Improving Operational Efficiency of Pharmaceutical Inventory

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Abstract

The pharmaceutical inventory is one of the significant parts involved in hospital operations. However, the limitation of inventory space causes the complexity of inventory control. The purpose of this research is to improve the efficiency of Maharaj Nakorn Chiang Mai Hospital's Pharmaceutical Inventory. The principle of ABC-VED Classification is applied in this research to prioritize the medicine inventory. Moreover, the optimal number of inventory is defined using Economic Order Quantity (EOQ), Safety Stock (SS), and Reorder Point (ROP). The result of the developed models can reduce the total cost by 17.62%, medicine storage by 64.40% and medicine shortages.

Keywords
Inventory Management, Healthcare Logistics, Pharmaceutical Inventory

1. Introduction

Nowadays, every business tends to become more competitive every year (Chonsawat & Sopadang, 2019; Sopadang et al., 2020; Ramingwong et al., 2021), both industrial and service sectors including a hospital that is one of the service businesses. All of these businesses involve logistics activities in their operations (Manopiniwes et al., 2019). All of the logistics activities generate costs. The costliest logistics activities for organizations were transportation activity at 54%, and inventory management at 37%. The problem of inventory cost is one of the most common activities to solve. Inefficient inventory management leads to various problems including high cost, stock difference, and can affect other departments. Systematic inventory management is one of the ways to tackle these problems (Kokemuller, 2016).

Maharaj Nakorn Chiang Mai Hospital, also known as Suan Dok Hospital, is the largest hospital in the northern part of Thailand. The hospital is fully equipped with up-to-date technology. According to the data in 2018, the hospital has served 1,388,373 patients. The number of patients in the hospital has increased every year, which is hard to support. As the result, the hospital requires to provide a variety of medical services including outpatient medical services, inpatient treatment services, accident center, emergency center, and medical excellence center. Moreover, the accidental patients from other northern hospitals were also transferred to Maharaj Nakorn Chiang Mai Hospital.

This research uses the medicine inventory of Maharaj Nakorn Chiang Mai as a case study. The limitation of inventory space causes the complexity of inventory control. It is an objective of this research to reduce the number of medicine shortage, medicine storage, and total cost, using inventory management models, i.e., Economic Order Quantity (EOQ), Safety Stock (SS), and Reorder Point (ROP).

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2. Literature Review

2.1 ABC-VED Classification

The principal of ABC Classification is an analysis to divide the inventory into 3 groups. Group A is the most important one, requiring good control due to its highest cost. Group B is the moderate important group with moderate cost, requiring moderate control. And Group C is the least important group that normally has high volume but the low price. The classification considers the yearly volume of use and product price. (Jacobs et al, 2011)

The principal of VED Classification is another inventory classification customized for medical use, aiming to divide the inventory into 3 groups. Group V is a Vital medicine group, which is very necessary to save the patients' life. Group E is an Essential medicine group, which nearly to being vital. And Group D is a Desirable medicine group, which is the least important of the 3 groups (Sagar, et al., 2020).

According to a literature review related to the ABC-VED Classification, this technique has been applied to healthcare inventory management. For example, Sukhbir Singh et al. (2015) applied the principle of ABC-VED Classification to medical inventory in India's hospital. It is used to identify groups of medicine that needed specific control by using the ABC-VED Matrix analysis tool. The result showed that the processes were more efficient. Similar to the research entitled ABC-VED analysis of expendable medical stores at a tertiary care hospital (Kumar M, & Chakravarty B, 2014), the medicines were divided using ABC-VED Classification to facilitate drug management. The result showed that the classification helped controls and manage goods in inventory more efficiently, more easily, and the storage costs were reduced.

Based on research studies, it shows that the combination of ABC Classification and VED Classification principles can improve inventory management's efficiency and help workers to estimate the amount of each medicine's storage according to the demand and importance. Moreover, this increases the ability to control large inventory, to cover, and to solve the problem in inventory management. ABC Classification and VED Classification will be applied in this research to divide medicine into categories according to their importance and demand.

2.2 Inventory Management Model

The most common inventory management model are Economic Order Quantity (EOQ), Re-Order Point (ROP), and Safety Stock (SS). Where EOQ is the model used to find as the most appropriate number or quantity of orders of each time, aiming to avoid excessive orders that raise the cost or storing goods. Re-Order Point (ROP) is the point to prevent the lack of goods in the inventory, aiming to avoid shortages while waiting for a new batch to defend out of hand while waiting for a new set of goods. Safety Stock (SS) is the amount of the lowest stock in the inventory to prepare goods for customer's needs, aiming to prevent the loss of the goods while waiting for the next shipment.

2.2.1 Economic Order Quantity (EOQ)

EOQ is calculated as the most appropriate number or quantity of orders each time. It will avoid excessive orders that raise the cost or storing goods. EOQ can be calculated from Equation (1).

$$EOQ = \sqrt{(2DS/H)} \qquad (1)$$

D = A year's demand
S = Cost per each order
H = The holding cost per unit per year

2.2.2 Safety Stock (SS)

Safety Stock or otherwise known as the Buffer Stock is the amount of the lowest stock in the inventory to prepare goods for customer's needs and to prevent the loss of the goods while waiting for the next shipment. When the customer's demand exceeds the normal demand level. Safety stock will be used. SS can be calculated from Equation (2).

$$SS = Z_{SL} * \sigma_d \quad (2)$$

Z_{SL} = Z value obtained from opening the table
σ_d = Standard deviation of demand during the order period

2.2.3 Re-Order Point (ROP)

Re-Order Point is the point to prevent the lack of goods in the inventory. The principle of Re-Order Point is when the goods in the inventory have been used up to a certain point, a new order must be ordered immediately to avoid shortages while waiting for a new batch to defend out of hand while waiting for a new set of goods. ROP can be calculated from Equation (3).

$$ROP = (\bar{d}\bar{L}) + SS \quad (3)$$

R = reorder point
$\bar{d}$ = average product demand rate
$\bar{L}$ = Average order length
SS = Safety stock

The inventory model helps to keep the processes in the warehouse run smoothly. If there is too much product in stock, it can lead to sinking costs including the deterioration of products, and storage costs. Therefore, each business has to keep managing their warehouse systematically and efficiently. According to research by Hanafi, et al. (2019) which applying inventory control principles of ROP and SS in motorcycle parts warehouse management, the result showed that the cost could be reduced.

For the research related to the application in the hospital, it was widely popular because the hospital must reserve sufficient medicine for the patient. Inventory management principles are applied in the hospital's medicine warehouse facility to prevent unnecessary purchases. In research entitled improving healthcare warehouse operations through 5S, VSM and 5S principles, these models were used to redefine quantities and ordering points. The result showed that the storage space was increased by 16% (Venkateswaran et al., 2013). The research entitled the development of an inventory management system for the Royal Thai Air Force medical depot (SukSrisomboon, 2007) also improved medicine warehouse by applying the principle of EOQ with ROP to control the purchasing order and the number of medicine in the warehouse. The inventory cost was reduced.

In this research, the inventory model is used to reduce medicine storage in the inventory, and calculate the minimum stock to prevent shortages and expired medicines.

3. Methods

This research focused on the medicine in inventory, the demand, the number of orders, and medicine issuing in the year 2019. The limitation of inventory storage criteria in Maharaj Nakorn Chiang Mai Hospital was also investigated. The research started from ABC-VED analysis to classify the medicine into 9 groups. Then, significant medicines from the classified result are used to identify suitable inventory. Next, the EOQ technique is applied to find EOQ, ROP, and SS. The demand is taken from data collected in the last 3 years (Oct. 2016-Sep. 2019). The data was analyzed using Microsoft Excel. Finally, real data and model data are compared to identify if there is an improvement. The processes of this research are shown in Figure 1.

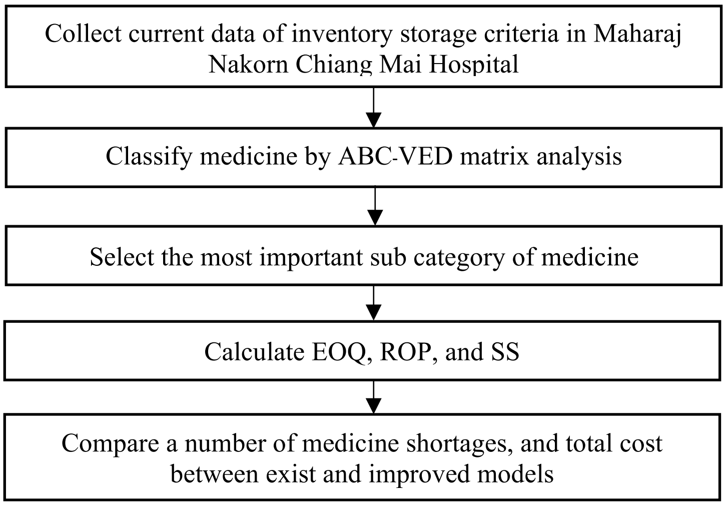

Figure 1: Research process flow

3.1 VED Classification

There are a total of 1,365 items in the case study inventory. The medicine will be divided into 3 groups classified by its importance; V, E, and D respectively. The V group, i.e., Vital, is a life-saving drug and cannot be replaced with an alternative drug. The E group (i.e. Essential) is a necessary drug in which the lack of it will not cause any fatal cases. And the D group (i.e. Desirable) is a drug that relieves symptoms and can be replaced by other drugs if there is a shortage in order.

3.2 ABC Classification

The medicine will be divided into 3 groups, classified by its frequency and extent of use (per month) of 2019, i.e., A, B, and C respectively. Group A is the drug that is highly used in both volume and frequency. Group B is a drug with moderate quantity and frequency of use. And group C is a drug with the lowest use and the lowest frequency.

3.3 ABC-VED Matrix Analysis

Multi-criteria analysis is based on two factors, i.e., VED Classification and ABC Classification. ABC analysis concerns the amount of demand and frequency of use. VED analysis concern the importance of medicine. The medicine will be divided into 3 groups, i.e., I, II, and III. Group I will focus on a very important and highest level (AV, AE, AD, BV, and CV). Group II is the moderately important group, and the middle level used (BE, BD, and CE). Group III is the least important and the lowest level used (CD). The ABC-VED Matrix is shown in Table 1.

Table 1: ABC-VED Matrix

	V	E	D	
A	AV	AE	AD	I
B	BV	BE	BD	II
C	CV	CE	CD	III

4. Results and Discussion

The data collected from the medicine inventory of Maharaj Nakorn Chiang Mai Hospital in 2019. There are 1,365 items. The result of using principle ABC, VED, and ABC-VED matrix analysis are shown in Tables 1,2, and 3.

Table 2: ABC analysis

Analysis Parameter	Category			Total
	A	B	C	
No. of items	80	186	1,099	1,365
% of items	5.86	13.63	80.51	100
%of annual consumption	58.81	28.36	12.82	100

The result of the ABC analysis in Table 2 shows that out of 1,365 items in the medicine list, 80 items can be considered Class-A. They account for 5.86% of the total items. The demand is 4,396,909 units, accounting for 58.81% of the total demand. There are 186 items in class B, accounting for 2,120,607 units or 28.36% of the total demand. Then, there are 1,099 items in class C. The demand is 958,701 units or 12.82% of the total demand. Figure 2 shows the cumulative percentage of inventory items.

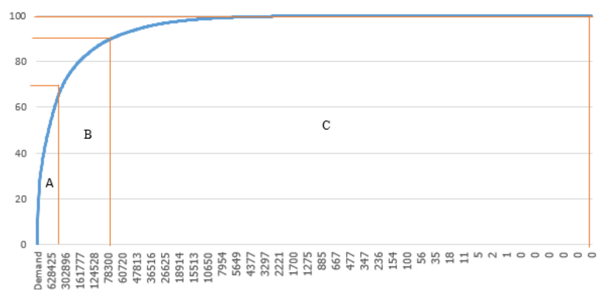

Figure 2: ABC Pareto of medicines inventory

Table 3: VED analysis

Analysis Parameter	Category			Total
	V	E	D	
No. of items	18	706	641	1,365
% of items	1.32	51.72	46.96	100

The medicine was classified into V, E, and D categories, shown in Table 3. The result shows that out of 1,365 items, there are 18 items (1.32% of items) in Vital items (V). There are 706 items in Essential items (E). And there are 641 items in Desirable (D).

The result of Tables 2 and 3 can be clustered into the proposed ABC-VED matrix analysis in Table 4. The medicine can be grouping into 3 groups (I, II, and III). There are 98 items (7.18%) in **I** group (AV, AE, AD, BV, and CV). There are 751 items (55.02%) in **II** group (BE, BD, and CE). There are 516 items (37.80%) in **III** group (CD).

Table 4: ABC-VED matrix analysis

	V	E	D	Total
A	0	52	28	80
B	0	89	97	186
C	18	565	516	1,099
Total	18	706	641	1,365

The EOQ, ROP, and SS of medicine items are determined by the equations (1), (2), and (3). The total demand for medicine was defined as demand (D). Ordering cost (Co) is calculated by the activity in the ordering process including ordering cost, transportation cost, electronic data exchange cost, and document cost, and is assumed at 740 THB per order. Holding cost (Cc) included salary, space, equipment, electricity, and other related costs.

The sample of calculation of medicine code FOLT02 with demand in the year 2019 of 2,888,000 units is expressed as follows:

$$Q = \sqrt{\frac{2(2888000)(740)}{0.0066}}$$

$= 988,000$ units per time

$$SS = (1.04) * (41427.76)$$

$= 43097.08$ units

$$ROP = (8022.22) * (12) + 43097.08$$

$= 139363.74$ units

The total cost can be calculated from Equation (4). Of interest, the factors for calculated total cost are Ordering cost (Co) and Holding cost (Cc). Here, the total cost (TC) only considers the main logistics cost. Medicine cost and administrative logistics cost are excluded. FOLT02 was used to be sample as follow:

$$TC = \frac{CoD}{Q} + \frac{CcQ}{2} \quad (4)$$

$$TC = \left(\frac{740*2888000}{988000}\right)+\left(\frac{0.0066*988000}{2}\right)$$

$TC = 11,918$ THB per year

In the year 2019, the actual demand for FOLT02 was 2,888,000 units and the actual total cost was 13,060 THB/year. When using the EOQ model, the total cost was reduced to 11,918 THB/year, a saving of 1,1,42 THB/year. For 80 medicines in AE and AD groups, the EOQ model can reduce the total cost from 1,613,317 THB to 1,329,092 THB. The saving is 17.62%, shown in Table 5.

Table 5: The comparison of actual total cost and EOQ total cost of AE and AD groups.

Code	Actual TC (THB/year)	EOQ TC (THB/year)	Saving (THB/year)
FOLT02	13,060	11,918	1,142
PRET05	11,892	9,665	2,227
BCOT01	12,268	9,401	2,867
MADT03	79,818	72,279	7,539
METT03	10,275	3,759	6,516
. . .	. . .	. . .	. . .
ZIMT01	8,867	5,132	3,736
Total	1,613,317	1,329,092	284,225

Considering medicine storage, FOLT02 is used as an example here. The actual inventory was shown in Figure 3. While the forecasting storage by EOQ model was shown in Figure 4. The actual average storage was 1,403,071 units in the year 2019. Comparing to the EOQ model, the average storage can be reduced to 499,500 units per. The storage for FOLT02 can be reduced by 64.40%, shown in Table 6.

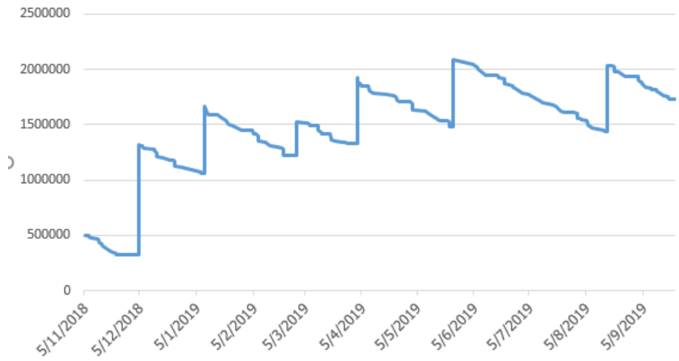

Figure 3: The actual storage of FOLT02

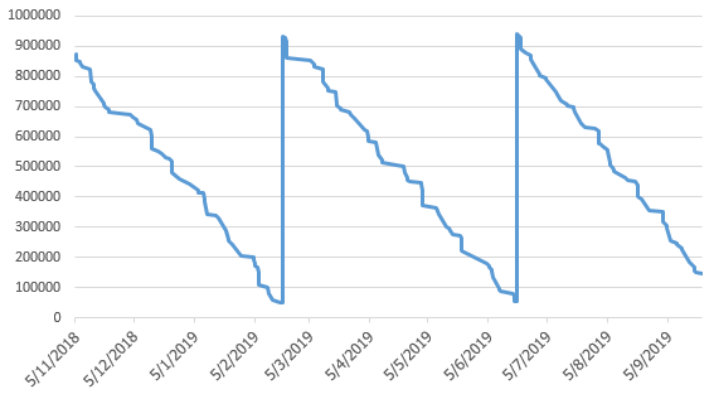

Figure 4: The EOQ model of FOLT02

Table 6: The comparison number of actual storage and proposed model of FOLT02.

FOLT02	Actual storage (units)	Proposed Model (units)
Average Storage	1,403,071.42	499,500

Considering medicine shortages that has occurred a few times in the year 2019, however, it can be crutial. Here, BCOT01 is used as an example of the calculation. In the middle of May 2019, the BCOT01 was in shortage, see Figure 5. If the proposed model was used, this problem can be solved. The result was shown in Figure 6. There would be no shortage.

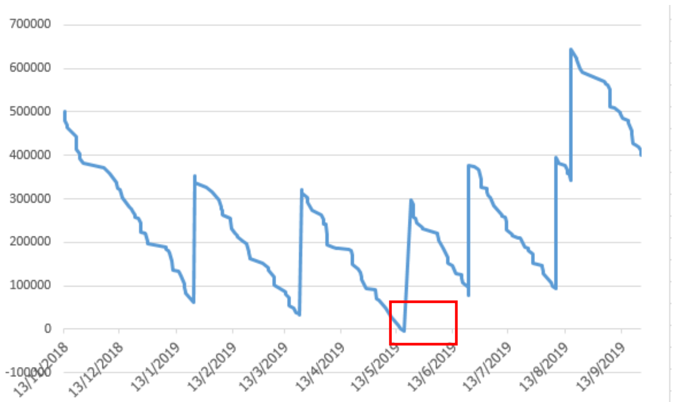

Figure 5: The actual usage of BCOT01

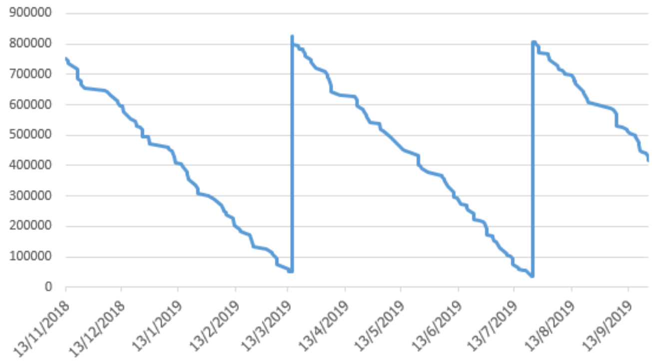

Figure 6: The EOQ model of BCOT01

5. Conclusion

The improvement of medicine inventory in Maharaj Nakorn Chiang Mai Hospital started from ABC-VED classification dividing the medicine into 9 groups according to their significance. Then, significant medicine is used to identify a suitable inventory. The result showed that 80 items are the most required. The inventory model is then applied to identify Economic Order Quantity (EOQ), Re-Order Point (ROP), and Safety Stock (SS). After applying these techniques, the actual data and model data are compared. The result found that the model can reduce the total cost by 17.62%, reduce the number of medicine storage by 64.40%, and it can improve medicine shortage.

Acknowledgments

The authors gratefully Maharaj Nakorn Chiang Mai Hospital for the data support, Graduate School of Chiang Mai University for the general and financial support, assistance of the Pharmacist and subject experts who suggested and provided content, guidgline and review include: Assist.Prof.Nantawarn Kitikannakorn, Ph.D., Dr.Anutra Khangtragool, Miss. Anongnart Teeyasuntranonn and Miss Jatuporn Jaikla.

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