

# Inventory Management in Medical Stores of Secondary Care Unit Service Level Hospitals in Northeast of Thailand

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**Abstract.** *Non-profit organizations such as the government hospitals have a core function to provide high quality services for the people and societies. However, most hospitals encountered problems of high cost for inventory controlling for the drugs in the medical stores. This research presents the inventory management model that aims to improve efficient inventory control for the medical stores while enhancing the satisfaction of the service of the secondary care unit service level hospitals in the Northeast of Thailand. The proposed ABC-VED matrix analytical model was proposed to classify and define criticality for the drug items under study. The analytical results obtained from the proposed model showed that the vital and expensive drug category (category I) contained the highest cost by 70.85% (164,056,376 baht) of the total expenditure. In addition, the always used and essential drugs (AE) sub-category I was the most influent category on the cost of the drug control under the study, which affected by 95.75% (157,087,143 baht) of the total expenditure of category I. The analysis based exponential smoothing technique was also adopted to predict the demand of 95 drug items of AE sub-category I and was measured by the economic order quantity (EOQ) and re-order point (ROP) analytical model. The result finally showed that the proposed ABC-VED model could reduce the total costs by 0.046% (6,283,485.72 baht) compared to the conventional First Expire-First Oupt (FEFO) model.*

## Keywords:

ABC-VED matrix, forecasting, EOQ, ROP, government hospitals

## 1. Introduction

Non-profit organizations have the main purpose to provide goods and services for people and societies with limited budgets. The non-profit services given by these organizations for several services, such as health care, education, social protection, transport infrastructure, culture

and arts, extremely affect the quality of people, economies, incomes and so on nationwide; especially, for the developing countries such as Thailand [1].

Health care organizations such as the government hospitals are also the non-profit organizations that are generally required to provide sufficient services covered all parts of the country as much as possible but through the available resources [2]. Nowadays, hospitals have more challenge on not only the increasing demand of services but also the higher quality of service that meets the expectation of patients. Unfortunately, there are some difficulties on the high costs, poor service control and insufficient health care workers [3]. Among these obstacles, the cost of health care system is likely to be the most important factor that leads to low quality in services in many countries; particularly, in government hospitals, non-profit organizations, that are directly assigned to support nation through the official strategies and policies towards health care for all citizens with limited resources. Generally, stock of pharmaceuticals and supplies in the government hospitals are the main costs that shares by 30-40% of the total hospital annual budget [4]. Consequently, medical store inventory management of government hospitals usually focuses on managing this cost efficiently in order to enhance the health care quality of the hospitals as much as possible [5].

As mentioned above, the inventory control of the medical store becomes the core cost for most government hospitals; especially, in the developing countries where most of their annual budgets are limited amount and come only from the government [6]. The expense on pharmaceutical supply chain in health care is also part of this core cost and significantly increases for all the government hospitals [7]. Unfortunately, most hospitals do not have enough research on good management and control for this issue and therefore, it would worth to do research on this issue regarding the control of the stock costs of pharmaceuticals and supplies in their medical store with a more cost-effective way.

There are some research on inventory management that help to improve the overall efficiency of health care organizations with the purpose to effectively utilize the limited budget while enhance the customer satisfaction, by mean of high quality, of the service [8].

The analytical models such as the ABC analysis and VED analyses have widely applied for the medical stores, i.e., categorizing the pharmaceuticals and supplies to achieve more competence by analysis the prioritized inventory matrix to identify inventory management strategy [9]-[12]. The ABC and VED analyses could be also possible to be applied for the health care inventory management in government organizations [13]-[15]. In addition, the ABC and VED analyses also combine with the economic order quantity model (EOQ) to control inventory and calculates the re-order point (ROP) of pharmaceuticals and supplies [16]-[20]. However, as aforementioned, there are only few publications on the health care inventory management that would be the forecasting model by using the ABC analysis and the VED analysis together to improve efficiency of inventory management for the medical stores of the government hospitals [21]-[22].

In Thailand, there are a diverse of diseases appeared in each region of the country (North, Northeast, Central and South) that is because the people in each region has particularity different in living behavior and foods. Thus, drugs used for the people in each region are dissimilarity to the others. In this research will focus on the Northeast of Thailand where the authors are familiar in. There are 22 secondary care service hospitals in the Northeast of Thailand [23]. Some investigations on inventory management in this area are proposed in [24]-[27], but with different analytical tools. This paper proposes a different tool using the application of forecasting model with ABC-VED matrix analysis, which has not been published yet.

Consequently, this research also proposes the constructive inventory management model for the medical stores of secondary care service hospitals using combination of ABC-VED matrix analysis, the forecasting model and the economic order quantity (EOQ) to investigate the improvement in inventory management efficiency and total inventory cost reduction.

## 2. Problem Description

The hospitals under this study are the middle size government hospitals (the secondary care unit service level hospitals) located in the Northeast of Thailand; where their service levels are as the secondary class hospitals with 400 patient beds. There were 658 drug items considered in the medical stores under the study. The focusing time period under the observation was between October, 2016 - September, 2017 which having the total annual drug expenditure of 248,525,357 baht.

Generally, the First Expire-First Out (FEFO) is the currently used model for the medical stores in the hospitals in Thailand. To predict and manage the drug consumption for the next year, they apply average purchasing data from last 3 fiscal years for the estimation. Although the FEFO could be controlled the orders of the drugs used effectively, the pharmacists are still unable to identify the priority of the drugs. Moreover, the medical store manager may not have the suitable inventory management policies for the medical stores. These problems could be minimized by the forecasting model proposed in this paper, which is detailed in the following sections.

## 3. Methodology

This research work starts with the study of current inventory management policy, drug consumption and drug expenditure in the fiscal year 2017 of the medical stores of the government hospitals in the Northeast of Thailand. The implement of the ABC-VED matrix analysis was employed to classify the drugs into category **I**, **II** and **III**. Then, the categorization results of the drugs were used to identify the suitable inventory policy for each category. Next, the sub-category with a high expenditure and clinical importance were selected into consideration. The demand of the selected sub-category was forecasted using the exponential smoothing technique by using the data collected from the last 3 years (October 2014 to September 2016); following by the EOQ technique that was applied to find economic quantity and re-order point. Finally, the comparison of expenditure in the fiscal year 2017 (October, 2016-September, 2017) of the selected sub-category between existed method and proposed model were compared and evaluated. The flowchart of the processes of this research is depicted in Fig. 1.

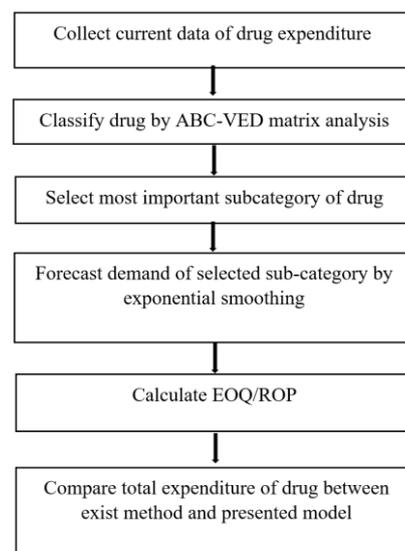


Fig. 1: Research flow process

### 3.1 ABC Analysis

The data of annual consumption and expenditure on each drug items (658 items) in the medical stores for the fiscal year 2017 was collected and recorded in an MS Excel spreadsheet. The annual expenditure for each drug item was calculated by multiplying the unit cost of that drug with its annual consumption. For ABC analysis, the resultant figures were arranged in descending order of drug values. The drugs were then classified into A (Always), B (Better) and C (Control) categories according to the cumulative of drug expenditure percentage of 70 %, 20 %, and 10 % of the total expense, respectively.

### 3.2 VED Analysis

There are 3 groups of the drug items (658 items) in the medical stores that were classified by criticality analysis of all of the drug items: V, E and D groups. The V group (Vital lifesaving drugs) was the group for those drug items which were critically needed as the lifesaving drugs and must be available all the times. The items with less criticality needs as well as those that may be available in the hospitals were classified into the E group (Essential drugs). The items with lowest criticality and shortage may not pose a threat to the health of the patients were included in the D group (Desirable drugs).

### 3.3 ABC-VED Matrix Analysis

The proposed ABC-VED matrix analysis, the data were coupled by the cross-tabulating of the ABC analysis and the VED analysis. The ABC analysis was subjected to the consumption value while the VED analysis was subjected to the clinical importance. Then, the drugs could be classified into 3 categories: **I**, **II** and **III**. The category **I** contained of drug items that were vital and expensive, which were in the mixture of the sub-group of AV, AE, AD, BV and CV. The category **II** contained the drug items that included the essential drugs but having low cost items in the sub-categories BE, CE and BD. The category **III** consisted of the drugs in the sub-category CD that were the desirable drugs but with lowest cost items. It should be noted that the first and the second alphabets of these sub-categories represents the groups of the drug items under the ABC analysis and the VED analysis, respectively.

### 3.4 Forecasting Model

The time series forecasting techniques: exponential smoothing [28] and moving average [29] were adopted to predict the drug consumption in the medical stores in this study. The demand of the drugs in the fiscal year 2016 (October 2015 to September 2016) were collected and used to forecast the drug consumption for the fiscal year 2017 (October, 2016-September, 2017).

Assuming that the demand under the period  $t$ . The exponential smoothing technique can be determined by using (1) while the demand of the forecast can be represented by moving average that is expressed in (2).

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \tag{1}$$

$$F_t = \frac{A_{t-1} + A_{t-2} + A_{t-3} + \dots + A_{t-n}}{n} \tag{2}$$

; where

$F_t$  = forecast demand for period  $t$

$F_{t-1}$  = forecast for the prior period

$A_{t-1}$  = actual demand in prior period

$\alpha$  = smoothing constant

$n$  = number of periods to be averaged

Then, the Mean Absolute Deviation (MAD) technique and the Mean Absolute Percentage Error (MAPE) technique [30] were used to measure the accuracy of the forecasting models, as shown by equations (3)-(4).

$$MAD = \sum_{t=1}^n \frac{|A_t - F_t|}{n} \tag{3}$$

$$MAPE = \frac{100}{n} \sum_{t=1}^n \left| \frac{A_t - F_t}{A_t} \right| \tag{4}$$

### 3.5 EOQ Technique

The Economic Order Quantity (EOQ) is a technique used for calculating economic quantity of order placement. Assumptions of the basic EOQ model are as follows: demand rate and lead time are known and constant, purchase price and transportation cost are constant, and independence of the amount ordered and distance of traveling. The EOQ is generated used to determine the trade-off point between the ordering cost and the holding cost [31]; the ordering cost is the cost occurred from one ordering activity while the holding cost is the additional cost involved in storing and maintaining pieces of inventory in the stores. The basic EOQ ( $Q^*$ ) and the Re-Order Point (ROP) can be calculated by using the following equations:

$$Q^* = \sqrt{\frac{2Kd}{h}} \tag{5}$$

$$ROP = \sqrt{\frac{2K}{dh}} \tag{6}$$

; where  $d$ ,  $K$  and  $h$  are demand (unit/year), ordering cost (baht/order) and holding cost (baht/unit/year), and  $T_c$  is the total cost (baht/unit), which can be calculated using (7).

$$T_c = \frac{dK}{Q^*} + dc + \frac{hQ^*}{2} \tag{7}$$

**4. Results and Discussions**

The hospitals located in the Northeast of Thailand, which are the second class government hospitals with 400 beds. The data collected from their medical stores with the FEFO management for the drug items. There are 658 drug items considered. The time period under the study was the fiscal year 2017 and the total expenditure of drugs was 248,525,357 baht. The analytical results obtained from the tools presented in section 3 are as follows:

The Classification results of 658 drug items using the ABC analysis are shown in Table 1.

**Table 1:** ABC analysis

Analysis parameters	Category			Total
	A	B	C	
No. of items	106	135	417	658
% of items	16.12	20.51	63.37	100
% of annual expenditure	69.96	20.01	10.03	100

By applying the ABC analysis, the category A had 106 items (16.12%) that consuming 173,861,188 baht (69.96%) of the total annual expenditure. The category B has 135 (20.51%) items with 49,738,505 baht (20.01%) of total expenditure, and 417 items (63.37%) belong to the category C with 24,925,665 baht (10.03%) of total expenditure.

Each drug item was defined into V, E, or D category by the medical specialists. There were 72 drug items that the hospital undefined into the VED system. Thus, VED analysis was adopted to classify drug criticality of 586 items shown in Table 2. The results shown that the number of the drugs in the V group was small (8 items) due to the class of the hospitals.

The analytical results from Table 1 and Table 2 could be then transformed into the proposed ABC-VED matrix analysis as shown in Table 3.

**Table 2:** VED analysis

Analysis parameters	Category			Total
	V	E	D	
No. of items	8	550	28	586
% of items	1.37	93.86	4.78	100

**Table 3:** The resultant ABC-VED matrix analysis

	V	E	D	Total
A	1	95	4	100
B	1	118	5	124
C	6	19	337	362
Total	8	232	346	586

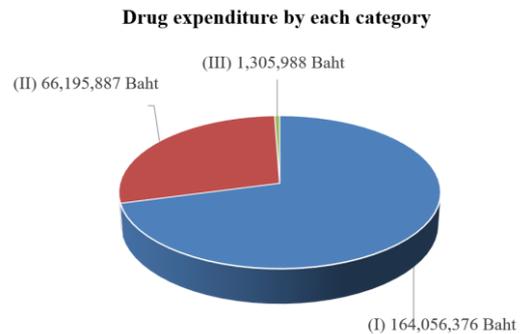
Data from Table 3 can be grouping into **I**, **II** and **III** categories as follows:

Category **I** (AV, AE, AD, BV and CV) shows total of 107 items or 18.26%.

Category **II** (BE, CE and BD) includes of 142 items or 31.06%.

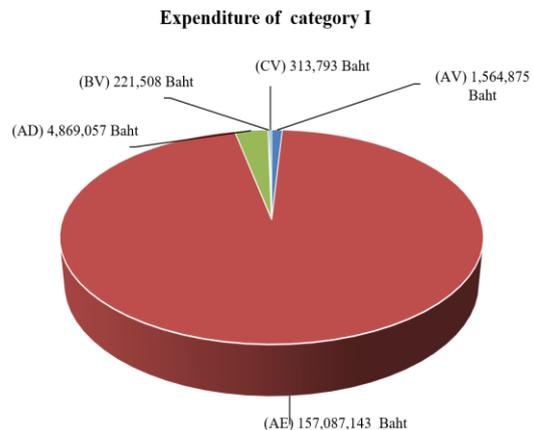
Category **III**, CD subcategory contains of 337 items or 50.68%.

The portion of expenditure of each category is shown in Fig. 2. It can be seen that the category **I** revealed the highest portion of 70.85% (164,056,376 baht) where the category **II** and category **III** contained 28.59% (66,195,887 baht) and 0.56% (1,305,988 baht) of total expenditure, respectively. It could be concluded then that the category **I** requires the topmost management control for whole budget and availability of drugs at the same time.



**Fig. 2:** Value of drug expenditure by each category

Fig. 3 shows details of sub-expenditure of category **I**. It was shown that the AE sub-category contained 95.75% (157,087,143 baht) of the expenditure. The AE sub-category was defined as a group of the essential drugs with high values that should be stored at a lower level but more frequently purchased. Regarding to significant of AE sub-category, forecasting model and EOQ were implemented to predict drug demand and determine order quantity of 95 drug items in this group.



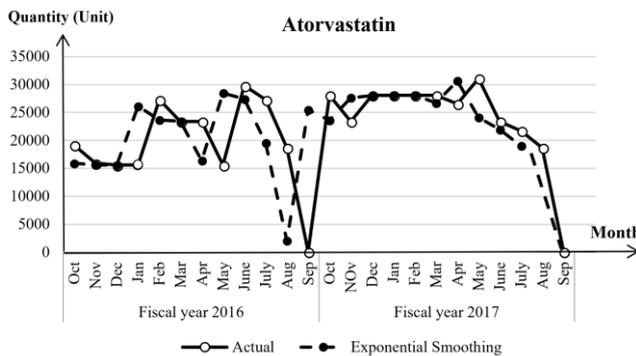
**Fig. 3:** Drug expenditure of category **I**

In this work, the exponential smoothing technique with difference smoothing constant ( $\alpha = 0.1$  and  $0.2$ ) and the moving average technique were applied to predict the demand of 95 drug items contained in the AE of the category I. The accuracy of forecasting model was measured using the MAD and MAPE tools. The comparison of the error indicators of Atorvastatin is shown in table 4.

**Table 4:** Comparison of error indicators of Atorvastatin

Forecasting model	MAD	MAPE
Exponential smoothing ( $\alpha = 0.1$ )	518.19	5.66
Exponential smoothing ( $\alpha = 0.2$ )	991.41	11.49
Moving average	4,002.48	47.67

For all the 95 drug items under the AE sub-category, there are 54 drug items that exponential smoothing with  $\alpha = 0.1$  performs better in the error indicator. There are 40 drug items that were fit for the prediction by the moving average technique. There was only 1 item that was suitable for exponential smoothing with  $\alpha = 0.2$ . Thus, exponential smoothing with  $\alpha = 0.1$  was selected to predict the drug demand of the AE sub-category. The demand forecasting of Atorvastatin expressed in Fig. 4.



**Fig. 4:** Forecasting demand of Atorvastatin using exponential smoothing

The EOQ and ROP of drug items that contained in the AE group were determined by the equations (5) and (6). The total demand of the drugs for the fiscal year 2017 forecasted from exponential smoothing was defined as drug demand ( $d$ ). Ordering cost ( $K$ ) was calculated by expenses of ordering process (preparing order, transportation, receiving, electronic data interchange) shown as 113.24 baht/order. Holding cost ( $h$ ) included of electricity, overtime, salary, and space cost that expressed of 0.03 baht/unit/year.

The example of the EOQ and ROP calculation of Atorvastatin ( $d=285,318$  panels) expressed as follows:

$$Q^* = \sqrt{\frac{2(113.24)(285,318)}{0.03}} = 46,411 \text{ panels}$$

$$ROP = \sqrt{\frac{2(113.24)}{(285,318)(0.03)}} = 0.162 \text{ year (or 1.95 month)}$$

Price of Atorvastatin was therefore 24.97 baht/panel. Thus, total cost ( $T_c$ ) can be determined as follow:

$$T_c = \frac{(285,318)(113.24)}{46,411} + (285,318)(24.97) + \frac{(0.03)(285,318)}{2} = 7,132,613.24 \text{ baht/year}$$

In fiscal year 2017, actual amount of Atorvastatin consumption was 285,300 panels by only once time. Consequently, the actual total cost was 7,135,860.09 baht/year. It was shown that total cost of Atorvastatin was reduced as 3,246.85 baht/year. For all 95 drug items of AE sub-category, forecasting model with EOQ can be reduced total cost of 6,283,485.72 baht or 0.046% by approximately shown in Table 5.

**Table 5:** Comparison total cost of actual and EOQ of AE sub-category

Drug item	Price (Baht/Unit)	Actual $T_c$ (Baht/year)	EOQ $T_c$ (Baht/year)	Diff. (Baht/year)
Atorvastatin	24.97	7,135,860.09	7,132,613.24	3,246.85
Epoetin alpha	590.00	6,495,900.00	6,190,761.70	305,138.30
Sevoflurane	6,322.63	3,433,188.09	2,944,086.68	489,101.41
Gabapentin	5.00	2,310,000.00	2,392,859.52	-82,859.52
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Insulin glargine	72.76	150,977.00	137,576.41	13,400.59
Total		157,087,143.00	150,803,657.28	6,283,485.72

Nevertheless, the drug consumption from the EOQ must be controlled and operated by sufficient safety stock level to prevent shortage of drugs in the medical stores.

### 5. Conclusion

Inventory management is an influence factor affected the service quality of health care organization; especially, in the government hospitals. The inventory classification must be taken into the medical stores to make decision for the inventory control model. The classification using the proposed ABC-VED matrix analysis could be effectively adopted to focus on highly prioritized drug items and to reduce unnecessary time and costs. In addition, the size and service quality of the hospitals are the important issues for the managers to choose the appropriated strategies for the inventory control.

The proposed forecasting technique was also applicable for predicting the demand of drug items. The EOQ could be adopted to determine the economic order quantity and the re-order point. It can be concluded that the proposed model could be reduced the total cost of drug inventory in the medical store of the secondary care service unit, government hospitals.

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## Biography



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