THE ANALYSIS OF MEDICINE INVENTORY CONTROL IN A HOSPITAL

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ABSTRACT: *An inventory control is very important for a hospital to determine policies in the procurement of inventories in the optimal amount. A pharmacy installation of a hospital is one of the most important part of the unit that contributes very high in a hospital. As a provider of drugs and medical devices for consumers to prevent the occurrence of vacancies or excess drugs and medical devices, it is necessary to have good inventory control.Planning for the procurement of drugs in pharmaceutical installations in a hospital in this study was carried out by using analysis of ABC critical index by looking at the analysis of use value, analysis of investment, and critical value, to get any drugs that entered the critical index A, B and C groups. Furthermore, forecast of the priority drug needs is the group of the critical index A. To get the optimum order, namely the Economic Order Quantity (EOQ) multi item with the constraints of investment and storage space, the method of Lagrange Multiplier is used to obtain the optimal order quantity solution for these constraints. From the results of analysis for optimal ordering of drugs that are a priority by using the Lagrange multiplier method, there is a decrease in the inventory cost of IDR 2.209.772.719 – IDR 2.000.000.000 = IDR 209 772 719.*

Keywords*:* ABC critical index, optimum EOQ multi-item, Lagrange Multiplier

INTRODUCTION

The pharmacy service of a hospital is one of the hospital activities that support the quality services in health.The case also as a compulsory by the decree of Minister of Health Republic of Indonesia No: 1333/Menkes/ SK/ XII/1999 about the standard service of a hospital, which states that the pharmacy service of a hospital as integral part of the hospital services which oriented on patient satisfaction, the supply of drug quality including the service of drugs quality for all patients.The pharmacy installation of hospital is one of the divisionin hospital which has a high impact on the development of hospital, revenue and operational cost and has relationship one another. The pharmacy service is the main service of hospital, since almost all services given to the patients based on the supply of pharmacy and medical devices.A pharmacy installation of a hospitalis one of the division in hospital and in charge all the supply of pharmacy and medical devices that used in the hospital, start from the planning, selection, specification, procurement, quality assurance, storage, and *dispensing*, distribution to patients, controlling the effect and giving the information, so that the supply of drugs and medical devices will be guaranty, useful and safe [1].The service which is not well manage can cause deficiency or surplus can cause disadvantage for the hospital. The oversupply can cause high cost for the hospitals and also high storage cost. Besides, over supply is not efficient since the cost can be used for the other activities. The oversupply also can increase the risk damage and expired [2].The drug is a main priority for the hospital to pay attention so that in procurement/ buying sometimes the hospital has a problem due to the shortage of drug and budget. Besides the purchase of the drug sometimes based on subjectivity or the same amount as before. Therefore, the planning and controlling for pharmacy services should be optimized the supply including planning, buying, storage, distribution and controlling. A good planning and controlling can support the hospital management to overcome the problem of procurement of drugs so that the efficiency can be attained. In this study, it will be discussed what kind of drugs become the priority of the hospital and how to plan the optimal of drugs supply by considering the constraint on investment of the hospital. With the aim to know the planning, controlling for drugs supply and the priority includes total drugs used, used values, and critical values in Hospital Pertamina Bintang Amin also to know the system analysis planning and controlling drug stocks optimally based on the constraint of investment and storage spaces for drugs which become priority (group A) based on ABC critical index by using Lagrange multiplier.

STUDY OF LITERATURE

The supply is an idle resources waiting for the coming processes. The coming processes is the production activities at manufacture system, selling activities at distribution system or consumptive activities in house hold [3]. Basically supply simplify or facilitate operation of a company for production or services to the consumers [4]. Controlling supply is one of the importance managerial function, since drugs supply will need cost with high cost investment [5].

a. Analysis ABC critical index

Suciati and Adisasmito [6] in their study about analysis drugs planning based on ABC critical index in pharmacy installation, state that in ABC analysis includes total used, investment values, and critical values toward patients' services. Drug critical values toward patient services is evaluated by the user and will be used to decides drugs stock for category A,B or C. To determine their values of critical index, we used the formula as follows:

$$CIV = UV + \text{Investment Value} + (2 \times \text{Critical Values})$$

Where CIV = Critical Index Values, UV= Use Values.

Drugs then will be grouped into ABC based on criteria:

Group A with CIV : 9.5 – 12
Group B with CIV : 6.5 – 9.4
Group C with CIV : 4.0 – 6.4

Decision for total Order

Economic Order Quantity (EOQ)is one of the methods to decide total order economically. The basic concept of EOQ is the availability of order quantity for each items such that the balanced optimum is attained for the cost of storage and cost of order [7].

EOQ single item

Total order that can minimized total cost order is called Economic Order Quantity (EOQ). Where supply model which considered ideal where we have to know the optimum position, the average level of use, and to know when we have to reorder [8]. Where Q is total buying and when the order is accepted the total supply is Q.With the level of user is fixed, the supply will finish in certain time and when the supply only enough for the need of certain time the order should be conducted (reorder Point = ROP) [8].

If there is no shortage*(stock out*), then supply cost yearly

Total Cost = cost of purchase + cost of order + cost of storage

$$TC\ (Q) = PD + \frac{CD}{Q} + \frac{HQ}{2} \quad (2.1)$$

where D = total need in unit, P= cost of purchase in unit, C= cost of order for every order,

H = *i*. P = cost of storage per unit per year, Q = total order in unit, *i* = percentage cost of storage per year, F = frequency of order for a year, V= interval of time between order. To decide total order minimum of stock, we need to know the frequency of order per year and the interval time between order, namely formulated as follows:

$$Q^* = \sqrt{\frac{2CD}{H}} = \sqrt{\frac{2CD}{Pi}} \quad (2.2)$$

$$F = \frac{D}{Q^*} = \sqrt{\frac{H.D}{2C}} \quad (2.3)$$

$$V = \frac{1}{F} = \frac{Q^*}{D} = \sqrt{\frac{2C}{HD}} \quad (2.4)$$

Reorder (reorder point =ROP) determine based on the need in between the order. If the supply is enough in between the order time, then reorder has to do as many as Q^* unit or EOQ.

$$\text{Reorder point} = ROP = \frac{DL}{N} \quad (2.5)$$

L = Lead time

N = Total operation time (day/week/month) in a year.

In the used of EOQ, there are some assumption used [8] :

1. The need resources or product can be determined relative fixed and continuously.
2. In between interval time of order can be determined and relatively fixed (lead time).
3. It is not allowed a shortage of supplies.
4. The structure of cost is not changed for cost of order or preparation is the same regardless of the amount ordered, and cost of storage is based on linear function toward the mean of supply and cost of purchase per unit is constant.
5. Orders arrive at once and will add to inventory

Inventory Multi Item withConstrain

In the EOQ model is only used for one item, this is good for each item when there is no limit to the overall inventory. Limits that need to be considered in the inventory system are the investment limits, and the limits of storage space, or the combination of both if the working capital / investment limits and also the limitation of storage space, the best determination can be calculated using Lagrange multiplier [8].

Method of Lagrange Multiplier

In the system of inventory multi item, the cost of inventory per year is estimated from sum of total cost per year from each items which involve in the system.If there are n items in the system, then the total cost (per year = total cost of purchase + Total cost of order + total cost of inventory) [9].

$$TC\ (Q_1, Q_2, \ldots Q_n) = \left(\sum_{j=1}^{n} Pj.Dj + C\sum_{j=1}^{n}\frac{Dj}{Qj} + i\sum_{j=1}^{n}\frac{PjxQj}{2}\right) \quad (2.6)$$

where :

TC	= total cost/cost of inventory per year
Qj	= total order for n units
Pj	= cost of purchase per unit j
Dj	= level of order per year
C	= cost of order
H	= i.Pj = cost of inventory
i	= cost of inventory in percentage
B	= total investment of supply in rupiah (IDR)
w_j	=the need of space for each unit j
W	= total area of inventory available
λ	= factor multiplication of Lagrange

Model Lagrange Multiplier for Inventory System with constrain on Investment

If there is a constrain on investment, where the total unit's purchase may not exceed existing Investment (A), then the following equation applies:

$$\sum_{j=1}^{n} Pj.Qj \le A \quad (2.7)$$

Step 1

If n is total items, then the goal of the solution for this problem is to minimize total cost of supply per period. The first step is to find the order quantity which is optimal by neglected the constraint, so that to find the value of $Q_j^*$is used:

$$Qj = \sqrt{\frac{2\,CjDj}{i.Pj}}, \qquad j = 1,2,3,\ldots.n \quad (2.8)$$

To know whether Qj* optimum feasible, we substitute the value Qj into equation (2.7). If the equation is satisfied, then the order quantity is optimum at Qj, if not then Lagrange method is used to findthe Qj which is optimal.

Step 2

By Lagrange equation (lagrangian exppression = LE) as follows:

$$LE\ (Qj,\lambda) = \sum_{j=1}^{n}\left(\frac{CjDj}{Qj} + \frac{i.P_jQj}{2}\right) + \lambda\left(\sum_{j=1}^{n} PjQj - A\right) \quad (2.9)$$

$$\frac{\partial L}{\partial Q_j} = \left(\frac{-C_j.D_j}{Q_i^2} + \frac{i.P_j}{2}\right) + \lambda P_j = 0$$

$$\frac{\partial L}{\partial \lambda} = \left(\sum C_jQj\right) - A = 0$$

where λis Lagrange multiplier. By the first derivative of (2.9) with respect to Qj, and set equal to zero, we have

$$Q_j^* = \sqrt{\frac{2CjDj}{Pj(i+2\lambda^*)}} \quad (2.10)$$

While the value of λ* is given by equation 2.11 obtained by entering equation 2.10 into the constraint

$$\lambda^* = \frac{1}{2}\left(\frac{1}{A}\sum_{j=1}^{n}\sqrt{2C_jD_jP_j}\right)^2 - \frac{i}{2} \quad (2.11)$$

By substitution of λ into(2.10), we have Q_j^* optimum.

Model Lagrange Multiplier for Inventory System with constraint on Area of Inventory

If the area of inventory (storage) maximum is available for total W m^2, then determining the best amount of inventory can be calculated by using a multiplier. The formula is as follows:

$$\text{Minimized TC} = \sum_{j=1}^{n} TC\ (Qj) = \sum_{j=1}^{n}\left(\frac{CjDj}{Qj} + \frac{i.P_j\,Qj}{2}\right) \quad (2.12)$$

$$\text{Constraint} \sum_{j=1}^{n} wjQj \le W$$

$Qj \geq 0$

By the similar procedure by the constraint on investment, then we have the optimum order

$$Qj^* = \sqrt{\frac{2CjDj}{P_j.(i+2\lambda^* w_j)}} \quad (2.13)$$

To find the Lagrange value (λ) then equation (2.13) is substituted into the constrain, it will be obtained λ (Lagrange value)

$$\lambda^* = \frac{1}{2}\left(\frac{1}{W}\sum_{j=1}^{n}\sqrt{2CjDjwj}\right)^2 - \frac{i.Pj}{2} \quad (2.14)$$

RESULTS AND DISCUSSION

In the process of procurement of drugs, there are some points to be considered, namely: standardized drugs, and standardized cure that the drugs which are going to be used in pharmacy installation of hospital, should attain the standardized of drugs.This standardized is evaluated yearly to know the effectiveness use of drugs that has been ordered by users(doctor). This standardized is very helpful in supply the need of drugs.

Drugs grouping based on the analysis of critical index ABC

The data used for the analysis of critical index ABC is the combined data values of the drug used, values of investment, and values of critical index from the analysis of ABC index toward 342drugs in pharmacy installation in hospital, and the results are presented in the following tables:

Table. 1. Analysis critical index ABC

Group	CIV	Investment	%	Total item	%
A	9,5–12	IDR 2104008900	59.9%	20	5,8%
B	6,5–9,4	IDR 885205712	25.2%	83	24,3%
C	4,0–6,4	IDR 524897033	14.9%	239	69,9%
Total		IDR 3514111645	100%	342	100 %

Note: CIV= critical index values.

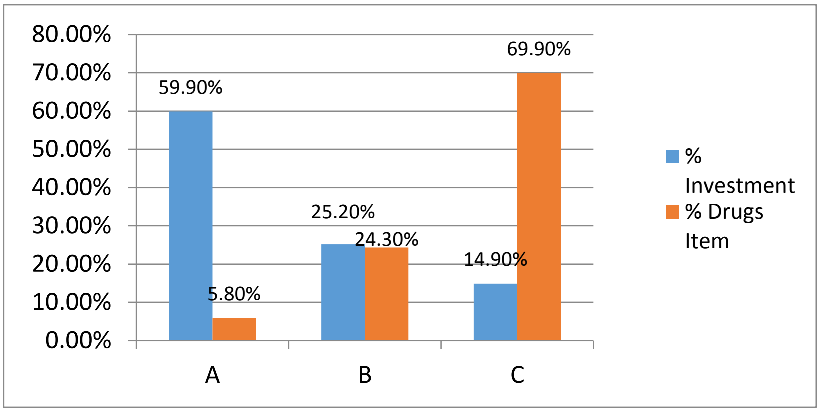

Figure 1. Graph analysis of critical index ABC

Table. 2 Drug in priority of group A, based on critical index values ABC

No	Drugs	Total
1	Ceftriaxone 1 Gr	14775
2	Azythromycin 500 Mg Tab	8617
3	Metronidazole Infuse	6109
4	Ciprofloxacin 500 Mg	38873
5	Cefoperazone 1 Gr	2982
6	Cefadroxil 500 Mg	32117
7	Cefixime 100 Mg	19707
8	Dex Ketoprofen 25 Mg Tab	12593
9	Harnal Ocas Tab	10152
10	Ketorolac 30 Mg Inj	6091
11	Bisoprolol 5 Mg Tab ,	11332
12	Celocid 750 Mg Inj	3156
13	Ibuprofen 400 Mg	15522
14	Levofloxacin Infus	2523
15	Meloxicam 15 Mg	8123
16	Meloxicam 7,5 Mg	10876
17	Tramadol 50 Mg	19589
18	Asam Mefenamat 500 Mg	59262
19	Pronalgess Supp	3530
20	Tutofusin Ops 500 Ml	3476

Forecasting

Forecasting is used to eliminate risk due to decision maker in planning production. The aims of forecasting in production activities is to minimize uncertainty, such that we have an estimate that close to the real condition. Therefore, forecasting can not be ascertained exactly because there are external factors that affect the actual situation [2].

The results of forecasting and the level of accuracy by using*Mean Absolute Deviation* (MAD) is given below:

Table 3 Forecasting results of drug of group A

No	Drugs	Total
1	Ceftriaxone 1 Gr	15155
2	Azythromycin 500 Mg Tab	8189
3	Metronidazole Infuse	6196
4	Ciprofloxacin 500 Mg	39008
5	Cefoperazone 1 Gr	3001
6	Cefadroxil 500 Mg	32116
7	Cefixime 100 Mg	20305
8	Dex Ketoprofen 25 Mg Tab	12460
9	Harnal Ocas Tab	10122
10	Ketorolac 30 Mg Inj	6434
11	Bisoprolol 5 Mg Tab ,	11343
12	Celocid 750 Mg Inj	3068
13	Ibuprofen 400 Mg	16133
14	Levofloxacin Infuse	1871
15	Meloxicam 15 Mg	7950
16	Meloxicam 7,5 Mg	11306
17	Tramadol 50 Mg	19973
18	Asam Mefenamat 500 Mg	55513
19	Pronalgess Supp	3543
20	Tutofusin Ops 500 Ml	3431

Optimal analysis

Optimization with the constrain on investment. It is available that the cost of inventory 1,2% and cost of order is IDR 650.000, for all order, then we have the calculation for Qj.

Table. 4 Optimum Supply (Qj) for drug items without constraint

No	Drugs	Demand (Dj)	Price/unit (Pj)	Qj
1	Ceftriaxone 1 Gr	15155	IDR 8,450	13939
2	Azythromycin 500 Mg Tab	8189	IDR 30,145	5425
3	Metronidazole Infuse	6196	IDR 1,300	22723
4	Ciprofloxacin 500 Mg	39008	IDR 89,722	6863
5	Cefoperazone 1 Gr	2999	IDR 55,000	2430
6	Cefadroxil 500 Mg	32116	IDR 1,400	49851
7	Cefixime 100 Mg	20305	IDR 6,700	18119
8	Dex Ketoprofen 25 Mg Tab	12460	IDR 6,300	14638
9	Harnal Ocas Tab ,	10122	IDR 7,400	12173
10	Ketorolac 30 Mg Inj	6434	IDR 3,450	14214
11	Bisoprolol 5 Mg Tab ,	11343	IDR 1,753	26476
12	Celocid 750 Mg Inj	3068	IDR 71,500	2156
13	Ibuprofen 400 Mg	16133	IDR 1,450	34718
14	Levofloxacin Infuse	1871	IDR 88,000	1518
15	Meloxicam 15 Mg	7950	IDR 1,825	21724
16	Meloxicam 7,5 Mg	11306	IDR 1,255	31240
17	Tramadol 50 Mg	19973	IDR 750	53712
18	Asam Mefenamat 500 Mg	55513	IDR 265	150645
19	Pronalgess Supp	3543	IDR 13,450	5342
20	Tutofusin Ops 500 Ml ,	3431	IDR 33,500	3331

The optimization method used to solve this inventory problem is to look at the constraints that exist in working capital that the hospital has and the constraint where to store drugs. From the results of calculation with constraint on investment (capital) for drugs which are priority to be handled, the investment for the drugs is IDR 2,000 000,000. From the analysis to find the optimum of Qj^* , costs incurred exceed the investment (working capital) so the order of Q is not feasible where $\sum_{j=1}^{n} Pj.Dj \leq$ A not fulfilled, where IDR 2,209 772,719 $\geq$ 2,000,000,000, then we used Lagrange method and we found the value for Lagrange multiplier is $\lambda^* = 0.001325$ and $\sum_{j=1}^{n} PjQL \leq A$ where IDR 2,000 000 000 ≤ IDR 2,000,000,000 , the optimum as in Table 5 the optimum Qj * results for ordering group A drugs are as follows:

Table. 5 Supply (QL) optimum for drugs item with constraint

No	Drugs	Demand (Dj)	Purchase Price/unit (Pj)	Qj^* optimum
1	Ceftriaxone 1 Gr	15155	IDR 8,450	12616
2	Azythromycin 500 Mg Tab	8189	IDR 30,145	4910
3	Metronidazole Infuse	6196	IDR 1,300	20566
4	Ciprofloxacin 500 Mg	39008	IDR 89,722	6211
5	Cefoperazone 1 Gr	2999	IDR 55,000	2200
6	Cefadroxil 500 Mg	32116	IDR 1,400	45119
7	Cefixime 100 Mg	20305	IDR 6,700	16399
8	Dex Ketoprofen 25 Mg Tab	12460	IDR 6,300	13248
9	Harnal Ocas Tab ,	10122	IDR 7,400	11017
10	Ketorolac 30 Mg Inj	6434	IDR 3,450	12865
11	Bisoprolol 5 Mg Tab ,	11343	IDR 1,753	23963
12	Celocid 750 Mg Inj	3068	IDR 71,500	1951
13	Ibuprofen 400 Mg	16133	IDR 1,450	31422
14	Levofloxacin Infus	1871	IDR 88,000	1374
15	Meloxicam 15 Mg	7950	IDR 1,825	19661
16	Meloxicam 7,5 Mg	11306	IDR 1,255	28275
17	Tramadol 50 Mg	19973	IDR 750	48613
18	Asam Mefenamat 500 Mg	55513	IDR 265	136345
19	Pronalgess Supp	3543	IDR 13,450	4835
20	Tutofusin Ops 500 Ml ,	3431	IDR 33,500	3015

Optimization with Constraint on Area of Storage.

If the area of the warehouse become a constraint in the inventory system optimum order determination can be solved by the Lagrange method, in this study where the case of storage space is available in Pertamina Bintang Amin hospitals are 203.28 m^2, while the drug needs in for group A in critical index ABC obtained a space limit is 100 m^2 . From the calculation that it is needed for the storage of drug supplies only 98.235m^2 , so for the problem of storage space at this hospital has no problem. From the calculation of orderoptimum,the one that need to paid attention is the constraint of investment (working capital) for drugs purchase.

CONCLUSION

From the results of the analysis, it shows that the optimization of supply with the constraint on investment and area of storage (inventory) by using Lagrange multiplier is very helpful to find the optimum solution needed for drugs. The Lagrange method or the method of lot size inventory management Interpolation Technique can be used to determine total order optimum if in the system there is a constraint. The planning of procurement of drugs by A pharmacy installation of a hospital so far without careful planning where planning is based on subjectivity and looking at the existing disease conditions.

From the results and discussion, we have:Based on the analysis of critical index ABC, we can conclude as follows: From the analysis of critical index ABC for group A only consist of 20 item drugs or 5,85% out of total item drugs, with the total investment 59,9 % of the total investment of critical index ABC. The critical index is used to increase the efficiency use of funds (investment) by grouping drugs or pharmaceutical supplies, especially drugs used based on their impact on health. Data analysis is conducted step by step by combining use value, investment value, and critical value of the drugs.

Planning analysis for drugs (medicines)

a. The planning of drugs supplies without constraint based on result of forecasting for group critical index A, then we have EOQ (*Economic Order Quantity*) multi item with total cost of purchase IDR 2.209.772.719, total cost of orderIDR 13.426.131, totalcost of inventory 13.426.131 with total cost of supply is IDR 2.264.540.712.
b. The planning of drugs supplies with the constraint on investment with only available investment isIDR 2.000.000.000 from the calculation of EOQ without constraint is not feasible, then we calculate the Lagrange multiplier and we have $\lambda^* = 0,001325$and we found the value of Qj^* optimum for each item with the total cost of purchaseIDR 2.000.000.000, total cost of orderIDR 14.649.286, total cost of inventory 12.000.000.

Based on the calculation of total cost of order and inventory increase from IDR 26,517 273 (policy optimum) toIDR 26,649 749 (constraint policy investment). After we calculate by using Lagrange method with the constraint on investment (working capital) increase cost asIDR 169,487. But total cost of supply decrease IDR 2.209 772 719 – 2.000.000.000 = IDR 209,772.719.

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