ABC-VED Analysis and Economic Order Interval (EOI)-Multiple Items for Medicines Inventory Control in Hospital

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Abstract

In hospital, about one-third of the annual expenditure budget is spent on inventory, including medicines. To minimize the inventory investment, the hospital may keep the medicines inventory low, but on the other hand, maximum service to the patients can not be provided. Therefore, an effective inventory management is needed to achieve satisfactory level of customer service while keeping inventory costs within reasonable bounds.

The objectives of this study are to identify the categories of medicines requiring greater managerial control, because not all inventories need to be controlled with equal attention and to conduct economic analysis of medicines expenditure at Installation of Pharmacy, Government Hospital, Sukabumi, West Java, Indonesia.

Data analysis of medicines expenditure of price vocabulary medical stores for year 2007 was undertaken. A matrix that coupled ABC analysis (based on cost criteria) and VED analysis (based on criticality) was formulated for prioritization. Then, Economic Order Interval (EOI)-multiple items model has been proposed to determine 'when' and 'how much' the order should be placed.

It was observed that 40 medicines (11.90%) were classified into category 1(AV+BV+CV+AE+AD) for stringent control. Application of EOI-multiple items would also allow effective control of annual total expenditure.

***Keywords**: ABC-VED analysis, EOI-multiple items, medicines inventory control*

INTRODUCTION

Inventory is the stock of any item or resource used in an organization (Chase, et al., 2004), including raw materials, component parts, work in process, supplies, and finished goods. Inventory is one of the most expensive assets of many organizations, representing as much as 50% of total invested capital (Heizer, Render; 2004). Because of the large portion of expenditures, the effective management of inventory is crucial to the performance of many organizations (including manufactures, wholesalers, retails, hospitals, universities, governments, etc). It can have serious implications for

the finance, production, and marketing functions of any organization. Finance is influenced through liquidity and return on investment, production through efficiency and cost of operations, and marketing through sales and customer relations (Tersine, 1994).

Different types of organizations have different inventory requirements. Typical organizations such as hospitals, finance institutions, universities, and penal institutions, are organizations that provide the ultimate consumer with goods and services. Inventory is purchased in a salable form and is usable without further processing or conversion. The organizations that provide services to consumers experience only a supplies inventory problem (Tersine, 1994).

In hospital, about one-third of the annual expenditure budget is spent on buying those supplies, including medicines (Kant S., et al; 1997). To minimize the inventory investment, the hospital may keep the medicines inventory low, but on the other hand, maximum service to the patients can not be provided and the lack of medicines for patients in critical condition may cause serious problem. Therefore, effective inventory management is required to balance inventory investment against demands for medicines. The overall objective of inventory management is to achieve satisfactory level of customer service while keeping inventory costs within reasonable bounds.

In practice, a hospital provides many types of medicines and managing all those inventory items will take personnel time and costs money. When there are limits on these resources, the decision maker should use the available resources in the best way, because not all inventories need to be controlled with equal attention. In other words, priorities must be developed to allow management to decide which items should receive the most effort in controlling. Kant S., et al. (1997) observed that ABC analysis for prioritization was a feasible and efficient technique for effective management of store in hospitals. It would allow effective control over two-third of the total expenditure by controlling only one-fourth of the items. Then, Thawani, et al. (2004) and Gupta, et al. (2007) proposed that in hospital inventory management, ABC analysis (based on cost criteria) should be coupled with VED analysis (based on the criticality of an item) to narrow down the group of medicines requiring greater managerial monitoring. Based on ABC-VED analysis, the two fundamental decisions that must be made then relate to the timing and size of orders.

In this research, analysis of the annual medicines expenditure at Hospital “X”, Sukabumi, West Java, Indonesia, using ABC-VED analysis was formulated for prioritization. Then, Economic Order Interval (EOI)-multiple item has been proposed to determine “when” and “how much” the order should be placed.

LITERATURE STUDY

Inventory is a necessary part of doing business and provided by most organizations in any sector of economy. Inventory exists because supply and demand are difficult to synchronize perfectly and it takes time to perform material-related operations (Tersine, 1994). Inventory serves five purposes within the firm (Stock and Lambert, 2001):

1. It enables the firm to achieve economics of scale.
2. It balances supply and demand.
3. It enables specialization in manufacturing.
4. It provides protection from uncertainties in demand and order cycle.
5. It acts as a buffer between critical interfaces within the supply chain.

Inventory can be a source of conflict among different managers in organization because different managers have different roles to play which involve the use of inventory. The conflicting roles of managers must not be allowed to impair the organization as a whole (Tersine, 1994). To overcome this conflict, inventory management should be everybody's concern.

The objective of inventory management is to have the appropriate amounts of materials in the right place, at the right time, and at low cost (Tersine, 1994). Therefore, inventory decision problem can be solved by using economic criteria. One of the most important prerequisites is an understanding of the more relevant costs to inventory system. There are four types of inventory costs (Schroeder, 2000):

Item cost

Item cost is the cost of buying or producing the individual inventory items. The item cost is usually expressed as a cost per unit multiplied by the quantity procured or produced.

Ordering/ setup cost

Ordering cost is associated with ordering a batch or a lot of items. It does not depend on the number of items ordered, but assigned to the entire batch, including transportation costs, receiving costs, and so on. When the item is produced within the firm, there are also costs associated with placing an order, called setup costs, including paperwork costs and the costs required to set up the production equipment for a run.

Carrying/ holding costs

This cost is associated with keeping items in inventory for a period of time. The carrying/ holding cost is typically charged as a percentage of dollar value per unit time. In practice, this cost typically range from 15% - 30% per year. The carrying/ holding cost consists of three components:

- Cost of capital
  This represents a cost of foregone opportunities for other investments, which is assigned to inventory as an opportunity cost.
- Cost of storage
  This cost includes variable space cost, insurance, and taxes.
- Costs of obsolescence, deterioration, and loss

  Obsolescence costs should be assigned to items that have a high risk of becoming obsolete. Perishable products should be charges with deterioration costs when the item deteriorates over time. The costs of loss include pilferage and breakage costs associated with holding items in inventory.

Stock out cost

Stock out cost reflects the economic consequences of running out of stock, including back ordered cost and loss sales.

Organizations should ensure that they take specific actions to optimize the inventory level with the minimum total annual inventory cost and they implement the actions consistently. But, to determine which actions are the right ones for the organizations, they first carry out the detailed analysis of the inventory. The results of the analysis can be used as a basis for defining the appropriate inventory optimization measures (Hoppe, 2006).

ABC analysis can be used as one of inventory analysis instrument. ABC analysis is a method for dividing on-hand inventory into three classifications based on annual dollar volume (Heizer and Render, 2004). ABC analysis is an inventory application of Pareto principle. The Pareto principle states that there are a “critical few and trivial many”. The idea is to establish inventory policies that focus resources on the few critical inventory parts and not the many trivial ones. It is not realistic to monitor inexpensive items with the same intensity as very expensive items. According to Pareto principle, inventory has been divided into the following categories (Gupta, et al. 2007):

- Class A items may represent only about 10% of total inventory items, but they represent about 70% of the total money value.
- Class B items may represent about 20% of total inventory items, and they represent about 20% of the total money value.

- Class C items may represent about 10% of total inventory items, but they represent only about 10% of the total money value.

Using the classification, each category should be handled in different way, with more attention being devoted to category A, less to B, and still less to C. The points should be considered for each class is shown in Appendix 1.

In hospital inventory management, VED analysis has been commonly used together with ABC analysis. VED analysis is based on the criticality of an item. “V” is for vital items without which a hospital can not function, “E” for essential items without which a hospital can function but may affect the quality of the services, and “D” for desirable items, unavailability of which with not interfere with functioning (Gupta, et al., 2007).

By combining ABC and VED analysis, the medicines can be coupled into the following group (Gupta, et al., 2007):

Class I: AV+BV+CV+AE+AD

Class II: BE+CE+BD

Class III: CD

Class I is the highest priority group, needing greatest attention. The management of class I medicines by top management would help in keeping a check on the annual budget and their availability. Moderate attention should be devoted by middle level management for class II, and the loose attention is devoted by lower level management for class III.

After the inventory has been classified, the two fundamental questions posed to any inventory system are how many and when to order. There are 2 (two) inventory system can be used to answer the questions (Tersine, 1994):

1. Fixed order size system

Fixed order interval system

In fixed order size system, the same number of units (how many) is always ordered, and the time between orders (when) is not expected to vary. This system is also termed as Q-system, since the size of order (Q) is fixed for each replenishment. The stock level is reviewed with each transaction, and whenever the inventory position reaches a predetermined point, an order for a fixed number of units is placed. Thus, the defining parameters of the system are reorder point (B) and the size of the order (Q).

The fixed order interval system or periodic inventory system, is based on a periodic rather than a continuous review of the inventory stock position. It is a time-

based inventory system in which orders are placed at equally interval, predetermined points in time, and the order quantity is dependent upon the usage between order review periods. This system is also termed as T-system, since the order interval is constant. A maximum inventory level for each item is developed, based on usage during lead time and order interval. After a fixed period of time has passed, the stock position of the item is determined. An order is placed to replenish the stock with the sufficient size to bring the present stock level up to the maximum inventory level. Therefore, the defining parameters of the system are fixed review period (T) and the maximum inventory level (E).

There are 2 (two) models in fixed order interval system, they are:

1. Economic order interval-single item

Economic order interval-multiple items

In hospital, more than one item of medicine should be placed and a separate order is rarely placed for each item. The medicine supplier usually provides numerous items, and it is more economical to place joint orders. Therefore, economic order interval (EOI)-multiple item has been proposed in this study.

The economic order interval can be obtained by minimizing the total annual cost. The formulation is (Tersine, 1994):

Total annual cost = item cost + ordering cost + holding cost

$$TC(T) = \sum_{i=1}^{n} P_i R_i + \frac{C + nc}{T} + \frac{TF}{2} \sum_{i=1}^{n} P_i R_i \qquad (1)$$

The minimum cost order interval is obtained by taking the first derivative of the total annual cost with respect to the order interval (T) and setting it equal to zero, thus the economic order interval in years can be obtained as:

$$T^* = \sqrt{\frac{2(C + nc)}{F \sum_{i=1}^{n} P_i R_i}} \qquad (2)$$

The maximum inventory is determined as follows when the order interval and lead time are expressed in days and there are N operating days in year:

$$E_i = \frac{R_i T}{N} + \frac{R_i L}{N} = \frac{R_i (T + L)}{N} \qquad (3)$$

By replacing T with T^*, the total annual cost can be expressed as follows:

$$TC(T^*) = (1 + FT^*) \sum_{i=1}^{n} P_i R_i \qquad (4)$$

RESEARCH METHOD

The study was conducted at Installation of Pharmacy, Hospital "X", Sukabumi, West Java, Indonesia. The installation provides all medicines and medical equipments required by patients and internal units of the hospital. Data Analysis of medicines expenditure of price vocabulary medical stores for year 2007 was undertaken. Since most patients of this hospital were the middle class of social economics, most medicines available included generic medicines. The total number of medicine items was 336 items.

For ABC analysis, the following procedure is conducted:

- Total annual value for each item is calculated by multiplying annual usage of each item by the cost of the item.
- Add the total annual value to determine the aggregate annual expenditures.
- The total annual value of each item is divided by the aggregate annual expenditures to obtain the percentage of annual value for each item.
- List the items in rank order on the basis of the percentage of aggregate usage.
- Examine annual usage distribution and group items on basis of percentage of annual value.

Then, VED analysis of all the medicines was done to classify the medicines inventory into vital (V), essential (E) and desirable (D) categories. The medicines that critically needed for the survival of the patients, which must be available in the hospital all the times, were included in vital (V) category. Medicines with lower critically need, which may be available in the hospital, were included in the essential (E) category. The remaining medicines with lowest critically, the absence of which will not be detrimental to the health of the patients, were included in the desirable (D) category (Thawani, et al., 2004). For VED analysis, lists of all generic medicines were distributed to a panel of doctors, consisting of general medicine, dentistry, obstetrics and gynecology, surgeon, internist, pediatrician, oto-rhino-laryngologist, ophthalmologist, dermatologist, and neurologist. They were asked to classify the medicines into vital, essential, and desirable. The medicines were categorized if more than 50% members of panel concurred.

A matrix was formulated by combining ABC and VED analysis which can be used for prioritization. Category I was the high priority group, needing greater attention, consisting of the AV, AE, AD, BV, and BE category of medicines. Category II of lower management priority, consisting of BD, CV, CE and CD category of medicines.

Category III was the lowest priority group, consisting of CD category of medicines. Economic order interval-multiple items was used to assess the expenditure for the medicines inventory Installation of Pharmacy, Hospital "X".

RESULTS AND ANALYSIS

Shown in Appendix 2 are the total annual value, percentage of annual value, number of items and percentage number of items that are group into ABC classifications.

From 336 items of medicines, 26 items (7.74%) consume 70.84% of annual value and classified into class A, 37 items (11.01%) consume 19.23% of annual value classified into class B, and 273 items (81.25%) of annual value consume only 9.93% forming class C.

Policies that may be based on ABC analysis include the following (Haizer, Render, 2004):

- Purchasing resources expended on supplier development should be much higher for individual class A than for class C.
- Class A should have tighter physical inventory control, perhaps they belong in more secure area, and perhaps the accuracy of inventory records for Class A should be verified more frequently.
- Forecasting class A may warrant more care than forecasting class B and class C.

However, for medicine inventory control, if we consider ABC analysis alone, we only effectively control 26 items of class A, but would ignore the vital nature of class B and class C (310 items). Therefore, analysis based on the vital, essential, and desirable (VED) critically need of medicines has been commonly used in hospital inventory management. VED analysis of all the medicines was done to classify the medicines into vital (V), essential (E), and desirable (D) categories. The medicines were classified into VED category based on justification by the study group of doctors that reached a collective consensus as shown in Appendix 3.

Appendix 3 shows that 22 items (6.6%) are vital, 113 items (33.6%) are essential, and 201 items (59.8) are desirable. If we only consider VED analysis alone, ideal control can be exercised on the vital or essential category. But we found that desirable category also contained class A, hence it was not possible to ignore the desirable category totally. Thus, the suggested ABC-VED coupling matrix model is used for prioritization as shown in Appendix 4.

Based on ABC-VED matrix shown in Appendix 4, the medicines can be categorized into the following group:

Class I:	AV+BV+CV+AE+AD	= 40 items (11.90%)
Class II:	BE+CE+BD	= 127 items (37.80%)
Class III:	CD	= 169 items (50.30%)

The management of class I (40 items) would help in keeping a check on the annual budget and the availability.

In this case, the supplier provides numerous items of medicines, and it is more economical to place joint orders. When all items from the same source are ordered jointly, the quantity of each item to order depends on the time interval (T) between orders for the entire group. By using the formula 1, known the order costs are IDR58,344 and carrying costs are 5% per year, we can get T=0.05 years, or 0.6 months, or 18 days. Every 18 days the hospital should place a new order for the 40 items.

Once the optimum time interval (T) is established, and known lead time is 3 days, the desired maximum inventory level for each item(E_i) that is shown in Appendix 5 can be obtained by using formula 3. From there, the individual order quantities can be calculated between each item's maximum inventory level and its stock position at the time of the order review (Tersine, 1994).

The minimum annual total cost of IDR 1,088,938,964 has been estimated from *Economic Order Interval (EOI)-multiple items model*, while the annual total cost that has been determined by using the hospital's current methods is IDR 1,140,534,575, there is annual total cost savings of 4.52%.

SUMMARY

ABC-VED analysis helps to narrow down and prioritize medicines that need better managerial control on the annual expenditures and at the same time their availability in hospital. In this case, 40 items (11.90%) were categorized into class I (AV+BV+CV+AE+AD) for stringent control.

Application of *Economic Order Interval (EOI)-multiple items model* against 40 items of medicines class I has generated annual total cost saving of 4.52% compared with the hospital's current methods.

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Appendix 1.

Comparison of A, B, and C Classes

Class	Degree of control	Types of records	Lot sizes	Frequency of review	Safety stocks
A	Tight	Accurate and complete	Low	Continuous	Small
B	Moderate	Good	Medium	Occasional	Moderate
C	Loose	Simple	Large	Infrequent	Large

Source: Tanwari, et al., 2000

Appendix 2.

ABC Classification of Medicines

Class	Total Annual Value (IDR)	Percentage of Annual Value	Number of Items	% of Number of Items
A	1,053,716,897	70.84%	26	7.74%
B	285,952,898	19.23%	37	11.01%
C	147,651,592	9.93%	273	81.25%
Total	1,487,321,387	100%	336	100%

Source: Data Analysis

Appendix 3.

VED Classification of Medicines

Class	Number Of Items	% of Number of Items	Concurrence of Doctors on Medicines Classification					
			100%	90%	80%	70%	60%	50%
V	22	6.60	-	-	-	2	4	16
E	113	33.6	-	-	4	14	40	55
D	201	59.8	3	4	17	26	62	89
Total	336	100	3	4	21	42	106	160

Source: Data Analysis

Appendix 4.

ABC-VED Matrix

Class	V	E	D	Total
A	8	5	13	26
B	3	15	19	37
C	11	93	169	273
Total	22	113	201	336

Source: Data Analysis

Appendix 5.

Maximum Inventory of Each Items of Medicines

Number of Item	Item (*i*)	Annual Demand (R_i)	Maximum Inventory (E_i)	Number of Item	Item (*i*)	Annual Demand (R_i)	Maximum Inventory (E_i)
1	Cefotaxim Inj	9532	556	21	Noorcuran inj	240	14
2	O2	13406	782	22	Abocath 22 Abbott	1311	76
3	Disp 3cc	51039	2977	23	Ethilon 10-0	93	5
4	Abocath 20 Abbott	6956	406	24	Cat gut 3/0	15	1
5	Disp 5 cc	44481	2595	25	Oxytoxin inj	3169	185
6	SevoFlurane 20	27	2	26	Cat gut 2/0	14	1
7	Nacl 0.9%	11391	664	27	ATS 1500 UI	148	9
8	Ringer Laktat	9342	545	28	ADS 20000	23	1
9	Tranfusiset	2480	145	29	Dopamin inj	147	9
10	Abocath 24 NIPRO	2986	174	30	Abocath 16 Abbott	51	3
11	Pirasetam 3 g inj	1898	111	31	Aminofilin Inj	365	21
12	Atramat no 1	444	26	32	D 40%	26	2
13	Ceftazidime inj	611	36	33	Vit K Inj	503	29
14	Cefriaxone	1885	110	34	Diazepam Inj	468	27
15	ATS 20000 UI	75	4	35	Lidocain Inj	4445	259
16	Abocath 18 Abbott	1974	115	36	Luminal Inj	51	3
17	Leucoplast 5 cm	1233	72	37	Meylon	166	10
18	Laminaria	377	22	38	MGSO4 40%	239	14
19	Kasa Binda	192	11	39	Phetidin Inj	300	18
20	Bucain spinal inj	335	20	40	Valium Inj	30	2

Source: Data Analysis