# SIMULATION-BASED ENHANCEMENT OF WAREHOUSE LAYOUT AND INVENTORY CONTROL IN AN INDONESIAN PHARMACEUTICAL MANUFACTURER

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**Abstract:**

**Background:** PT X, a pharmaceutical manufacturer in Indonesia, faces challenges in inventory management due to the lack of an optimal reorder system. This problem leads to overstock and high costs. Additionally, disorganized warehouse arrangements for packaging materials complicate retrieval and prolong order-picking times.
**Purpose:** This study aims to optimize inventory management and improve warehouse layout to reduce costs and enhance operational efficiency.
**Design/methodology/approach:** Inventory optimization was achieved using a two-pronged approach. The probabilistic Economic Order Quantity (EOQ) method was applied for items classified as Category A, while a periodic review method was used for items in Categories B and C. ABC analysis and demand forecasting informed the reorder quantities. A class-based storage system was implemented to improve warehouse layout, grouping packaging materials by type and organizing them sequentially according to ABC classification. Simulations in Promodel 6.0 compared warehouse conditions before and after improvements.
**Findings/Results:** The optimized inventory system reduced total costs by 0.66%, from IDR26,809,071,104.17 to IDR26,630,856,055. The improved warehouse layout decreased order-picking time by 21.9%, from 19.14 minutes to 14.95 minutes, and reduced movement distances by 21.9%, from 1,469.97 meters to 1,148.03 meters.
**Conclusion:** Integrating inventory optimization using a probabilistic EOQ and periodic review system with a class-based storage layout effectively reduces costs and enhances productivity in warehouse management. According to the ABC classification, the sequential arrangement significantly improves order-picking efficiency by reducing movement distances and time.
**Originality/Value (State of the Art):** This study offers a novel combination of probabilistic EOQ, periodic review, and class-based storage, validated through simulation, to address inventory and warehouse management challenges in the pharmaceutical industry. The detailed quantitative analysis provides valuable insights into cost savings and operational improvements.

**Keywords:** ABC analysis, class-based storage, inventory system, forecasting, warehouse simulation

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## INTRODUCTION

Industrial competition in Indonesia is becoming increasingly intense, especially among companies operating in the same sector. Companies must continuously innovate their products and optimize their operational processes to remain competitive. One critical area that requires attention is inventory and warehouse management, particularly in response to diverse and fluctuating market demand (Karongkong et al. 2018). Inefficient storage capacity and poorly designed warehouse layouts can lead to operational disruptions, increased costs, and delays in order fulfillment (Mulyati & Tarigan, 2021). PT X is a pharmaceutical company specializing in ethical, non-prescription, and dermatological skincare products. The company faces two major challenges in its packaging material warehouse: inefficient inventory control and a disorganized storage system. The warehouse contains 391 types of packaging materials, categorized into 222 secondary packaging materials (boxes, inner boxes, and brochures) and 169 primary packaging materials (bottles, tubes, jars, and applicators). These materials are critical to the production process, making their availability and accessibility essential for maintaining an efficient workflow.

Much research has been done on optimizing inventory and designing warehouse layouts. However, little research has been done on using probabilistic EOQ and periodic review methods with a class-based storage system to manage pharmaceutical inventory. Previous research has used ABC classification to prioritize inventory (Meilani, 2018; Pamungkas & Handayani, 2018) and simulations to find better warehouse layouts (Fazrin & Ludiya, 2023; Noviani et al. 2017). However, prior research has not comprehensively combined these methods to address pharmaceutical warehouse inefficiencies. We add a new probabilistic EOQ for items in Category A, a review method for items in Categories B and C, and a class-based storage system to make the warehouse run more efficiently in this study. The application of simulation software to validate layout improvements and order-picking efficiency further differentiates this study from existing literature.

The primary issues identified at PT X's packaging material warehouse include the absence of a structured reordering strategy and an inefficient warehouse layout. Reorder decisions rely on stock card information and managerial discretion, leading to overstock, dead stock, and increased carrying costs. In addition, warehouse staff place items based on available space rather than following a structured system, resulting in inconsistent item locations and inefficient order-picking activities. This study uses an integrated inventory and warehouse management approach to solve these issues. It combines ABC analysis, demand forecasting, Economic Order Quantity (EOQ), review methods that happen regularly, and a class-based storage system. The ABC analysis sorts packaging materials into groups based on how much they add to the total value of the inventory. This analysis ensures that the most important items get more attention during inventory control (Fazrin & Ludiya, 2023; Noviani et al. 2017). Demand forecasting uses data from 2021 to 2022 for Category A items, which helps make more accurate predictions of future demand and avoids stock shortages (Heriansyah & Hasibuan, 2018; Hermanto et al. 2019).

Following demand forecasting, inventory control methods are applied based on the ABC classification. The probabilistic EOQ model determines the optimal order quantity for Category A items, minimizing inventory costs while maintaining stock availability (Bawono & Erik, 2023; Nurcahyawati et al. 2023). Meanwhile, Category B and C items are managed using the periodic review method, where stock levels are checked at fixed intervals and replenished accordingly (Siahaan, Andrawina, & Yulianti, 2021). This study uses a class-based storage system to make the warehouse more efficient. It puts similar items in the same group and arranges them in order using the ABC classification (Imansuri et al. 2023; Kelvin & Rahayu, 2020). This structured layout reduces movement distances and improves order-picking efficiency, especially for high-demand items. Finally, we conduct a simulation-based evaluation using Promodel 6.0 software to compare warehouse performance before and after implementing the improvements. The simulation checks that the proposed solutions work by measuring the time it takes to pick up orders and the distances people travel. This measurement ensures that the new system improves warehouse operations (Hermanto et al. 2019; Hutapea, 2017).

This research aims to reduce total inventory costs and optimize warehouse management at PT X by implementing a data-driven inventory control system and a structured warehouse layout. This study uses the probabilistic EOQ model for Category A items and the periodic review method for Categories B and

C. The goal is to reduce the amount of stock that is kept on hand that is not needed and make strategies for restocking better (Wirawana & Yunus, 2022; Laoli et al. 2022). Another important goal is to make better use of warehouse space. The class-based storage method (Rosihin et al. 2021) can achieve this by sorting and grouping packaging materials based on ABC classification. The new layout reduces movement distances and streamlines order-picking operations by placing frequently used and high-value items closer to the warehouse entrance and exit. Simulation analysis that compares order-picking times and movement distances before and after the warehouse layout redesign shows that these changes work (Heriansyah & Hasibuan, 2018). This study contributes to better logistics and supply chain management in the pharmaceutical industry by integrating inventory control optimization with structured warehouse improvements. The findings provide a practical framework for companies seeking to enhance operational efficiency while maintaining cost-effective inventory management strategies.

## METHODS

The hypothesis is that combining probabilistic EOQ inventory control with class-based storage layout optimization will lower the total cost of inventory and make the warehouse run more efficiently by cutting down on movement distance and the time it takes to pick orders. To prove this, the first step in this study is to conduct observations related to the problems in the company's packaging warehouse, and then formulate the problem based on the issues identified. Before collecting data, it is necessary to conduct a literature study first to obtain the appropriate theory and scientific basis. It will be used to analyze the research data.

Data collection was conducted using historical data analysis, direct observations, and interviews with warehouse staff to gain insights into inventory management practices and layout challenges. Historical data on packaging material usage from 2021 to 2023 was gathered from the company's inventory management system, while observational data was recorded to assess movement distances and order-picking times. Interviews were conducted to understand operational constraints and warehouse staff experiences. PT X collaborates with several suppliers to help provide all packaging materials they store. Each supplier has a minimum purchase policy for each packaging material item. Each purchase must adjust the minimum order quantity policy when the company's packaging material purchase planning is below the supplier's order limit.

PT X has two main warehouse sections, namely primary and secondary warehouses. Both warehouses have different rooms with different layouts and numbers of shelves. In this difference, the number of shelves in the secondary warehouse is more than in the primary warehouse because the room size is larger. In the secondary warehouse, there are 120 shelves with 396 levels available. In the initial layout of the secondary warehouse, each shelf level can be filled with one to four different items. In shelves A, B, and C's aisles are primary packaging material items. Primary packaging materials need to be stored at a cooler temperature than secondary packaging materials because primary packaging materials are mostly made of plastic and aluminum. Hence, they must avoid possible damage, such as deformation or softening. Meanwhile, secondary packaging materials such as cardboard (inner boxes) tend to require a dry area to prevent damage caused by humidity.

The processing time is when warehouse staff must take goods from the shelves and arrange them for material handling in hand pallets. The process time obtained amounted to 30 data points. Then, a distribution fitting will be carried out to determine the appropriate distribution for the 30 data points. Data analysis was performed using SPSS for statistical analysis, including distribution fitting and hypothesis testing. In contrast, EasyFit software was used to determine the appropriate distribution model for process times and material handling speed. In addition, Promodel 6.0 simulation software was utilized to compare the initial and improved warehouse layouts, enabling a detailed evaluation of movement distances and order-picking times. The simulation results were validated by comparing them with operational data collected during observations. It was obtained that the appropriate distribution was a normal distribution with an average value of 3.54 minutes and a standard deviation of 0.58. In addition, data was collected on material handling speed in the form of hand pallets. Data collection was carried out 10 times, and the following is a table of material handling speed data. The data processing stage begins with the ABC classification of each type of packaging material. The ABC concept is a concept that divides inventory into three categories, namely Category A, which is an item with a high value;

Category B, which has a medium value; and Category C, which has the lowest value (Fazrin & Ludiya, 2023). This concept is used to determine the priority of inventory that needs to be considered by the company. The ABC concept is based on the Pareto principle, also known as the 80/20 principle, which focuses inventory control on high-value rather than low-value inventory (Wahyuni, 2015). ABC analysis categorizes packaging materials to determine the right inventory system. Inventory is one of the assets owned by a company in the form of goods to support the company's operational activities. According to Rizal et al. (2022), inventory is a resource in the form of raw materials, semi-finished materials, or finished products stored for future use. The main goal of inventory management is to have the right amount of inventory at a low cost. In this study, packaging materials with category A use the Probabilistic EOQ method. According to Apriyani & Muhsin (2017) and Daud (2017), the Economic Order Quantity (EOQ) method is one of the inventory control methods to determine the economic order quantity to minimize total storage costs. Wirawana & Yunus (2022) and Laoli et al. (2022) explore the optimization of the inventory system using the probabilistic EOQ method, focusing on reducing inventory costs and maximizing warehouse space utilization. Demand fluctuates in the probabilistic EOQ model, and lead time is uncertain. In the probabilistic EOQ model, safety stock and reorder point calculations are carried out (Bawono & Erik, 2023; Nurcahyawati et al. 2023). A comparison of the total inventory costs of the initial and post-repair conditions focuses on category A items. Packaging materials in categories B and C are grouped according to supplier and type. Calculations will be carried out using the periodic review method. According to Siahaan, Andrawina, and Yulianti (2021), the periodic review method is an inventory control method that reviews inventory conditions at certain intervals. The review time interval is fixed, but the number of goods ordered varies for each period by considering the maximum inventory limit for each item.

The next step is to calculate the shelf requirements for each item of packaging material by considering the inventory decision, shelf capacity, and dimensions of the goods. It is continued by making a layout improvement design using the class-based storage method. According to Rosihin et al. (2021), the class-based storage method is a storage policy that divides the items of goods stored into various classes based on the similarity of the goods to other goods. A clear classification can make it easier for warehouse staff to identify storage locations for each product class. The last step at this stage is to create a simulation model of the initial and proposed warehouse conditions for improvement to compare the distance of movement and the time of order-picking activities. Simulation is one way to describe the conditions or appearance of a real system (Hermanto et al. 2019; Hutapea, 2017). Simulation is used to compare the initial system conditions and the proposed improved system created with the help of software. Simulation allows research results to be evaluated before implementation, so that errors can be reduced when the proposed system is implemented in a real system. The data collection methods, including historical data analysis, observational recordings, and interview guidelines, were standardized and documented to ensure reproducibility. Analytical procedures, such as distribution fitting, ABC classification, and EOQ calculations, were followed by established inventory management methodologies, ensuring consistent and repeatable results.

The framework of thought for this study is from problem identification to solution implementation. It visually represents the research process, including data collection, analysis, and evaluation stages. It ensures a structured approach to optimizing inventory management and warehouse layout. The research framework starts with problem identification, highlighting two main issues: (1) the lack of a proper ordering method that leads to overstock situations and (2) a disorganized warehouse layout that randomly places newly arrived items on empty shelves. These inefficiencies disrupt warehouse operations and increase inventory costs. We perform an ABC analysis to address these challenges, classifying packaging materials based on their importance and consumption value. Demand forecasting uses historical data to predict future needs for Category A items, which contribute the most to inventory value. Based on these predictions, the Economic Order Quantity (EOQ) method determines the best order quantities, safety stock levels, and reorder points. This method keeps inventory under control and stops overstocking. The impact of this optimization is measured through a reduction in total inventory cost. For Category B and C items, a different approach is applied. Instead of demand forecasting, inventory control follows the Economic Production Quantity (EPQ) method, which determines appropriate order intervals and maximum stock levels. Additionally, the warehouse layout design is restructured to improve material organization, facilitating a smoother flow of goods. We conduct a simulation-based evaluation to validate these improvements, comparing warehouse conditions before and after the layout redesign. This simulation ensures that the proposed changes lead to shorter movement distances and reduced order-picking times. This study shows a complete and organized way to lower inventory costs and make warehouses more efficient by combining ABC classification, EOQ, and class-based storage optimization. The final stage ensures the proposed system yields measurable operational improvements, contributing to more effective inventory and warehouse management.

## RESULTS

This study utilizes primary and secondary data to optimize inventory management and warehouse layout at PT X. Primary data was collected through direct observations of warehouse operations, including order-picking activities, material handling, and movement patterns. Time studies using Promodel 6.0 simulation software evaluated warehouse efficiency. Secondary data was obtained from company records, including packaging material usage (2021–2023), inventory stock levels, supplier lead times, purchasing policies, and warehouse layout dimensions. ABC analysis classified packaging materials based on consumption value and purchase price (Fazrin & Ludiya, 2023; Noviani et al. 2017). Data was processed using demand forecasting, probabilistic EOQ for Category A items, and periodic review for Categories B and C. We assessed the warehouse layout improvement through simulation, comparing order-picking times and distances before and after implementation. This structured data approach ensures validity, reliability, and replicability for similar industry applications.

### ABC Analysis

ABC classification is carried out on all types of packaging materials owned by PT X. PT X has seven packaging materials, divided into two parts: four types of primary packaging materials and three types of secondary packaging materials. The findings of this study align with those of Nababan et al. (2019), who emphasize the importance of ABC classification in prioritizing high-usage raw materials for inventory management. This research extends the application by incorporating a class-based storage method to enhance warehouse efficiency further. Compared to previous studies, the integration of probabilistic EOQ and ABC analysis in this study provides a more dynamic approach to demand fluctuations, addressing the limitations of traditional inventory methods. The practical implication is a significant reduction in movement distances and order-picking times. In contrast, the theoretical implication supports the effectiveness of hybrid inventory models for optimizing warehouse operations. This study uses buffer stock to ensure continuity of raw material supply in the face of fluctuations in demand and supplier waiting times. ABC analysis in this research will pay attention to the purchase price of packaging materials per piece and the total demand in 1 year, namely 2023. The percentage is obtained by multiplying the demand by the purchase price. The percentage obtained is then sorted from the highest to the lowest rate, and an accumulation calculation is carried out. From the accumulation calculation, the ABC category is divided for each packaging material. Packaging materials with an accumulation of less than 80% are classified into Category A, packaging materials with an accumulation of $80\% \leq x < 95\%$ are classified into Category B, and packaging materials with an accumulation of $\geq 95\%$ are classified into Category C. Overall, there are 119 items of packaging materials in category A, 101 items of packaging materials in category B, and 171 items of packaging materials in category C. The following is Table 1, an example of the calculation of ABC analysis on applicator-type packaging materials.

### Forecasting

Forecasting is done for category A packaging material items of each type that have been previously classified. According to Heriansyah & Hasibuan (2018) and Hermanto et al. (2019), forecasting is only done on packaging materials that are classified as category A because packaging materials in this category require stricter control and attention than packaging materials in categories B and C. Forecasting is done using historical data on the use of these packaging materials in the period 2021 to 2022 to obtain demand forecasts in 2023. After collecting historical data on the use of packaging materials from 2021 to 2022, there are only 43 items that are not involved in demand forecasting because they often experience conditions without demand in 1 month, affecting the forecast's accuracy. Forecasting uses Minitab 17 software to help find a forecasting method based on the data plot with the smallest mean square deviation (MSD) value. All packaging material demand forecasts are listed in Table 2.

Table 1. ABC Analysis of Applicator Packaging Materials

| No | Code | Total Demand (pcs) | Total Cost for Demand (IDR) | Percentage | Cumulative Percentage | ABC Classification |
|---|---|---|---|---|---|---|
| 1 | BK.S.SP001 | 78,839 | 630,712,000 | 37.52% | 37.52% | A |
| 2 | BK.L.KR001 | 94,494 | 519,717,000 | 30.91% | 68.43% | A |
| 3 | BK.L.PE003.2 | 27,273 | 163,638,000 | 9.73% | 78.17% | A |
| 4 | BK.L.PE003.1 | 25,514 | 153,084,000 | 9.11% | 87.27% | B |
| 5 | BK.L.SO001 | 10,398 | 80,584,500 | 4.79% | 92.07% | B |
| 6 | BK.L.NA004.1 | 10,093 | 60,558,000 | 3.60% | 95.67% | C |
| 7 | BK.L.ME009.4<br>BK.L.ME009.3<br>BK.L.ME009.2 | 8,466 | 42,330,000 | 2.52% | 98.19% | C |
| 8 | BK.L.PU001 | 3,449 | 17,245,000 | 1.32% | 99.50% | C |
| 9 | BK.C.PU001 | 3,414 | 6,315,900 | 0.38% | 99.88% | C |
| 10 | BK.L.ME004 | 335 | 2,010,000 | 0.12% | 100.00% | C |
| | Total (IDR) | 1,681,125,400 | | | | |

Table 2. Forecasting Method for Each Packaging Material

| No | Code | Forecasting Method | Notes | MSD Value |
|---|---|---|---|---|
| 1 | BK.T.VI012 | Moving Average | Length 3 | 639,021,236 |
| 2 | BK.T.ME031 | Decomposition | Seasonal only<br>Seasonal length 4 | 449,930,649 |
| 3 | BK.T.PO030 | Decomposition | Trend plus seasonal<br>Seasonal length 10 | 48,069,517 |
| 4 | BK.T.ME026 | Decomposition | Seasonal only<br>Seasonal length 7 | 297,650,316 |
| 5 | BK.T.ME030 | Moving Average | Length 3 | 32,393,130 |
| 6 | BK.T.KL003 | Moving Average | Length 3 | 403,783,033 |
| ... | | | | |
| 76 | BK.X.BX019 | Decomposition | Trend plus seasonal<br>Seasonal length 8 | 25,846 |

**EOQ Probabilistic**

The EOQ calculation focuses on 76 items of category A packaging materials that have gone through the demand forecasting process. The ordering cost in one transaction is in the form of telephone costs to suppliers. The ordering cost for one transaction is IDR10,000/transaction for domestic suppliers and $10/ transaction for import suppliers. The dollar exchange rate used is the average dollar exchange rate in 2023, which is IDR15,240. Regarding storage costs, the company sets a storage cost of 5% per item per year from the purchase price of the item that has been given. The company expects a service level value of 95%, so the z-value used is 1.64. The calculation table using the probabilistic EOQ method is shown in Table 3.

The company considers the optimal ordering obtained too small; for example, an order of 12,000 pcs needs to be bigger for item BK.T.VI012. To meet the demand for this item, the company needs to make purchases 58.76 times in one year, which means purchases are made weekly. Because optimal ordering cannot be implemented in theory, an adjusted order quantity (adjusted Q) is then made. The determination of adjusted Q is based on the decision of the warehouse manager; namely, for packaging material items with a purchase frequency of more than 12 times a year, the order quantity for these items will be adjusted to the lead time from the supplier. The company must be able to meet demand forecasts during the lead time. The safety stock of each packaging material item is obtained by calculating the root of the MSD value.

### Total Cost Comparison

Three conditions will be compared, namely, the initial condition of the company before the improvement, the condition after theoretical improvement, and the condition of improvement after going through readjustment. The theoretical improvement condition uses the results of the optimal ordering calculation (Q*). In contrast, the improvement condition after adjustment will use the results of adjusted Q. The total cost comparison table is shown in Table 4. The smallest total inventory cost is when the improvement condition uses theoretical calculations, IDR26,534,818,905. However, because the company cannot implement theoretical improvements, a recalculation is carried out using adjusted Q, which results in a total inventory cost of IDR26,630,055. This total cost is higher than the total inventory cost with theoretical improvements but lower than the company's initial condition, worth IDR26,809,071,104.17. Improvement with adjusted Q reduced the total storage cost by 9,17%, equivalent to IDR20.964.849. This improvement shows that purchases in the company's initial condition were made on a large scale. Hence, the average item stored was high, which resulted in high storage costs. In addition, the increased order cost in the post-repair condition also supports the previous statement that the company makes purchases with low frequency in 1 year. Still, purchases in one transaction are made on a large scale. Purchases in large quantities in one transaction will minimize order costs, as proven in Table 4, which is an increase of 28.78% in the total order cost of the company's initial condition. However, the total inventory cost decreased by 0.66%, equivalent to IDR 178,215.04.

Table 3. Calculation Table for Category A Packaging Material EOQ Method

| No | Code | Optimal Order (Q*) (pcs) | Frequency | Adjusted Q (pcs) | Frequency | Safety Stock (SS) (pcs) | Reorder Point (pcs) |
|---|---|---|---|---|---|---|---|
| 1 | BK.T.VI012 | 12 | 58.76 | 177 | 3.98 | 20,791 | 197,059 |
| 2 | BK.T.ME031 | 11 | 47.39 | 130 | 4.01 | 17,445 | 147,759 |
| … | | | | | | | |
| 76 | BK.X.BX019 | 1,3 | 4.22 | 1,3 | 4.22 | 77 | 535 |

Table 4. Total Cost Comparison

| Element of Total Cost | Existing Condition | New Condition | New Condition after Improvement with Adjusted Q | Gap between existing and after improvement with Adjusted Q | Percentage Change (%) |
|---|---|---|---|---|---|
| Total Purchasing Cost (IDR) | 26,577,115,000 | 26,439,090,000 | 26,418,490,000 | 158,625,000 | 0.60% |
| Total Ordering Cost (IDR) | 3,402,000 | 17,108,400 | 4,776,800 | -1,374,800 | 28.78% |
| Total Inventory Cost (IDR) | 228,554,104 | 78,620,505 | 207,589,255 | 20,964,849 | 9.17% |
| Total Cost (IDR) | 26,809,071,104 | 26,534,818,905 | 26,630,856,055 | 178,215,049 | 0.66% |

### Warehouse Layout Improvements

The improvement of PT X's warehouse layout uses the class-based storage method, which divides inventory according to the similarity of its type. The arrangement is adjusted to the results of the ABC analysis to determine the type of packaging material located near the warehouse exit. The following is a picture of the initial warehouse layout according to its kind and ABC classification.

In the initial condition, PT X still needs to group the packaging materials in the primary warehouse based on their type. As can be seen in Figure 1, there is a rack arrangement that stores three different types of packaging materials. In addition, on the rack, there is a pot of packaging material, which is a primary packaging material, and is in the wrong place. The company still needs to implement the ABC concept. Several items with Category A are further from the exit when compared to those with Category B and Category C, even though they have the same packaging material.

In the initial condition, the company still stores inner box packaging materials with category A on the rack, even though there are inner box items with category C on the rack that have a shorter distance. Figure 2 shows a picture of the warehouse layout after improvements were made using the class-based storage method.

Improvements using the class-based storage method group the types of packaging materials, and for each type, ABC analysis is carried out to prioritize the packaging materials that will be placed in the area close to the warehouse exit. Grouping the types of packaging materials aims to make it easier for warehouse staff to search for packaging materials. When packaging materials of the same kind are in the same area, warehouse staff can better memorize the location of each type of packaging material. In addition, each packaging material of the same type will also be re-sorted based on the ABC classification to determine the packaging material items that are in the area close to the warehouse entrance and exit. When category A packaging materials with high value or high demand are in an area far from the warehouse entrance and exit, the transfer time and distance of the packaging material will be affected when there is an order-picking activity. When improvements are made, each item of packaging material of the same type will be sorted according to the ABC concept. Category A packaging materials will be prioritized for the area closest to the warehouse entrance and exit.

### Simulation

After improving the layout of PT X's warehouse, a test was conducted to prove that there was a decrease in the distance of movement and time for order-picking activities in the warehouse. Order-picking activities include handling material in the form of hand pallets in each warehouse's outer area. Furthermore, warehouse staff will go to the intended shelf according to the order that has been received. Order picking is done separately between 1 product variant and another. When warehouse staff have taken 1 item, they will go to the warehouse entrance and exit to place the item in the area near the elevator before being lowered together with other items in 1 order. The simulation was carried out with the help of Promodel 6.0 software by comparing the total time and distance of movement required to fulfill the order.

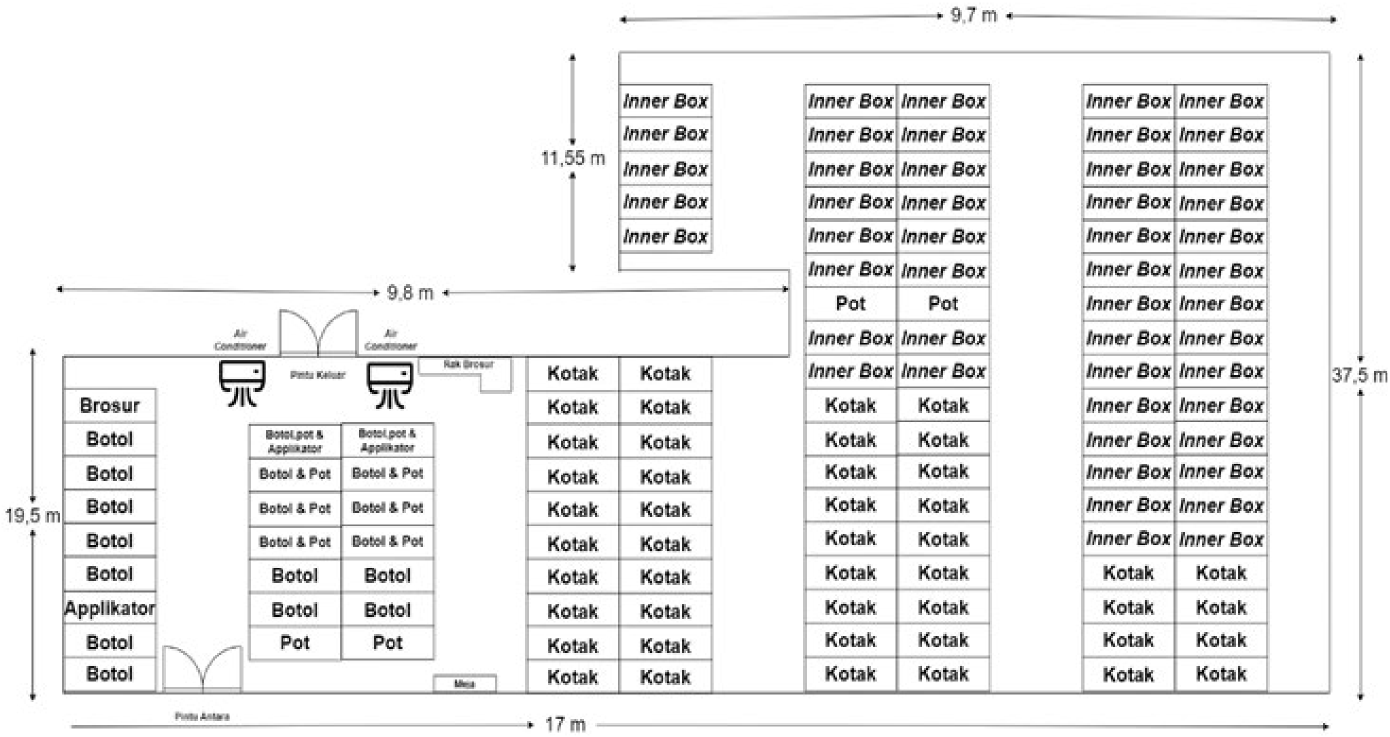


Figure 1. The existing warehouse layout is based on the types

Based on Table 5, improving PT X's warehouse layout has reduced the time and distance of moving from order-picking activities. The time required for order-picking activities has decreased by 21.9% from 19.14 minutes to 14.95 minutes. The decrease is linear with the distance traveled to move packaging materials; there was a decrease of 21.9%, which reduced the distance from 1,469.97 meters to 1,148.03 meters. The reduction in the two components occurred because the packaging materials that had been rearranged followed the ABC concept so that goods with high demand were placed in an area closer to the warehouse entrance and exit, which resulted in the distance of movement and the time required being smaller.

**Managerial Implications**

The results of this study highlight the practical benefits of structured warehouse management and inventory optimization. From the management's point of view, using a class-based storage system and placing items in the best way possible based on ABC classification helps businesses run more efficiently and avoid delays in the warehouse. The 21.9% reduction in order-picking time and movement distance directly translates into faster order fulfillment, reduced labor fatigue, and improved warehouse productivity. Additionally, lower movement distances reduce wear and tear on material handling equipment, decreasing maintenance costs over time.

Also, using simulations to test changes before implementing them in real life is a data-driven way to make decisions that lower risks and raise efficiency. Managers can utilize this methodology for continuous improvement in warehouse operations, adjusting layouts as demand patterns evolve. Lastly, these results show how important it is to keep track of inventory and use space efficiently to cut down on operational costs. Other manufacturing and distribution companies facing similar warehouse management issues can easily apply this method.

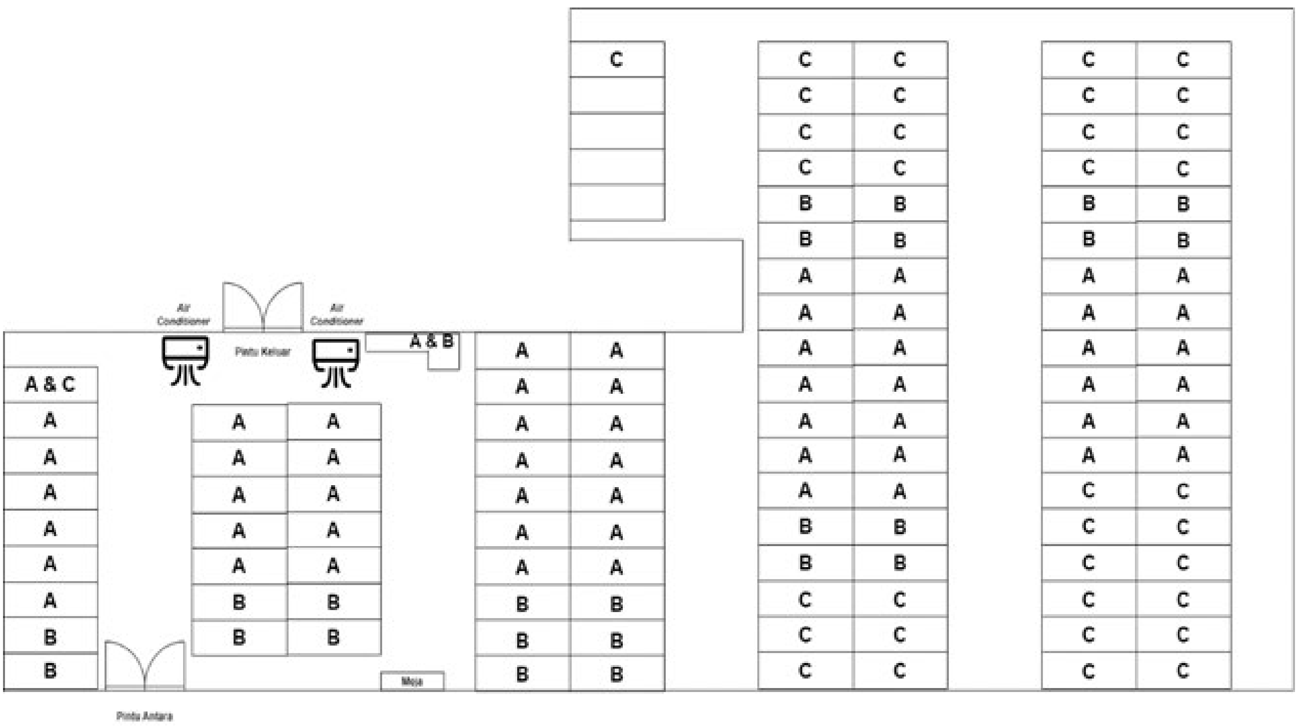


Figure 2. The new warehouse layout is based on the ABC method

Table 5. Comparison Table of Total Time and Distance of Order Picking Activities

| | Existing Warehouse Layout | New Warehouse Layout | Gap | Gap percentage |
|---|---|---|---|---|
| Time (minutes) | 19.14 | 14.95 | 4.19 | 21.9% |
| Distance (meters) | 1,469.97 | 1,148.03 | 321.94 | |

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

This study optimized PT X's inventory system using a dual-method approach: the probabilistic EOQ method for Category A items and the periodic review method for Categories B and C. Applying the probabilistic EOQ for Category A items effectively reduced inventory costs by 0.66%, from IDR 26,809,071,104.17 to IDR 26,630,856,055. Additionally, the class-based storage method enhanced warehouse layout by grouping packaging materials by type and organizing them sequentially according to ABC classification, leading to a more efficient order-picking process. The improved layout reduced order-picking time by 21.9%, from 19.14 minutes to 14.95 minutes, and decreased movement distance by 21.9%, from 1,469.97 meters to 1,148.03 meters. These results directly address the study's objective of minimizing inventory costs and optimizing warehouse efficiency.

This research's main contribution lies in integrating probabilistic EOQ and class-based storage systems, demonstrating their combined effectiveness in reducing costs and enhancing operational productivity. This hybrid approach offers a flexible inventory management framework that adapts to demand fluctuations while maintaining cost efficiency, thus advancing inventory control strategies in the pharmaceutical industry.

This study recommends that PT X continue to use the probabilistic EOQ model for Category A items due to its effectiveness in minimizing costs while maintaining optimal stock levels. For Categories B and C, the periodic review method is recommended to streamline order frequencies and reduce overstocking. Additionally, the implementation of class-based storage should be regularly evaluated and adjusted based on product demand patterns to maintain order-picking efficiency. Warehouse managers should also consider staff training on the new layout system to maximize productivity and reduce order-picking time.

Overall, this study provides a strategic framework for inventory and warehouse management, contributing to cost efficiency, productivity enhancement, and improved decision-making processes in the pharmaceutical supply chain.

### Recommendations

Recommendations for further research include evaluating the demand forecasting method, such as machine learning, to improve forecasting accuracy. In addition, an evaluation of ordering from suppliers using the multi-item single supplier method is needed to reduce ordering costs because various variants of packaging material items are ordered in one transaction.

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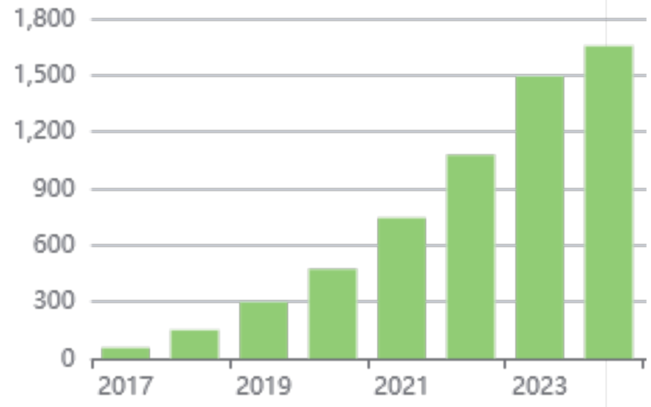


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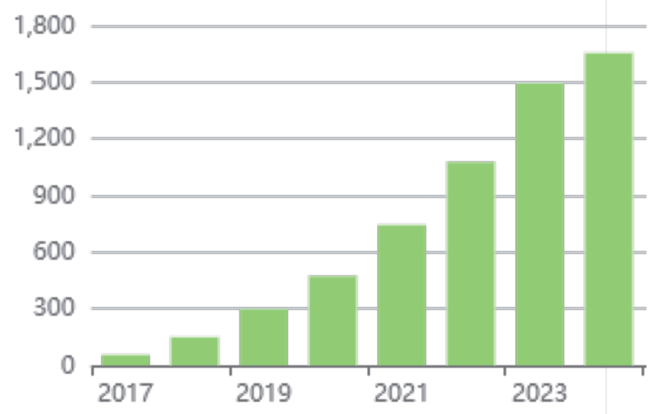


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