

Analysis of Factors Affecting Medication Stock-Out Times Using Cox Proportional Hazards Regression at PT Megah Tetap Sakti

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Abstract.

Drug inventory management is a crucial aspect in pharmaceutical distribution companies because it directly relates to the smooth running of healthcare services and the company's sales performance. One of the main problems that often occurs is drug stockouts, which can disrupt the distribution process and reduce customer satisfaction levels. This study aims to analyze the factors that influence drug stockout times at PT. Megah Tetap Sakti using the Cox proportional hazards regression method. This study uses secondary data obtained from the company's drug inventory records for a certain period. The dependent variable in this study is drug stockout times, while the independent variables include sales volume, drug price, discount, drug type, and supplier. Data analysis begins with descriptive statistics, Kaplan-Meier estimation, log-rank tests, and Cox proportional hazards regression. The results show that the discount variable is the most dominant factor influencing the risk of drug stockouts. Increasing discounts tend to accelerate stockouts due to increased demand. This study is expected to be a consideration for companies in formulating more effective and efficient drug stock management strategies.

Keywords: *Survival analysis, Kaplan-meier, Drug stock out and Proportional hazards regression.*

I. INTRODUCTION

Drug inventory management is a crucial aspect of the pharmaceutical industry worldwide. Stable drug availability ensures the smooth running of healthcare services. Conversely, stock instability can disrupt the supply chain and negatively impact healthcare services. One analytical method used to understand the factors influencing the duration of stock availability is Cox proportional hazards regression. This method allows for the identification of significant variables without requiring specific distribution assumptions for time-series data (Ferdiansyah et al., 2024).

In Indonesia, drug inventory management still faces various challenges, including fluctuating demand and limited distribution infrastructure. Applying appropriate analytical methods can help address these issues by providing in-depth insight into the factors influencing drug stock availability. The application of Cox proportional hazards regression allows companies to segment

Products are classified based on their risk of stockouts. High-risk products can be prioritized in procurement and distribution, while low-risk products can be managed with different strategies (Diponegoro et al., 2014). This method has been applied in various fields to analyze time-to-event data. For example, in healthcare, this method is used to analyze patient survival time.

The application of this method to drug inventory management in Indonesia is still rare. However, this analysis can provide valuable insights for companies in designing more effective and efficient inventory management strategies (Hilman & Budiarty, 2022).

This analysis can be used to evaluate the effectiveness of marketing strategies. For example, if a certain promotion increases demand for a drug, this will be reflected in the duration of stock availability. This allows companies to assess the impact of various marketing initiatives on inventory management. In the long term, implementing this analysis can improve customer satisfaction. Consistent and timely drug availability will increase customer trust in the company, which ultimately can increase loyalty and revenue (Fuadi et al., 2024). It's important to note that implementing Cox proportional hazards regression requires accurate and complete data. Incomplete or biased data can result in invalid models. Therefore, companies must ensure that data collection and recording systems are running smoothly. Furthermore, the interpretation of analysis results must be done carefully. Although the model can identify significant factors, management decisions must consider the operational context and overall business strategy (Diponegoro et al., 2014).

II. METHODS

Experimental (or Materials and Methods)

This research was conducted in September 2024 until the research was completed and the research location was at Jl. Duyung No.49C 109, Pandau Hulu II, Medan Area District, Medan City, North Sumatra 20233. This research was conducted at PT. Megah Tetap Sakti, a company engaged in the distribution of drugs and pharmaceutical products. The research was conducted in the period of September 2024 until completion. This research focuses on data related to drug stock available in the warehouse and drug stock-out times in pharmacies that are regular customers of the company.

The research used in this study is descriptive analytical research with a quantitative approach. According to Sugiy Ono (2017), descriptive research is a type of research that aims to determine the value of one or several variables (independent variables) without making comparisons or looking for relationships with other variables. According to Sugiyono (2017), a quantitative approach is a research method based on positive thinking, typically used in research on specific populations or samples. Data are collected using research instruments and analyzed quantitatively or statistically to test established hypotheses.

The purpose of this study was to analyze the factors influencing drug stock-out time using the Cox proportional hazards regression technique. This study not only describes the phenomena that occur but also identifies the relationship between existing variables (Savitri, 2022). The data sources used in this study are secondary data obtained from documents on discounts, prices, drug types, and restock history. The data used in this study are data from January to December 2024, which are considered sufficient to describe existing patterns related to factors influencing stock-outs.

III. RESULTS AND DISCUSSION

This study aims to analyze the factors that most influence drug stockouts at PT. Megah Tetap Sakti using the Cox proportional hazards regression method. It also presents an overview of the data used in the study, both in terms of the number of data and variable characteristics. The data used consists of 82 observations (drug data) over a certain period of time. The data used in this study were obtained from PT. Megah Tetap Sakti, which operates in the field of drug distribution. The data covers a period of 1 year, with data coverage including drug type, initial stock amount, stockouts, and other factors such as discounts, prices, suppliers, drug types (generic, syrup, tablets, capsules, powders, etc.), and the time calculated in days until the drug runs out. The selection of variables in this study is based on the main problem faced by PT. Megah Tetap Sakti, namely the occurrence of drug stockouts that impact the company's services and operations. Therefore, the researcher refers to inventory management theory and several previous studies to determine factors suspected of influencing the time to drug stockouts. Several factors were selected for the following reasons:

1. Beginning stock, incoming stock, outgoing stock, and ending stock: These four variables represent the dynamics of drug inventory, reflecting the pattern of incoming and outgoing goods. Beginning stock indicates the availability of drugs at the beginning of the period, incoming stock is the number of additions, outgoing stock reflects the level of demand/spending, and ending stock indicates remaining stock. These variables are often used in inventory management analysis to identify stockout trends.
2. Discounts are a sales strategy that can increase demand for certain medications. Offering substantial discounts can encourage increased demand, thereby shortening the time it takes to sell out. Therefore, this variable is considered an influential factor.
3. Price: The price variable is transformed into a logarithm to achieve a more normal distribution. Drug prices can influence demand; more expensive drugs tend to be purchased in smaller quantities, which can extend the shelf life of stocks.
4. Drug type: Drug types (e.g., syrup, tablets, capsules) have different characteristics in terms of storage, demand, and expiry times. Therefore, it is important to include drug type as a categorical variable in the model.
5. Different suppliers have varying levels of delivery reliability. This variable is important to analyze

because it can affect the frequency of stock arrivals and the speed at which drugs are depleted. To provide an overview of the data structure before transformation and further analysis, the initial research data before transformation is presented below.

No	Drug Name	Beginning Observation	End Observation	Time Finished	Status
1	Unibebi Fever 60 ml	January 1, 2024	10-Aug-2024	222	1
2	Doen Antacid 60 ml	January 1, 2024	June 5, 2024	156	1
3	Unicetamol Syrup	January 1, 2024	July 18, 2024	199	1
4	Antacid 100's	January 1, 2024	December 31, 2024	365	0
5	Unibebi Cough Syrup 60 ml	January 1, 2024	5-Oct-2024	278	1
6	Unidryl	January 1, 2024	21-Oct-2024	294	1
7	Glynasin Syrup 60ml	January 1, 2024	28-Sep-2024	271	1
8	Lactas 100 tablets	January 1, 2024	December 11, 2024	345	1
9	Tower Five 12'S	January 1, 2024	December 31, 2024	365	0
10	Mentasin 110 ml	January 1, 2024	10-Dec-2024	344	1
...	...	...	...	...	...
82	NATUR-E 32's [GREEN]	January 1, 2024	December 31, 2024	365	0

No	Type Drug	S.awal	S.enter	S.out	S.akhir	Discount	Price	Supplier
1	syrup	0	0	0	0	0	3485	Universal
2	syrup	0	0	0	0	0	2460	Universal
3	syrup	0	0	0	0	0	2890	Universal
4	capsule	0	7500	7310	190	0	7727	Universal
5	syrup	0	0	0	0	0	4432	Universal
6	syrup	0	0	0	0	0	2818	Universal
7	syrup	0	0	0	0	0	3545	Universal
8	tablet	0	3900	3900	0	0	5909	Universal
9	capsule	7318	23500	30022	796	10	22972	Universal
10	syrup	0	0	0	0	0	5758	Universal
...	...	...	...	...	...	...	...	...
82	Capsule	0	48	44	4	10	28874	Balatif

The table above displays some of the raw data from the total data used in the study. The data consists of several important variables: drug name, drug type, initial stock, incoming stock, outgoing stock, final stock, price, discount, supplier, and stock-out date. This data presentation aims to provide readers with an initial overview of the structure of the analyzed data and the background to the need for transformation before the data can be entered into the Cox proportional hazards regression model.

One concern is the difference in scale and units between variables. For example, the initial, incoming, outgoing, and final stock variables are measured in square units, the price variable is measured in rupiah, and the discount variable is measured in percentage. These differences in scale have the potential to cause problems in the analysis process, especially in multivariate statistical models such as Cox regression, which are sensitive to variable scale. If not normalized, variables with large scales (e.g., prices in thousands of rupiah) can dominate the model and obscure the influence of other variables with smaller absolute values. In addition, there are categorical variables such as drug type and supplier, which cannot be directly analyzed in text form. These variables need to be converted into numerical form through a dummy coding process to be accepted into the regression model. To do this, the following transformation is performed:

1. Numerical variables (initial stock, in, out, ending, discount) were transformed using Z-scores to have a

mean of zero and a standard deviation of one, so that the scales between variables were equal.

2. The price variable was transformed using natural logarithms to address non-normal data distribution and reduce the influence of extreme values.

3. The drug type and supplier variables are coded using categorical numeric coding, namely by giving a number to each category as a label, for example drug type: capsules = 1, tablets = 2 = 2, syrup = 3; and supplier: Balatif = 1, Universal = 2, Darya = 3. This coding aims to allow categorical variables to be entered into the cox regression model as numeric categorical variables, without providing order or value between categories.

By carrying out this transformation process, all data are ready for statistical analysis using Cox proportional hazards regression. This transformation is important to maintain model validity, improve estimation accuracy, and ensure that the influence of each variable on the risk of drug stockouts can be measured fairly and proportionally. Based on the results of the analysis using Cox proportional hazards regression with the forward likelihood ratio (forward LR) method, it was found that of the four independent variables analyzed, namely Initial Stock Zstok, Incoming Stock Zstok, Outgoing Stock Zstok A, and Discount Zstok, only Discount Zstok was proven to have a significant influence on the time of occurrence of the event in this study.

The Discount Zstok variable entered the final model with a significance value (p-value) of 0.000, indicating that this variable is statistically very significant. The negative regression coefficient value on Discount Zstok and the Exp(B) value of 0.379 indicate that each one standard unit increase in Discount Zstok reduces the risk (hazard) of the event by 62.1%. In other words, the greater the discount value given, the smaller the chance of an event occurring (for example: running out of stock, or a short sales duration), which indicates that

Discounts have a protective effect in the context of the time variable. The results of the chi-square loss test also confirm that the presence of the variable Zdiscount is very important in the model. If this variable is removed, the model loses significant predictive power with a loss value of 31.795 and $p = 0.0004$, which confirms that Zdiscount is a dominant variable that cannot be ignored. Meanwhile, other variables, namely Initial Zstock, Incoming Zstock, and Outgoing Zstock A, were not included in the final model because they did not meet the specified significance criteria ($p > 0.05$). This indicates that these variables do not make a significant contribution in explaining the time variable in the context of this study.

IV. CONCLUSION

Based on the results of data analysis using the Cox proportional hazards regression model and the forward likelihood ratio (forward LR) variable selection method, several important things can be concluded that directly answer the objectives of this study:

6. The use of the Cox Proportional Hazards Regression Model This study successfully proved that the Cox Proportional Hazards Regression Model is an appropriate and accurate analytical tool for measuring and predicting the duration of drug stockouts at PT. Megah Tetap Sakti. With this approach, researchers can analyze the relationship between several independent variables and the time of an event, namely stockouts. The Cox model is semi-parametric, which allows for estimating the hazard ratio of each variable without the need to make special distribution assumptions regarding the time of the event. This makes it suitable for real cases such as stock management, which may have irregular or non-normal time data characteristics. In addition, the use of the Forward LR method in the variable selection process shows its superiority in identifying truly significant and dominant variables, so that the model results become more efficient.

7. Factors that most influence drug stock-out time Of the four variables tested in the model (Initial Stock Z, Incoming Stock Z, Outgoing Stock Z, and Discount Z), only Discount Z was proven to be statistically significant in influencing the duration of drug stock-outs. This is indicated by a significance value of 0.000 and an Exp(B) value of 0.379, which means that the higher the discount given, the longer the stock-out time, or in other words, discounts can extend the product life cycle on the shelf or regulate consumer purchasing patterns more efficiently. The other variables were not included in the final model because they had

significance values that exceeded the threshold ($p > 0.05$), so they did not have a strong enough influence on the model. Thus, discounts are the main factor that has the most influence in determining the stock-out time in the company.

8. Implications of the results for drug stock management The finding that discounts are a dominant factor has very important practical implications for PT. Megah Tetap Sakti. Management can use this information to develop more efficient, data-driven promotional, procurement, and stock rotation strategies. The implication is that the company can implement strategic discount policies to control the speed of stock movement. Furthermore, discounts are not only a marketing tool, but also a logistics and supply chain control tool, as they have been shown to affect stock-out times. The stock management system can be improved by incorporating discount variables into an analytical-based stock monitoring or forecasting system. Overall, the results of this study not only provide theoretical contributions regarding the use of survival models in business, but also practical contributions to the Company's operational and marketing strategies.

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