Designing Hospital Inventory Control System Using Continuous and Hybrid Method To Minimize Total Inventory Cost

S F Basalamah[1,2], **A Y Ridwan**[1,3] **and H K Pambudi**[1,4]

[1]School of Industrial and System Engineering, Telkom University, Bandung, , West Java, Indonesia
[2] basalamah@student.telkomuniversity.ac.id , [3] ariyanuar@telkomuniversity.ac.id,
[4] hkpambudi@telkomuniversity.ac.id

Abstract. JAT Hospital is one of the privately owned hospitals located in Bekasi, West Java. In serving the people who seek treatment, the hospital has several installations, one of which is a pharmaceutical installation. Pharmaceutical installations serve to provide medical devices or medicines needed in other installations. The problem found in the pharmaceutical installation of JAT Hospital is the occurrence of overstocked drug supplies in the storage of the pharmacy installation. The occurrence of an excess supply of medicines is caused by the absence of a policy in ordering the amount to be purchased and when to purchase it. To deal with this problem, an analysis was carried out using ABC-VED analysis so that drugs can be grouped into three categories that can calculate the optimal inventory policy. Furthermore, an optimal inventory policy is carried out using probabilistic continuous review methods and a hybrid system to determine inventory policies. From the calculation results using continuous review, it resulted in a total proposed cost of IDR 124,552,596.05 or savings of 75% and in the hybrid system method it can save by 75% or IDR 20,442,011.72. Furthermore, from the results of the policy, an information system was created for monitoring supplies in hospitals.
Keywords: ABC-VED Classification, Probabilistic continuous review, Hybrid System, Drug, Overstock

1. Introduction

A hospital is a health care institution that organizes comprehensive individual health services that provide inpatient, outpatient, and emergency services. In improving the quality of hospital health services, it is supported by several installations, one of which is the pharmaceutical installation. The pharmaceutical installation is an important functional unit in organizing the provision of drugs needed by several other installations [1].

Inventory is an idle resource waiting for the production activity process such as in manufacturing systems, distribution of goods, office supplies, and in households [2]. With this definition of inventory, it is a resource owned by the company that is waiting for the next process.

JAT Hospital is a privately owned hospital that has a type C class, which is located in Bekasi, West Java. The hospital has a grouping of goods in the warehouse, such as consumables, pharmaceutical drugs, and non-drug pharmaceuticals / medical devices. The pharmaceutical drug category has a greater number of items compared to the consumables category or the non-drug

pharmaceutical category. By facing the condition of inventory of pharmaceutical drugs in hospitals that are overstocked every month due to the number of purchases, there are no provisions and items that must be stored for each drug.

From the data taken at the Pharmacy Installation, the actual amount of inventory is higher than the amount of inventory that can be accommodated by the hospital with an average of 38% in 1 year. With the high inventory accommodated by the hospital, the hospital incurs additional costs of 37% of the budget. With so much inventory in excess, the cost of inventory issued is higher than the available budget [3]. Hospitals can determine the classification using ABC-VED analysis in order to facilitate the separation of handling and prioritization of drugs, then determine the optimal inventory policy using continuous review (s, S) on category I drugs and hybrid systems on category II drugs and category III drugs.

2. Methods

2.1. Inventory

Inventory is an idle resource waiting and ready for further use. Its use can be in the form of production activities in manufacturing systems, distribution activities, provision of office supplies, or in households [2]. With idle resources, the cost of inventory is affected. The affected inventory costs include ordering costs, storage costs, and shortage costs [2]. With inventory costs affected, inventory management is very important for hospitals [4]. In medicine inventory control, if we have a static inventory, it only requires one order. And if you have a dynamic inventory, then replenishing medicines requires more than one order. From inventory control, inventory can be statistically characterized as uncertain inventory control, certain inventory control, and risk inventory control.

2.2. ABC-VED Classification

ABC-VED classification is a combination of ABC analysis with VED analysis that can make inventory control more efficient and effective [5]. The combined ABC-VED analysis is very suitable for drug inventory control in hospitals because there is a classification based on the time criticality of drug administration and the importance of drugs to patients [6]. With the combination of ABC analysis and VED analysis, 9 sub categories were obtained, which are: AV, AE, AD, BV, BE, BD, CV, CE, and CD [5]. The following are the steps in classifying using ABC-VED analysis.

    a. Calculating ABC analysis.
    b. VED classification questionnaire filled out by experts.
    c. Create a combination matrix of ABC analysis and VED analysis.

2.3. Probabilistic Inventory Control

Probabilistic inventory control is a model that does not know when the arrival and quantity of goods are coming, but can be predicted through the distribution of the expected value [7]. In probabilistic inventory control, there are decision variables including [8]:

    a. The size of the economical order quantity (q)
    b. When re-order is done (s)
    c. The size of the safety stock (ss)

2.4. Continuous Review

The continuous review method is a control method for this type of inventory with uncertainty [9]. The uncertainty is the amount of demand that is fluid over time but has a certain pattern [2]. The following are the inventory cost components for continuous review.

1. Order Cost

   The cost of the order (Op) is influenced by the number of items ordered (D), the cost of each order (A) and order lot size (q_0) .

   $$Op = \frac{AD}{q_0} \qquad (1)$$

2. Holding Cost

   The cost of storage (Os) is affected by the number of items stored with the cost of storing (h) the item in one period.

   $$Os = h \left(\frac{q}{2} + r - (DL)\right) \qquad (2)$$

3. Shortage Cost

   Shortage costs (Ok) are only possible during the out-time period and shortages occur when the demand amount is the demand amount during the out-time.

   $$Ok = (C_u DN)(q_0)^{-1} \qquad (3)$$

   Where:
   C_u : Shortage Cost per item
   N : The amount of inventory shortage each cycle

2.5. Hybrid System

The hybrid system method can be used if the inventory has reached the purchase point (s) but has not yet reached the purchase time. If the inventory is still there until the purchase time, the manager can order goods up to the maximum storage point [10]. The benefits of using this hybrid system can reduce costs and the amount of inventory handled compared to the previous policy (periodic policy) [11].

2.6. Hadley-Within Model

The Hadley-Within research solution is to determine the number of message lot sizes $(q_0{}^*)$ and reorder points (r^*). The analysis using Hadley-Within follows the following way [2].

1. Calculating the value of $q_{01}{}^* = q_{02}{}^*$ with Wilson formula.

   $$q_{01}^* = q_{02}^* = \left(\frac{2AD}{h}\right)^{1/2} \qquad (4)$$

2. Based on the $q_{01}{}^*$ value obtained, we will look for the possibility of an inventory shortage of α and after that calculate using the following formula:

   $$\alpha = \frac{h\,q_0}{CuD + hq_0} \qquad (5)$$

   $$r_1^* = D_L + Z_\alpha SL^{1/2} \qquad (6)$$

3. With the known $r_1{}^*$ obtained, it can calculate the value of $q_{02}{}^*$ by using the following equation:

   $$q_2 = \left(\frac{2D[A + Cu \times S_L[f(Z_\alpha) - Z_\alpha \Psi(Z_\alpha)]}{h}\right)^{1/2} \qquad (7)$$

4. Recalculate the values of α and $r_2{}^*$ with the equation (6).

5. After that, compare the results between the values of $r_1{}^*$ and $r_2{}^*$, if $r_2{}^*$ is the same as $r_1{}^*$ then the iteration is complete. If not, then the iteration continues using $r_1{}^*$ as $r_2{}^*$ and $q_1{}^*$ as $q_2{}^*$.

6. Calculating inventory policy
    a. Maximum Inventory Level (S)
    $$S = q_0 + r \qquad (8)$$
    b. Safety Stock (ss)
    $$ss = Z_\alpha S L^{1/2} \qquad (9)$$
    c. Total Inventory Cost (OT)
    $$OT = O_p + O_s + O_k \qquad (10)$$

3. Result and Discussion

3.1. ABC-VED Classification

By doing ABC analysis and VED analysis on drugs, it produces 9 sub-categories that can be made into a combination matrix of ABC analysis and VED analysis [5]. The following is a combination matrix of the two analyses.

Table 1. Combination ABC - VED

ABC-VED		Group		
		V	E	D
Group	A	149	19	1
	B	188	30	9
	C	339	101	98

Table.1 shows the combined results of ABC analysis and VED analysis. Furthermore, the analysis is grouped into 3 categories, namely drug category I with classes AV, AE, AD, BV, and CV. For drug category II is BE, BD, and CE, and the last for drug category III is CD. The following are the results of the three groups.

Table 2. The Result of ABC-VED

Category	Items	% Items	Total Sales	% Total Sales
I	696	75%	IDR 3,247,233,837	96%
II	140	15%	IDR 115,009,192	3%
III	98	10%	IDR 23,413,739	1%
Total	934	100%	IDR 3,385,656,768	100%

From the grouping results, it is known that category I drugs with a total of 696 items, category II drugs with 140 items, and category III drugs with 98 items. After the ABC-VED classification, proceed with the calculation of each cost using continuous review on category I medicines and hybrid systems on category II medicines and category III medicines.

3.2. Continuous Review (s, S)

For the calculation of continuous review, category I drugs are used, where category I drugs have the largest absorption rate of funds and a high level of criticality. The following is one of the calculations for category I drugs, namely Hepatitis B Biofarma.

Table 3. Hepatitis B Biofarma Data

Demand (D) = 509	Order Cost (A) = IDR 5,000
Standard Deviation (S) = 8.753787059	Holding Cost (h) = IDR 17,321
Leadtime (L) = 0.00273972602	Shortage Cost (Cu) = IDR 29,979

1. The first step is to find the value of N, but it is known that the service level (SL) value of the hospital is 95%.

   $$Service\ Level\ (\eta) = 1 - \frac{N}{D_L} x\ 100\%$$

   $N = (1 - \eta)\ x\ DL$
   $N = (1 - 0.95)\ x\ DL$
   $N = 0.069726$

2. Calculate value of q_0.

   $$q_0{}^* = (\frac{2D[A + Cu\ N]}{h})^{1/2}$$

   $q_0{}^* = 12$

3. Determine the value of the possible inventory shortage (α) and the Z value.

   $$\alpha = \frac{h\ q_0{}^*}{CuD + h\ q_0{}^*}$$

   $\alpha = 0.01$, dengan $Z_\alpha = 2.21$

4. Calculate value of $r_0{}^*$.

   $r_0{}^* = DL + Z_\alpha S\sqrt{l}$
   $r_0{}^* = 3$

5. Determine the maximum inventory level and safety stock.

   $S = r^* + q^* = 3 + 12 = 15$
   $ss = Z_\alpha S\sqrt{l} = 2$

6. Calculate the total cost inventory.

   a. Order Cost

   $$Op = \frac{A\ x\ D}{q_0{}^*} = \frac{IDR\ 5,000\ x\ 509}{12}$$

   $Op = IDR\ 212,083.33$

   b. Holding Cost

   $$Os = h\ x\ \left(\frac{q_0{}^*}{2} + r - (D\ x\ L)\right)$$

   $Os = IDR\ 131,739.99$

   c. Shortage Cost

   $$Ok = Cu\ x\ (\frac{D\ x\ N}{q_0{}^*})$$

   $Ok = IDR\ 40,923.20$

   d. Total Cost

   $OT = Op + Os + Ok$
   $OT = IDR\ 432,490.24$

3.3. Hybrid System

For the calculation of the hybrid system, category II & III drugs are used, where category II & III drugs have a moderate consumption rate. The following is one of the calculations for category II drugs and category III drugs, namely Analsik Tab.

Table 4. Analsik Tablet Data

Demand (D) = 1776	Order Cost (A) = IDR 5,000
Standard Deviation (S) = 50.27	Holding Cost (h) = IDR 414.70
Leadtime (L) = 0.00273972602	Shortage Cost (Cu) = IDR 558.25

1. The first step is to find the value of N, but it is known that the service level (SL) value of the hospital is 90%.

$$Service\ Level\ (\eta) = 1 - \frac{N}{D_L} x\ 100\%$$

$N = (1 - \eta)\ x\ D\ x\ L$

$N = (1 - 0.90)\ x\ DL$

$N = 0.486575$

2. Calculate value of q_0 .

$$q_0{}^* = (\frac{2D[A + Cu\ N]}{h})^{1/2}$$

$q_0{}^* = 49$

3. Determine the value of the possible inventory shortage (α) and the Z value.

$$\alpha = \frac{h\ q_0{}^*}{CuD + h\ q_0{}^*}$$

$\alpha = 0.02$, dengan $Z_\alpha = 2.05$

4. Calculate value of $r_0{}^*$.

$r_0{}^* = DL + Z_\alpha S\sqrt{l}$

$r_0{}^* = 11$

5. Determine the maximum inventory level and safety stock.

$S = r^* + q^* = 11 + 49 = 60$

$ss = Z_\alpha S\sqrt{l} = 6$

6. Determine Interval Order (T)

$$T = \frac{q^*}{D} = \frac{49}{1776} = 0.0276$$

$T = 11$ days

7. Calculate the total cost inventory.

   1. Order Cost

$$Op = \frac{A}{T} = \frac{IDR\ 5,000}{0.0276}$$

$Op = IDR\ 181,224.49$

   2. Holding Cost

$$Os = h\ x\ \left(R - DL + \frac{DT}{2}\right)$$

$Os = IDR\ 33,024.32$

   3. Shortage Cost

$$Ok = Cu\ x\ (\frac{D\ x\ N}{q_0{}^*})$$

$Ok = IDR\ 9,845.23$

   4. Total Cost

$OT = Op + Os + Ok$

$OT = IDR\ 224,094.04$

3.4. Cost Calculation

To get the minimization of the total inventory cost, a calculation is made first to the previous total inventory cost. The total cost of the proposed inventory is obtained from the optimal inventory policy using the method [12]. If the total cost of the proposed inventory is smaller than the budget and the total cost of the previous inventory, then it can be said that the total cost of the proposed

inventory is successful and the inventory policy can be used. Below is the table that shows the summary of total inventory costs from all medicines.

Table 5. Total Inventory Costs Summary

Medicine	Order Cost (Op)	Holding Cost (Os)	Shortage Cost (Ok)	Total Cost
ACARBOSE 100 MG	IDR 88,129.87	IDR 110,192.27	IDR 11,469.44	IDR 209,791.58
ACARBOSE TAB 50 MG	IDR 259,975.37	IDR 42,205.18	IDR 28,365.10	IDR 330,545.65
.	.	.	.	.
ZINKID SYR	IDR 15,000.00	IDR 22,675.21	IDR 38.84	IDR 37,714.04
ZITHROMAX INFUS 500 Mg/Vial	IDR 5,000.00	IDR 153,290.33	IDR 6.47	IDR 158,296.79
Total	IDR151,426,775	IDR 30,857,126	IDR 7,975,005	IDR190,258,908

3.5. Dashboard Monitoring

The results of the design of the inventory policy can display data visualization using a monitoring system through Microsoft Excel software. The data displayed is in the form of bar charts and timeseries to monitor the number of outgoing and incoming goods. The data that is also displayed is the amount of drugs in each category and the investment value. The following is a view of the Dashboard page for the monitoring process.

Figure 1. Dashboard Page Display

4. Conclusions

Based on the research conducted with the continuous review method (s, S) on category I drugs and the hybrid system method for category II and III drugs, it can be concluded from the proposed inventory policy as follows:

1. Calculation with the continuous review (s, S) method for category I drugs resulted in savings of 75% of the total inventory cost of the previous condition. In the previous condition, the total inventory cost was IDR 507,472,121.73 and decreased by IDR 382,919,525.68 until the total cost of inventory proposed using continuous review (s, S) reached IDR 124,552,596.05. These changes are caused by order costs, storage costs, and shortage costs.

2. Calculation with the hybrid system method for category II & III drugs resulted in savings of 57% of the total inventory cost of the previous condition. In the previous condition, the total inventory cost was IDR 47,606,929.20 and decreased by IDR 27,164,917.48 until the total cost of the proposed inventory using continuous review (s, S) reached IDR 20,442,011.72. These changes are caused by order costs, storage costs, and shortage costs.

3. Based on the calculation of the proposed inventory policy using the continuous review (s, S) method and the hybrid system, the hospital can minimize the total inventory cost by 69% or IDR 428,422,036 of the previous total inventory cost.

5. References

[1] Permenkes RI, "Klasifikasi dan Perizinan Rumah Sakit," *Implement. Sci.*, vol. 39, no. 1, pp. 1–15, 2020, [Online]. Available: https://peraturan.bpk.go.id/Home/Details/152506/permenkes-no-3-tahun-2020.

[2] S. N. Bahagia, *Sistem Inventori*. Bandung: Institut Teknik Bandung, 2006.

[3] P. Mely Permatasari, A. Yanuar Ridwan, and B. Santosa, "Inventory Policy Determination for Raw Materials in ILY Pharmaceutical using Periodic Review (R, s, S) and Periodic Review (R, S) Method to Minimize Total Inventory Cost," *MATEC Web Conf.*, vol. 135, pp. 1–6, 2017, doi: 10.1051/matecconf/201713500056.

[4] A. Maulaya, A. Ridwan, and B. Santoso, "Spare Part Inventory Policy Planning based on FRMIC (Fuzzy-Rule-based approach for Multi-Criteria Inventory Classification) using Base-Stock Policy Method (S-1, S)," vol. 173, no. Icoemis, pp. 260–267, 2019, doi: 10.2991/icoemis-19.2019.36.

[5] Z. Ceylan and S. Bulkan, "Drug Inventory Management of a Pharmacy using ABC and VED Analysis," *Eurasian J. Heal. Technol. Assess. Corresp. Author Zeynep CEYLAN*, vol. 2, no. 1, pp. 13–18, 2017.

[6] F. A. Fathoni, A. Y. Ridwan, and B. Santosa, "Development of Inventory Control Application for Pharmaceutical Product Using ABC-VED Cycle Counting Method to Increase Inventory Record Accuracy," vol. 2, no. IcoIESE 2018, pp. 0–5, 2019, doi: 10.2991/icoiese-18.2019.47.

[7] E. Fatma and D. S. Pulungan, "Analisis Pengendalian Persediaan Menggunakan Metode Probabilistik dengan Kebijakan Backorder dan Lost sales," *J. Tek. Ind.*, vol. 19, no. 1, p. 38, 2018, doi: 10.22219/jtiumm.vol19.no1.40-51.

[8] D. J. T. Edward A. Silver, David F.Pyke, *Inventory and Production Management in Supply Chains*, Fourth., vol. 4, no. 1. Taylor&Francis, 2016.

[9] N. K. C. Wahyuni, A. Y. Ridwan, and ..., "Penetuan Kebijakan Persediaan Auto Part Menggunkan Metode Continuous Review (s, S) Untuk Meningkatkan Service Level Dan ...," *J. Ind. ...*, vol. 3, no. 2, 2018.

[10] V. Gaspersz, *PRODUCTION PLANNING AND INVENTORY CONTROL Berdasarkan Pendekatan Sistem Terintegrasi MRP II dan JIT Menuju MANUFAKTURING 21*. Jakarta: Gramedia Pustaka Utama, 1998.

[11] C. R. Rosales, M. Magazine, and U. Rao, "Point-of-Use Hybrid Inventory Policy for Hospitals," *Decis. Sci.*, vol. 45, no. 5, pp. 913–937, 2014, doi: 10.1111/deci.12097.

[12] N. F. Shiddieq, A. Y. Ridwan, and B. Santosa, "Antibiotic Inventory Policy Design for Minimizing Total Inventory Costs in Pharmacies based on ABC-Fuzzy Classification Analysis Approach using Probabilistic Continuous Review Method," *ACM Int. Conf. Proceeding Ser.*, 2020, doi: 10.1145/3429789.3429852.