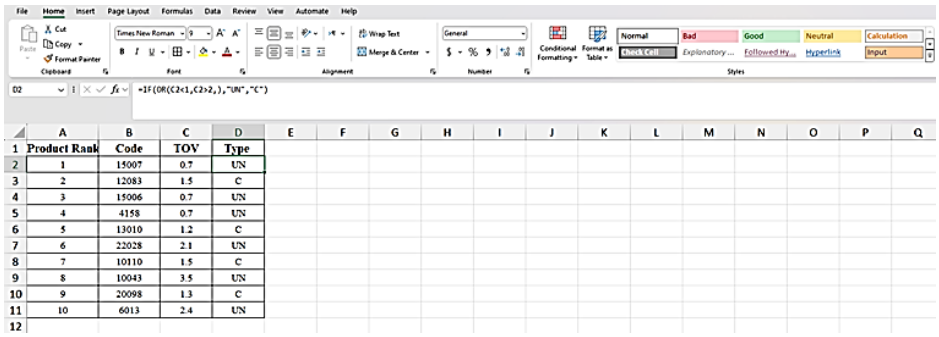


Figure 1. Initial graph for the data

Outliers in general are data points that largely deviate from other data points. From the initial graph, we can clearly see a point that is largely deviates from others. As it was identified immediately the graph is then redone with the removal of the of the point. Controllable products are items that fall in the region between (1~3). These products are recognized as controllable and therefore will be labeled as such. Since the two cases are bound with numbers that is set beforehand and the sample size is large an eye test wouldn't be an accurate approach to perform this analysis. The analysis needs an accurate methodology to recognize the items that fall out of the limit and the items that fall within, so the use of:

- Microsoft excel program the data was placed on column A was the code of the product with the order of the ranking on column B also each item TOV ratio was placed on the column C. After that in column D a combination of IF and OR function was used.
- The OR was inside the function IF, it has been established that an IF function is used to test the trueness of the statements inside it. The statement inside it was OR function which was (Cn<1, Cn>3) the statements clearly suggests that if the number on column C is less than 1 or more than 3.
- The statement of the OR function if proven true an acronym for Uncontrollable "UN" would show, and if proven to be false an acronym for Controllable "C" would show. The IF function at completion was IF (OR (Cn<1, Cn>3), "UN", "C"). A sample figure of Identifying controllable and uncontrollable method.



	A	B	C	D
1	Product Rank	Code	TOV	Type
2	1	15007	0.7	UN
3	2	12083	1.5	C
4	3	15006	0.7	UN
5	4	4158	0.7	UN
6	5	13010	1.2	C
7	6	22028	2.1	UN
8	7	10110	1.5	C
9	8	10043	3.5	UN
10	9	20098	1.3	C
11	10	6013	2.4	UN
12				

Figure 2. A sample figure of Identifying controllable and uncontrollable method

3.2 Root cause analysis using pareto chart

The percentages reveal the severity for each cause. Each main cause contributes to the problem based on the expert of the expert of the system. The causes then are gathered to be analyzed through a Pareto graph to select the cause that the project will work on eliminating.

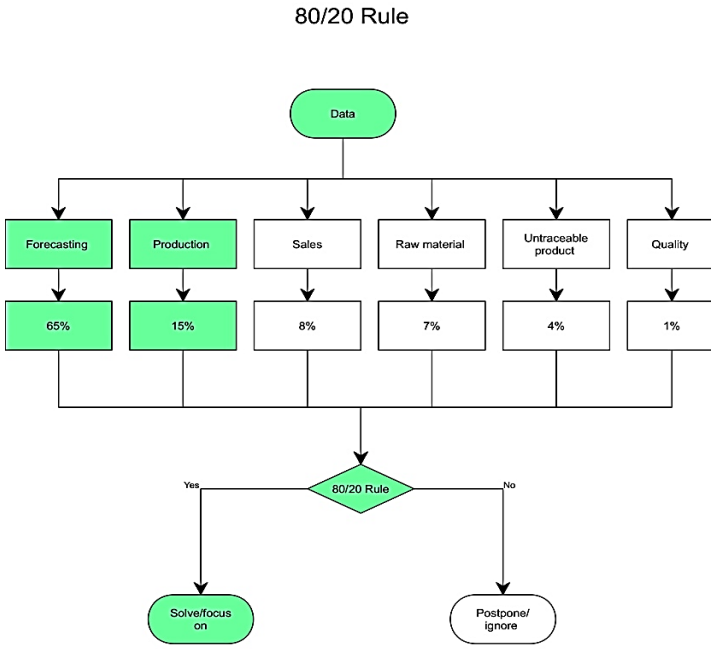


Figure 3. Framework 80/20 rule

4. Data Collection

The interview was used to collect data because it suits the current situation, and it is most effective and time efficient. The project group members held up a meeting with a company's personnel who has the position of general manager of warehouses at the inventory and is an expert in the system. The interview guide is written below and the path for data collection is in the figure below:

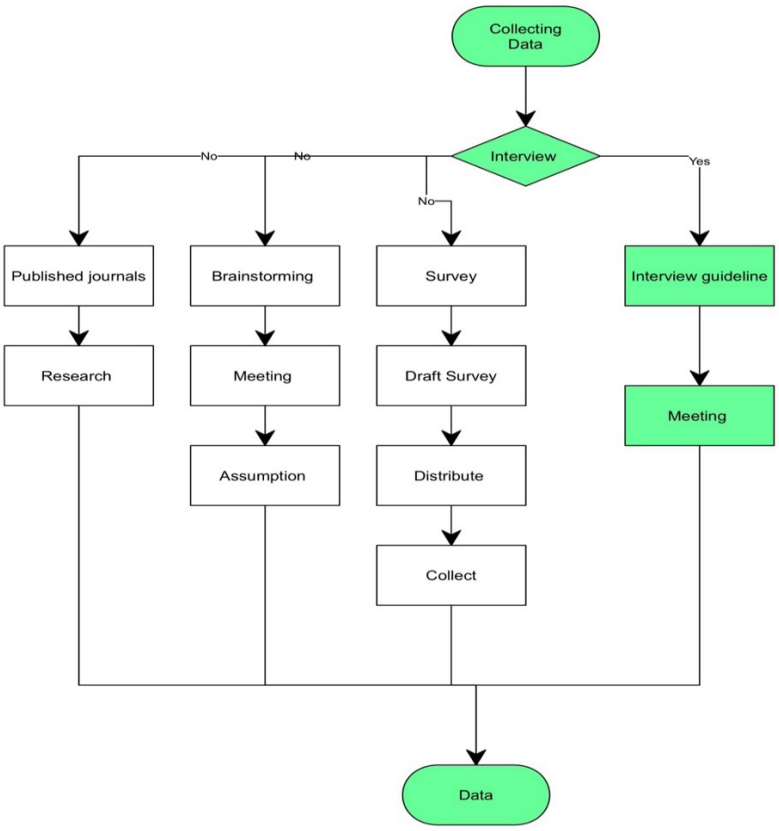


Figure 4. Data collection flow chart

4.1 Interview guide potential causes leading into expiry cases

Here are the questions that were discussed during the meeting.
What are the main potential causes for the expiry case?

- List many as you could.
- Describe each one.
- The reason for it to be a cause.
- Opinion on the scale of the effects.
- Limitations for the cause.

2) Can you detail the sub-causes for each potential cause for the expiry case?

- List many as you could.
- Describe each one.
- The reason for it to be a cause.
- Opinion on the scale of the effects.
- Limitations for the cause.

3) For each main potential cause can you give a weighted percentage for its relation for the problem in-hand?

- Remind him of how much percentage is left after each main cause.
- Read the recorded main causes.
- The reason for it to be this amount of percentage.

4.2 Quantitative data

Quantitative data is numerical and may be calculated mathematically. Different scales are used to measure quantitative data, and they are classed as nominal scale, ordinal scale, interval scale, and ratio scale. The data collected is secondary data that is recorded in the company database (Kabir, 2016).

4.2.1 Inventory turnover ratio

The inventory turnover ratio measures the amount of time that passes between when you purchase goods and when you sell it to your customers. It also reveals whether you have too much stock on your hands. A greater turnover ratio indicates that you are restocking inventory and moving products. However, if you don't keep enough inventory on hand to match demand, it can be a sign of lost revenue. This can be used to determine the out of stock and expiry cases of product. It is calculated by the following formula shown in equation 1. The data is shown on Table below.

$$Inventory\ turnover\ ratio = \frac{Total\ units\ sold\ per\ product}{Average\ inventory}$$

Table 1. Inventory turnover ratio

Product rank.	Code	Total Sold
1	15007	0.7
2	12083	1.5
3	15006	0.7
4	04158	0.7
5	13010	1.2
6	22028	2.1
7	10110	1.5
8	10043	3.5
…	…	…
…	…	…
144	10053	0.0
145	23038	0.0
146	06009	0.0
148	32009	0.0
149	20132	0.0
150	20208	0.0
151	10130	0.0

4.3 Qualitative data

Qualitative approaches try to answer the questions of "how" and "why" a program works, and they typically use unstructured data collection methods to do so. Open-ended questions are used in qualitative research. Qualitative methods are useful for exploring further into reasons for the problem, effects, and unexpected repercussions. The data collected in this section is primary data using methods such as Interviews, Observation, and Focus Group Interviews (Kabir 2016).

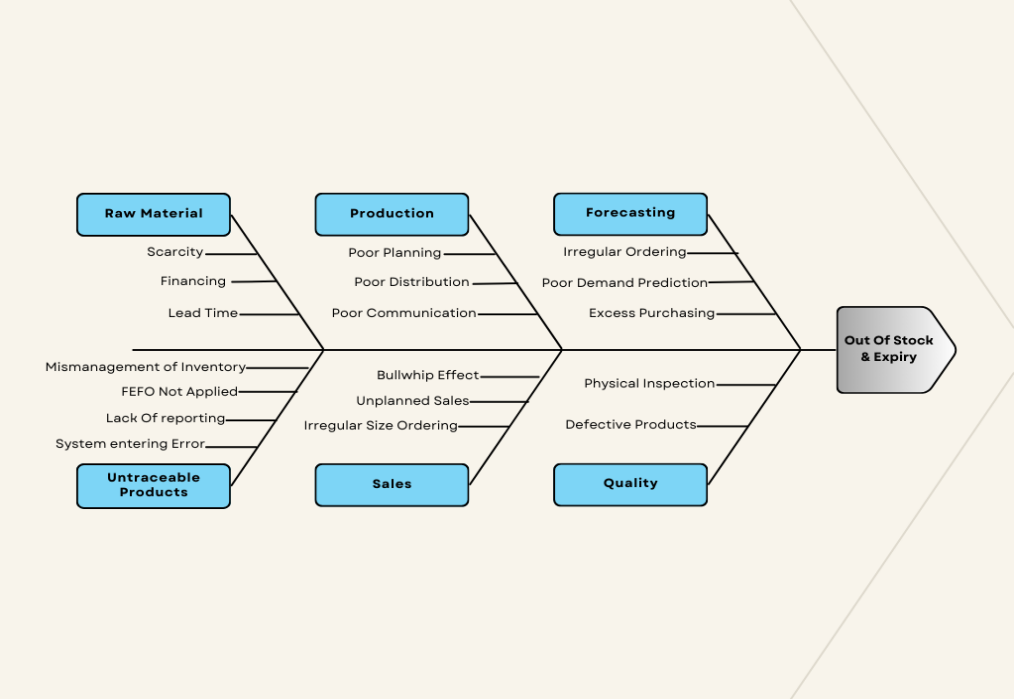


Figure 5. Root Cause Analysis

5. Results and Discussion

5.1 Analysis of Outliers in TOV Ratio

The products which are having 0 TOV ratio is because either they have no sales or minor quantities are sold relative to their production. Furthermore, the products that emerged as TOV ratio that is very high are products who are the opposite of what have been stated therefore they are not considered for the study. This reduces the number of products in hand which makes the process smoother moving forward and also reduces inconsistencies in the results. After determining that the TOV ratio is between 1-3, there have been products who have significantly higher or 0 as a TOV rate, thus they have been removed and are regarded as outliers. A total of 30 products were outliers and the rest are not.

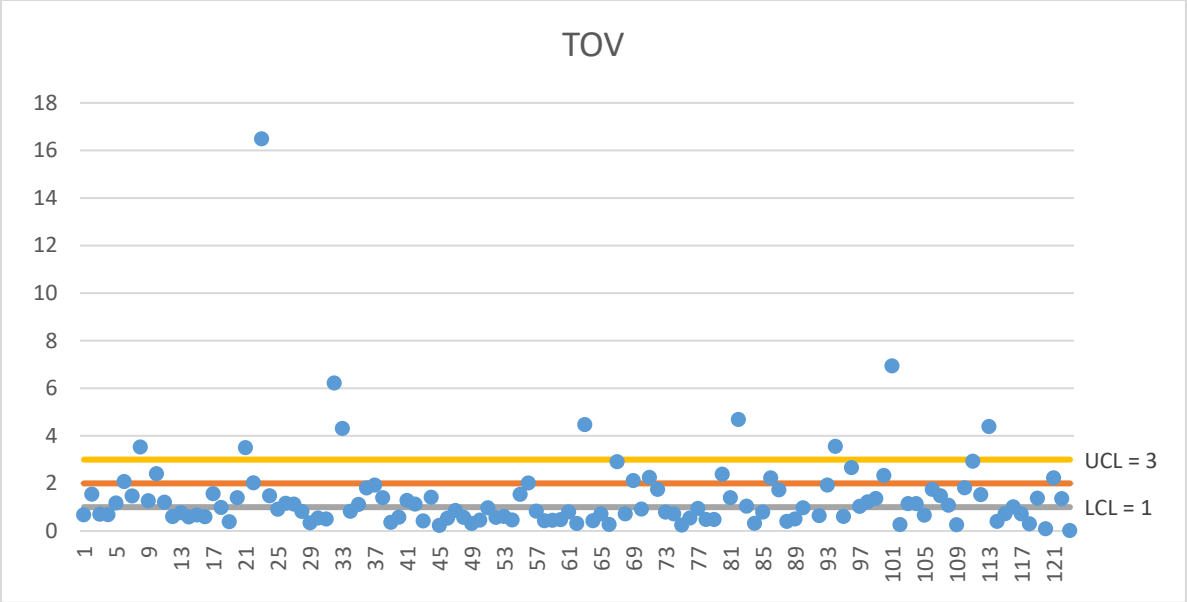


Figure 6. A graph without outliers

Figure number 6 shows graph without having any outliers. Y-axis on the graph represents the TOV ratio however the x axis represents the products. The ratio of each product is represented as the dots. Furthermore, the lower control limit (LCL) and upper control limit (UCL) are the ratio of which products should fall in between off. Any dots that is outside of the range are uncontrollable products while any dots within the range are controllable.

5.2 Applying the TOV Technique to Distinguish the Controllable and uncontrollable Products

The region of the TOV is between 1 - 3 the products that are controlled are within region therefore are exempted from further study while on the other side products that are uncontrolled are focused on. Same with outliers results ensures for a consistent outcome within a more concentrated scope.

- The result of the filtration concluded that there are 49 products within the controllable region and 73 uncontrollable products were identified.
- Controllable products make about 40.2% while uncontrollable make about 59.8% as shown in pie figure below.

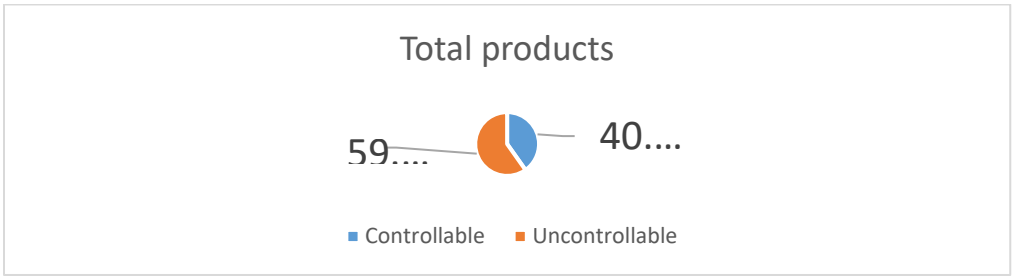


Figure 7. Percentage of controllable and uncontrollable

5.3 Main causes percentages using pareto chart

We can see from this chart that the x-axis represents the primary causes of the issue, while the y-axis shows how frequently the issue occurs. From this chart we can recognize that the main causes for the problem are forecasting (65%) and production (15%). The relationship between the two is that production doesn't meet the demand for the particular reason that the demand is inaccurate.

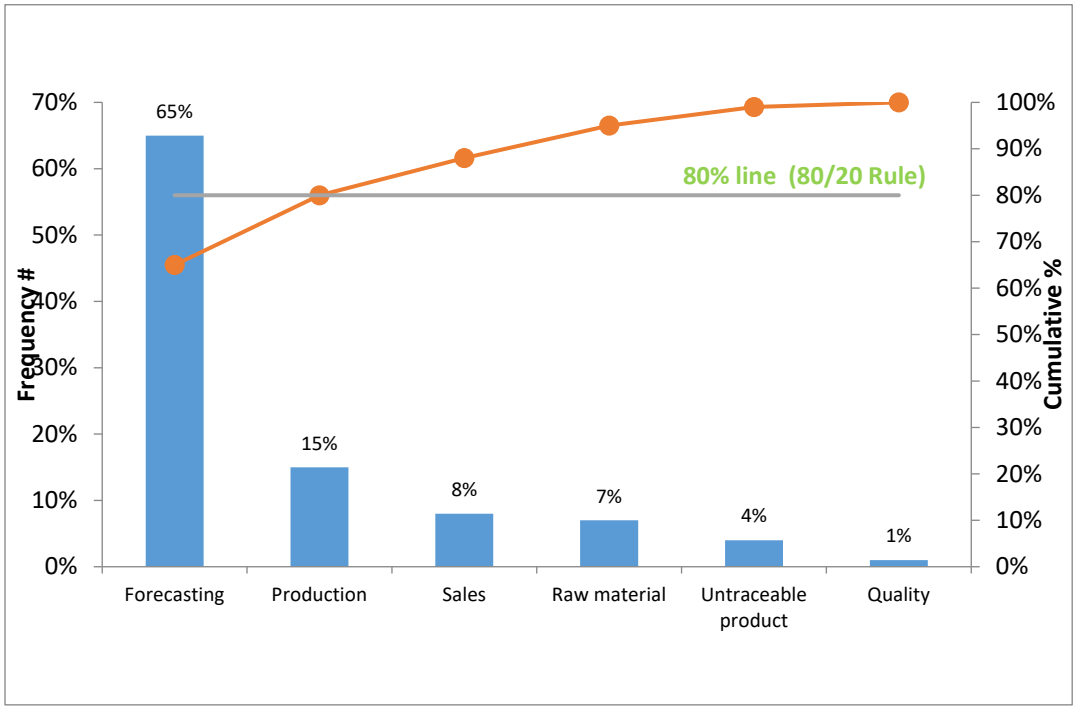


Figure 8. Pareto chart for the main causes

Proposed Improvements

One approach to improve the data gathering process could be to complement the employee surveys with in-person observations of the operational processes involved in medical product management. Researchers could conduct site visits to pharmaceutical manufacturing facilities, distribution centers, and healthcare settings to directly observe the day-to-day activities, workflows, and inventory management practices. Through these on-site observations, researchers would be able to gather firsthand insights into the actual practices and challenges faced by frontline personnel, rather than relying solely on self-reported survey data. They could document and analyze specific procedures, identify potential bottlenecks or inefficiencies, and observe how inventory is tracked, stored, and distributed. Additionally, researchers could incorporate process-mapping techniques, such as creating detailed flowcharts or swim lane diagrams, to visually document the end-to-end supply chain and inventory management processes. This would allow for a more comprehensive understanding of the various touchpoints, handoffs, and potential failure points that could contribute to product expiration.

6. Conclusion

This study has successfully addressed the key objectives set out to identify the root causes of medicine expiration in the warehouse of the Saudi medical company. Through a comprehensive examination of the company's existing warehouse and inventory management practices, the research has uncovered critical challenges and pain points that contribute to the mismatch between supply and demand. The unique contribution of this research lies in its holistic approach to addressing the challenge of medicine wastage. By delving into the intricate relationships between production, distribution, and inventory management, the study has uncovered the root causes of the problem and developed a framework that can be applied by other pharmaceutical companies facing similar challenges. This framework serves as a valuable tool to proactively manage inventory, reduce wastage, and improve patient access to critical medicines.

The study identified the following using root cause analysis:

- The pareto chart indicates that forecasting is the primary cause of expiration in the warehouse.
- Pareto chart indicates that production is the second most common reason for expiration.
- Sales fluctuations, a lack of raw materials, untraceable products, and operational quality combined accounted for 20% of the cause of expiration and were therefore not given the same emphasis as the other two factors.

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Biographies

Shamsan Saeed, is graduated with a bachelor's degree in industrial engineering from Al Yamamah University. He started his career as a COOP trainee at Ninja in Riyadh, where he worked for six months as an auditor and quality supervisor. Shamsan Saeed proved at Ninja how committed he was to lifelong learning and skill improvement. He obtained other certifications to further his expertise, such as a Safety Officer certificate from OSHA Academy and a Lean Six Sigma Green Belt. These extra credentials have given him a broad range of abilities and knowledge in the areas of process optimization, workplace safety, and quality management. Shamsan was able to apply his understanding of industrial engineering in his roles as a Quality Supervisor and auditor at Ninja. He was instrumental in making sure the business's operations followed quality standards and pinpointed opportunities for development. He has proven to be an invaluable asset to the companies he has worked with thanks to his capacity for data analysis, process optimization, and corrective action implementation.

Abdulaziz Senjab is employed by Alkhorayef Industries as a Planner & Inventory Controller Engineer. possessing an industrial engineering bachelor's degree from Saudi Arabia's Al Yamamah University in Riyadh. His career pursuits are motivated by his strong interest in supply chain and operations management. In his current position, he is in charge of inventory planning and control, making sure that warehouse management and other activities at Alkhorayef Industries function smoothly and effectively. He is essential in keeping the right amount of inventory on hand, liaising with other departments, and putting plans into action to enhance the performance of the supply chain as a whole. He has accumulated significant knowledge in a variety of industrial engineering fields throughout the course of his career, especially in supply chain management, operations, and warehouse management. Strategic planning, process optimization, inventory optimization, and warehouse management are among his areas of competence. Additionally, he is a member of the Saudi Council for Engineers, demonstrating his dedication to upholding the highest standards of professionalism and remaining in touch with the technical community.

Omar Abuhassna has completed his industrial engineering bachelor's degree at Al Yamamah University. He became quite interested in quality planning and management during his studies, and he holds a Lean Six Sigma Green Belt certification. Following graduation, he started working as an Operations Supervisor at Ninja Company, where he spent six months gaining expertise. Soon after, his diligence and hard work paid off, and he was elevated to the position of Operations Planning Engineer. As part of his new role, he was responsible for doing order projections in order to precisely ascertain and distribute labor resources throughout locations, guaranteeing the ideal staffing levels for effective order fulfillment. Additionally, he was crucial in assigning and scheduling retail employees to assist with business operations. His proficiency in planning, quality control, and industrial engineering has been crucial in boosting output and efficiency in the companies he has worked for. His employers have benefited from his abilities to evaluate data, optimize workflows, and manage resources efficiently. He is still using his expertise and abilities to help his organization succeed right now. He is dedicated to remaining current with the most recent advancements and trends in his industry, and he is constantly looking for ways to broaden his knowledge and take on new challenges.

Khaled Zreed obtained his industrial engineering bachelor's degree from Saudi Arabia's Al Yamamah University. He continued his study by graduating from SWIS Business School with an MBA in Supply Chain. He started his career as a COOP trainee at Ninja in Riyadh, where he worked for three months as an operations assistant. He was elevated to Operations Supervisor in June 2023 after showcasing his extraordinary abilities and commitment. He was officially hired by August 2023 and assumed the position of Process Improvement and Performance Manager-Last Mile. He is currently employed with Ninja in Riyadh, where his primary responsibility is to improve performance and operational efficiency in the last-mile delivery industry. Process optimization, supply chain management, and operational performance optimization are some of his professional interests.

Abdullah AbuDurrah holds a first-degree honors degree in industrial engineering and is currently a top performer in the telecommunications business at Channels By STC as a product management specialist. His exceptional educational background and real-world experience have given him a special combination of technical know-how and strategic insight, which has fueled the company's success with cutting-edge goods. He excelled in his class and graduated first, showcasing his early commitment to excellence and grasp of challenging technical topics. His professional trajectory has benefited greatly from this strong foundation, which has made it possible for him to move smoothly into the exciting world of product management. He is a key member of the team at Channels By STC, where he oversees the whole product lifecycle from concept to market launch, making sure every product meets the highest standards of

performance and quality. Abdullah takes a customer-focused and analytical approach to product management. His proficiency lies in recognizing market trends and comprehending consumer requirements, which he then converts into implementable tactics that propel product advancement. His capacity for productive cross-functional teamwork with engineers, designers, and marketers has been crucial to the development of novel products and their commercial success. devoted to ongoing development.

Dr. Madiha Rafaqat completed her BSc Industrial and Manufacturing Engineering (2007 – 2011) from the University of Engineering and Technology (UET), Lahore – Pakistan. She earned MSc in Manufacturing Engineering (2018 – 2020) from the same university (UET, Lahore). She has recently completed her PhD in Manufacturing Engineering (2020-2024). She served, as a lecturer for 5 years, in Princess Noura Bin Abdulrahman University (PNU), Riyadh – Saudi Arabia. In 2016, she was awarded with the certificate of appreciation from PNU based on her outstanding performance. Currently, she is a lecturer of Industrial Engineering Department (IED), College of Engineering and Architecture (COEA), Al Yamamah University, Riyadh – Kingdom of Saudi Arabia. Dr. Madiha has published several research papers in ISI journals in the field of Manufacturing Engineering. Her main research interests are: Manufacturing and Machining. Her teaching interests include the areas of Materials & Manufacturing Processes, Metrology & Quality Assurance, Project Management, and Business Communication.

Dr. Naveed Ahmed received BSc an MSc degrees in Industrial and Manufacturing Engineering from University of Engineering and Technology (UET), Lahore – Pakistan. He joined the same university as a Lecturer in 2007. Dr. Naveed Ahmed received PhD degree from King Saud University, Saudi Arabia, in 2016 and received King Saud University Award for Scientific Excellence in 2017. Currently, Dr. Naveed is working as an Associate Professor and Chairman of Industrial Engineering Department, Al Yamamah University, Kingdom of Saudi Arabia. His research interests are machining, manufacturing, and industrial engineering.