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, using a demand forecasting model. The ABC classification analysis shows that the percentage of items (percentage of value) are 8.35%(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. After the 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 the hospital’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 are forecasted by proper demand forecasting technique.

Therefore, the objective of this study is to improve the inventory management for medical supplies of a hospital in Thailand which has inefficient inventory management.

II. METHODOLOGY

Phase 1 Problem identification

The major cause of problems is inefficient inventory management. Historical data show that 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 variation to 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 of precise 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].
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 supplies from February 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 trend and 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 error in 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)**
  \[ \text{MAD} = \frac{\sum_{i=1}^{n} |Y_i - \hat{Y}_i|}{n} \]  
  (1)

- **Mean absolute percentage error (MAPE)**
  \[ \text{MAPE} = \frac{\sum_{i=1}^{n} \frac{|Y_i - \hat{Y}_i|}{Y_i}}{n} \times 100 \]  
  (2)

- **Tracking signal (TS)**
  \[ \text{TS} = \frac{\sum_{i=1}^{n} |Y_i - \hat{Y}_i|}{\text{MAD}} \]  
  (3)

Where:

- \( Y_i = \text{Demand forecast in period time} \)
- \( \hat{Y}_i = \text{Actual in period time} \)
- \( n = \text{The total number} \)

- **Square coefficient of Variation (CV²)**
  \[ CV^2 = \left( \frac{\text{SD}}{\bar{X}} \right)^2 \]  
  (4)

- **Average demand interval (ADI)**
  \[ ADI = \frac{\text{Demand}}{\text{Day}} \]  
  (5)

- **Variance (σ²)**
  \[ \sigma^2 = \frac{\sum_{i=1}^{N} (X_i - \bar{X})^2}{N-1} \]  
  (6)

Where:

- SD = Standard Deviation
- \( \sigma^2 = \text{Sample Variance} \)
- \( X = \text{Sample} \)
- \( \bar{X} = \text{Sample Mean} \)
\[ N = \text{Variance} \]

- **Turnover Rate (TR)**
  \[ TR = \frac{\text{No into Stock} - \text{Existing Stock}}{\text{No into Stock}} \times 100\% \quad (7) \]

- **Unnecessary Cost (UC)**
  \[ UC = A_i \times B_i \quad (8) \]

Where:

\[ A_i = \text{Number of item expired} \]
\[ B_i = \text{Cost of item expired} \]

### III. RESULTS

The category A was classified into 4 subcategories based on the average demand interval (ADI) and the square coefficient of variation (CV²) 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.3](image)

### Table II Example of Demand Forecasting

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Pattern of use</th>
<th>CV²</th>
<th>ADI</th>
<th>No. of items</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>Smooth Demand</td>
<td>&lt;0.5</td>
<td>&lt;20</td>
<td>34</td>
<td>ETHIBOND, MERSILK, PROLENE</td>
</tr>
<tr>
<td>A-2</td>
<td>Intermittent Demand</td>
<td>&lt;0.5</td>
<td>&gt;20</td>
<td>20</td>
<td>SURGIPRO, VASCUFIL, MONOPLUS</td>
</tr>
<tr>
<td>A-3</td>
<td>Erratic Demand</td>
<td>&gt;0.5</td>
<td>&lt;20</td>
<td>6</td>
<td>VICRYL, MONOCRYL</td>
</tr>
<tr>
<td>A-4</td>
<td>Lumpy Demand</td>
<td>&gt;0.5</td>
<td>&gt;20</td>
<td>12</td>
<td>PGA</td>
</tr>
</tbody>
</table>

### Table III Results of improvement of A-3 and A-4 subcategories by Holt’s model
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 for A-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 hashish variations, less inventory turnover rate and high unnecessary cost which are caused by 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-stock and 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.

**REFERENCES**


