INVENTORY MANAGEMENT USING DEMAND FORECASTING MODELFOR MEDICAL SUPPLIES IN SURGERY DEPARTMENT

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Abstract—The objective of this study is to improve inventory management for medical supplies in the surgery department at a hospital. There are problems, such as high variations, less inventory turnover rate and high unnecessary cost, caused by unknown statuses of medical supplies and lack of demand forecasting. The countermeasures comprises of, first, using ABC analysis to classify the categories of medical supplies; and, second, usinga demand forecasting model. The ABC classification analysis shows that the percentage of items (percentage of value) are8.35%(78.30%), 35.73%(12.70%), and 55.92%(9.00%)for A, B, and C category items respectively. Then, the category A is classified into 4 subcategories based on the Average Demand Interval (ADI) and the Square Coefficient of Variation (CV^2). The erratic demand (A-3) and lumpy demand (A-4) subcategory, which have high variation, are chosen to forecast demand. Afterthe demand forecasting model is presented, trend-corrected exponential smoothing model (Holt's model) is chosen for demand forecasting of these medical supplies inventory. The result of the improvement shows that the variation, turnover rate and unnecessary cost are improved 21.97%, 5.00%, and 50.34% respectively.

Index Terms– Inventory management, ABC analysis, Demand forecasting.

I. INTRODUCTION

Approximately 35% of thehospital's annual budget is spent on buying materials and medical supplies, including medicines [1]. The rising costs of drugs and medical supplies directly affect the total expenses of the hospital. Thus, inventory management should be developed in a cost effective manner [2], which supports enough products to each department. However, overstocking causes more financial problems and spends more time to resolve. Conversely, medical supply shortages can affect treatment, delay medical processes, and may result in medication error [3]. Thus, over and unnecessary stocking of medical supplies and lower stocking should be prevented [4].

This hospital inventory has a lot of medical supplies and high variation, which means that the inventory management is difficult to keep track of them all. The classification of medical supplies by ABC analysis is important since ABC analysis prioritizes the special items. When the special items are identified, these items areforecasted by proper demand forecasting technique.

Therefore, the objective of this studyis toimprove the inventory management for medical supplies of a hospital in Thailand whichhas inefficient inventory management.

II. METHODOLOGY

Phase 1 *Problem identification*
The major cause of problemsis inefficient inventory management. Historical data showthat a lot of medical supplies expire before use. They also have high variation (unstable demand), less inventory turnover rate, and high unnecessary costs. After using why-why-analysis theory, it is found that the roots of problem are the unknown status of medical supplies and lack of demand forecasting (Fig. 1)

Phase 2 *Problem solving*
There are a lot of medical supplies. Therefore, tracking all of them is unachievable. Therefore, the classification by ABC analysis is necessary. The special items are monitored and planned to forecast.

a) ABC Analysis
The annual consumption of all the medical supplies was calculated after multiplying unit by forecast annual value of individual items was arranged in descending order. After that, the items cumulative cost of all the items was calculated, as well as the cumulative percentage of the items. The medical supplies were classified into three categories: A, B and C. The cumulative cost percentage of A, B, and C were 70%, 20%, and 10% respectively [5]. In addition, this study applied variationto calculate [6].

b) Demand forecasting
In order to develop an appropriate inventory control, demand forecasting is highly needed. The major forecasting technique in healthcare setting is historical data which is employed to determine the future demand[7]. However, forecasting the accurate demand for drug and medical supplies is difficult [8]. One of the problems regarding this situation is the lack ofprecise data for medical supplies consumption [9]. Moreover, different uncertainties for predicting the demand. To deal with this, demand patterns analysis was done first. Then, The mathematical modeling for describing and simulating those patterns was developed [10].

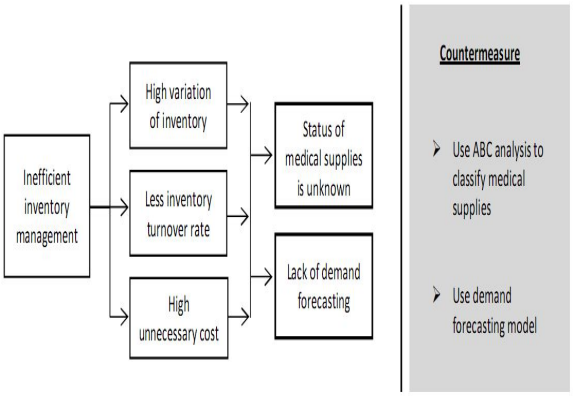

Fig. 1Why Why Analysis

Category	Items	% of items	Annual value	
			฿	%
A	72	8.35	10,080,738	78.30
B	308	35.73	1,635,062	12.70
C	482	55.92	1,158,705	9.00
Total	**862**	**100.00**	**12,874,504**	**100.00**

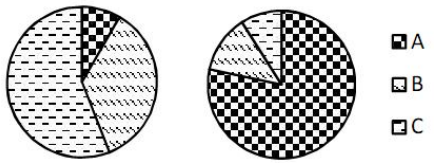

Fig. 2Proportion of ABC category by number of items (left) and forecast annual value (Right)

Phase 3 *Monitoring and evaluation*

After the ABC analysis and Demand forecasting were done, it is found that there were some special items needed to be monitored closely.

The present study was conducted of medical supplies in a minor store of the department of surgery. The medical supplies comprise of 862 items. In the Fig. 2, the total forecast annual value of medical suppliesfromFebruary 2013 to January 2014 was 12,874,504 ฿

Forecasting Techniques :

a) Moving average

Pro : Simple to calculate

Con **:** Not suitable for data which have the trend

b) Simple exponential smoothing (SES)

Pro: Simple to calculate and outlier was eliminated

Con**:** Not suitable for data which have the trendand outliers will always have some impact

c) Trend-corrected exponential smoothing (Holt's model)

Pro: Suitable for the trend series

Con**:** Not simple to calculate

Trend-seasonality-corrected exponential smoothing (Winter's model)

Pro: Suitable for data have the trend and seasonality series

Con**:** Not simple to calculate

Measures of forecast error are used to find a suitable technique for medical supplies. This comprise as follows;

- Mean absolute deviation (MAD): measures the size of error in forecast. It is calculated average errorin the same unit.
- Mean absolute percentage error (MAPE) **:**same MAD but calculated in percentage of error.
- Tracking signal (TS) :used to indicates amount of bias in forecasting model

Calculation :

➢ *Mean absolute deviation (MAD)*

$$MAD = \frac{\sum_{t=1}^{n}|Y_t - Y_i|}{n} \quad (1)$$

➢ *Mean absolute percentage error (MAPE)*

$$MAD = \frac{\sum_{t=1}^{n}\left|\frac{Y_t - Y_i}{Y_t}\right|}{n} \times 100 \quad (2)$$

➢ *Tracking signal (TS)*

$$TS = \frac{\sum_{t=1}^{n}|Y_t - Y_i|}{MAD} \quad (3)$$

Where :

$Y_t = Demand\ forcast\ in\ period\ \ time$
$Y_i = Actual\ in\ period\ time$
$n = The\ total\ number$

➢ *Square coefficient of Variation(CV^2)*

$$CV^2 = \left[\frac{SD}{\bar{X}}\right]^2 \quad (4)$$

➢ *Average demand interval (ADI)*

$$ADI = \frac{Demand}{Day} \quad (5)$$

➢ *Variance (σ^2)*

$$\sigma^2 = \frac{\sum(X - \bar{X})^2}{N-1} \quad (6)$$

Where :

$SD = Standard\ Deviation$
$\sigma^2 = Sample\ Variance$
$X = Sample$
$\bar{X} = Sample\ Mean$

$$N = Variance$$

- *Turnover Rate (TR)*

$$TR = \frac{No.into\ Stock - Existing\ Stock}{No.into\ Stock} \times 100\% \quad (7)$$

- *Unnecessary Cost (UC)*

$$UC = A_i \times B_i \quad (8)$$

Where:

$$A_i = Number\ of\ item\ expired$$
$$B_i = Cost\ of\ item\ expired$$

III. RESULTS

The category A was classified into 4 subcategories based on the average demand interval (ADI) and the square coefficient of variation (CV^2) calculated demand values comprising: Smooth demand (A-1), Intermittent Demand (A-2), Erratic Demand (A-3), and Lumpy Demand (A-4) (Fig. 3)
Erratic demand (A-3) and Lumpy Demand (A-4) have high variable (>0.5) and was forecasted in several technique. [11-12]

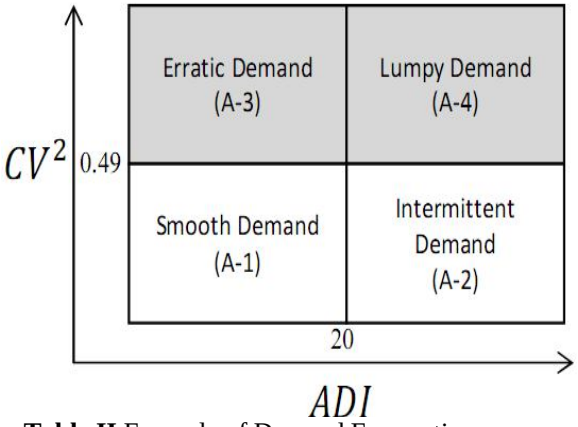

Fig.3Subcategories of demand patterns

Table II Example of Demand Forecasting

No.Item	Forecasting Method	MAD	MAPE (%)	TS Range
6510-976-49	Moving Average	23	35	/
	SES	21	44	/
	Holt's Model	18	36	/
	Winter Model	24	38	/
6510-914-05	**Moving Average**	6	25	/
	SES	8	26	/
	Holt's Model	8	24	/
	Winter Model	8	30	/
6530-049-68	Moving Average	130	119	/
	SES	110	132	/
	Holt's Model	102	120	/
	Winter Model	114	118	/
6510-900-167	Moving Average	88	44	/
	SES	78	30	/
	Holt's Model	68	18	/
	Winter Model	69	25	/
6510-976-16	Moving Average	3	28	/
	SES	4	26	/
	Holt's Model	2	18	/
	Winter Model	2	18	/
6510-229-08	Moving Average	305	28	/
	SES	380	30	/
	Holt's Model	212	32	/
	Winter Model	280	18	/
6530-049-165	Moving Average	105	140	/
	SES	88	94	/
	Holt's Model	90	75	/
	Winter Model	88	130	/
6510-040-09	Moving Average	8	15	/
	SES	12	18	/
	Holt's Model	10	8	/
	Winter Model	20	9	/
6510-040-13	Moving Average	307	45	/
	SES	324	63	/
	Holt's Model	252	38	/
	Winter Model	318	58	/

Table I The demand patterns of A category

Subcategory	Pattern of use	CV^2	ADI	No. of items	Example
A-1	smooth Demand	< 0.5	<20	34	ETHIBOND, MERSILK, PROLENE
A-2	intermittent Demand	< 0.5	>20	20	SURGIPRO, VASCUFIL, MONOPLUS
A-3	Erratic Demand	> 0.5	<20	6	VICRYL, MONOCRYL
A-4	Lumpy Demand	> 0.5	>20	12	PGA

Table III Results of improvement of A-3 and A-4 subcategories by Holt's model

No.	Parameter	Existing	Forecasted value	% of Improvement
1	Variation	34.68%	27.06%	21.97
2	Turnover Rate	82.46%	86.58%	5.00
3	Unnecessary Cost(฿)	2,192,888.14	1,089,076.96	50.34

Table II shows TS Rank of example item. This in between -6 to 6 it means that all the forecasting technique is acceptable. However, trend-corrected exponential smoothing has several smallest MAD and MAPE forA-3 and A-4 subcategories.

MAD is the mean of absolute deviations over all periods while MAPE is the average absolute error as the percentage of the demand. The smaller the value of MAD and MAPE is more accurate forecast in forecasting model.

The Holt's model most selected from Table II and can be described as appropriate technique for medical supplies demand forecasting in surgery department at hospital.

The result of improvement show that the variation, turnover rate and unnecessary cost were improved 21.97%, 5.00%, and 50.34% respectively.(see Table III)

DISCUSSION & CONCLUSION

The results of the present study show that the existing system of inventory management of medical supplies in surgery department at hospital is not much efficient. Historical data during 2013-2014 show that this store still hashigh variations, less inventory turnover rate and high unnecessary cost which are causedby unknown status of medical supplies and the lack of demand forecasting.There is a need of application of scientific inventory management tools for effective and efficient management of the medical supplies store and close supervision on items belonging to important categories. ABC analysis theory and demand forecasting technique can help identify the medical supplies requiring stringent control for optimal use of funds and avoid out-of-stockand expiration date situations in the medical supply store. The result of improvement show that the variation, turnover rate and unnecessary cost were improved 21.97%, 5.00%, and 50.34% respectively. Further study can be done by simulating inventory with forecast demand to find an appropriate inventory model.

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