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FINAL THESIS REPORT

DRUG INVENTORY CONTROL
Case: Thai International Hospital Mahasarakham

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ABSTRACT

This final thesis was conducted for Thai International Hospital Maharakham, a medium sized private hospital, located in the northeastern region of Thailand. Since drug expenditure is the main component of the hospital's spending, drug inventory control is an interesting area to study.

The objectives of this research were to analyze the current process of drug inventory control and to find possibility for improvement. Therefore, this paper serves as a proposal to propose the feasible improvement to the pharmacy department. The study was conducted by using qualitative research method. Relevant information was collected from both primary and secondary sources. Literature review, observation at premises and interviews were also carried out during the research. Relevant theories that could be applied to drug inventory management were presented.

After exploring and analyzing the current routine in the hospital pharmacy store, the main concerns were related to purchasing process. It was found that reorder point and order quantity were determined based on arbitrary policy. Findings of this thesis regarding inventory control showed that items in the pharmacy store should be classified and prioritized. Coupling of ABC and VEN analyses has proved to be an efficient and effective tool to classify medicinal products. The matrix retrieved from the combination of these two classification methods can ease up the inventory management by narrowing down number of items that need special attention and high level management.

Different inventory methods such as ROP, EOQ, fixed order interval approach and two-bin analysis were presented and explained. Nine drug groups, generated from coupling ABC and VEN, require different inventory methods and types of management. Therefore, utilization of inventory methods should be decided based on their suitability. The results of this thesis presented two primary steps for implementing drug inventory control. The study can propose the possibilities to improve drug inventory management in the hospital pharmacy.

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Key words: Drug Inventory Control   ABC Classification   VEN Classification

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List of Abbreviations

ABC	ABC Classification on basis of consumption value of item
EOQ	Economic Order Quantity
FEFO	First Expire – First Out
IPD	Inpatient Department
JIT	Just in Time
MoPH	Ministry of Public Health
OPD	Outpatient Department
OTB	Open to Buy Budget Method
ROP	Reorder Point
VEN	Vital, Essential, Nonessential
WHO	World Health Organization

I Introduction

This final thesis was conducted for Thai International Hospital Maharakham, a medium sized private hospital, located in the northeastern region of Thailand. The hospital's accounting report shows that drug expenditure is the main component of hospital's spending of pharmaceutical supplies. Therefore, the thesis is directed towards identifying opportunities for improvement of inventory control in the hospital pharmacy.

The first goal of the research was to analyze the current process of drug inventory control, in order to find possibilities for improvement. After studying and analyzing the current process in the pharmacy department, there were two main issues regarding inventory control, namely order quantity and reorder point – they are calculated and determined based on arbitrary policy. Also, it was discovered that drugs are not classified which makes controlling inventory more difficult. This fact led to identifying the more specific targets for the research to find the feasible solutions for these matters.

The main objective for the thesis was identified based on the main findings of inventory problems. The goal of the research is to find the suitable methods to classify drug inventory and to suggest utilization of different inventory control methods to each drug categories. Taking these methods into use will lead to the practical solutions to facilitate better performance of hospital pharmacy regarding drug inventory control.

In order to achieve the research goal the work began with observing and analyzing the current processes and activities of drug inventory management and decision making in inventory control. Literature with relevant topics were reviewed and studied in order to apply the suitable theories to hospital daily life. Discussions between the author and responsible persons from involved parties were carried out thorough out the research. Qualitative method was mostly used for the research by collecting primary information via observations at premises and interviews, and secondary information from organizational database and literature reviews.

This thesis is structured as follows. In Chapter II, the related theories and relevant studies are reviewed. The chapter begins with general information of private hospitals in Thailand and some important figures. Supply chain management and information about drug inventory classification are then presented. Different inventory control systems used for medicinal products are also discussed in this chapter.

Chapter III contains observations and analysis of the current process of inventory control in the hospital pharmacy. The problems that the pharmacy staff have encountered are also stated in this part. Research result and practical solutions are analyzed and discussed in Chapter IV. Finally, in Chapter V conclusions and recommendations are proposed for improving drug inventory control.

II Literature Review

1 Public Hospitals in Thailand

Thailand is well known as one of the most popular tourist destinations. Recently, it is also labelled as a destination for medical tourism. With an affordable, friendly and standard medical treatments and services, Thailand has led the growing medical tourism market in Asia without a doubt. In response, healthcare in Thailand has been rapidly growing in terms of personnel, technology and expenditure.

Thai healthcare facilities[1] are generally divided into public and private sectors. Operation of both public and private sectors are run under support and control of Ministry of Public Health (MoPH) which is the official core agency of Thai public health system. Since this final thesis is conducted for a private hospital, gathered information rather concentrates on the private sector.

According to the latest report provided by MoPH, proportions of hospitals by the agency, private hospital accounts for 24,4 % in 2005, declining from 27,9 % in 1998. With regards to proportions of hospital beds, private hospitals hold 20,2 % in 2005, compared to a slightly greater number of 23,2 % in 1998. However, when concentrating on a regional comparison, the report revealed that most of hospitals in Bangkok are private hospitals whose proportion accounted for 66,9 %.

Considering a decline in numbers of private hospitals and proportion of beds, this has led to another question whether demand for using private hospital also declined. On the contrary, figures from MoPH showed that household spending at private health facilities (clinics and hospitals) had a rising trend form 48,1 % in 1998 to 57,7 % in 2004 (information of 2005 was not available). The numbers implied that private hospitals play an important role in healthcare industry in Thailand. Demand for private hospital has been constantly growing even though there was a slightly decrease in number of facilities and beds.

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[1] Healthcare facilities refer to pharmacies, clinics, medical premises and hospitals.

When looking at trends in overall health expenditure spent by healthcare facilities, health expenditures in Thailand were on a rapid upward trend during 1995 - 2005. Thailand's drug expenditure is considered the main component of national health expenditures. In 2000, Thailand has spent 34,16 % of its total health spending on medicinal products and it has increased to 42.84 % in 2005. Almost 50 % of the allocated budget for health supplies was spent on hospital care. The trends of health care budget spent by hospitals have been on the rise. Regarding the sections of expenditure, hospitals spent 40.819, 49.222 and 57.994 million baht in 2005, 2006 and 2007 respectively.

The great numbers of national drug expenditures have led to a growing interest in pharmaceutical management. However, when searching for relevant information regarding drug inventory control in Thailand, number of existing information and researches is quite limited. With relevant information gathered, it is obvious that supply chain management and inventory control play important role in healthcare industry. Poor management in any level of healthcare facilities can more or less has a negative impact on supply system as a whole.

2 Supply Chain Management

Many theorists have given the definitions for the term supply chain management. One of them that can describe the term supply chain management really well and it seems to cover all related activities is that; (Basu & Wright 2008, 5)[2]

Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements.

As the definition implies, supply chain management has been developed for customers who play the most important role in businesses. Especially in this globalization era, customers, ever more demanding and powerful than before, are seeking for products and services with higher criteria. In order to meet customers' requirements and satisfactions, companies have to be proactive against globalized markets which can be changed and influenced by several factors. With an increase of use of technology like internet, some claim that there is no more geography in business nowadays. Offshore production, collaboration between international companies, and openness of the global market are the significance of the global environment. Supply chain management can therefore be labelled as global supply chain management in today's environment (Coyle, Bardi and Langley 2003, 9)

Based on the concept of supply chain management, it requires integration of many business components. In 1985, Michael Porter introduced and described his new concept for business management, the value chain. The concept of value chain has developed as a tool for competitive analysis and strategy. It is comprised of inbound and outbound logistics which are the primary components of this business model. The more integrated marketing, sales and production are also the important jigsaws that contribute 'value' to firm's customers.

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[2] Original source: Simchi-Levi, D., Kakinsky, P. and Simchi-Levi, E. 2003. *Designing and Managing the Supply Chain,* 2nd edn, McGraw-Hill, London.
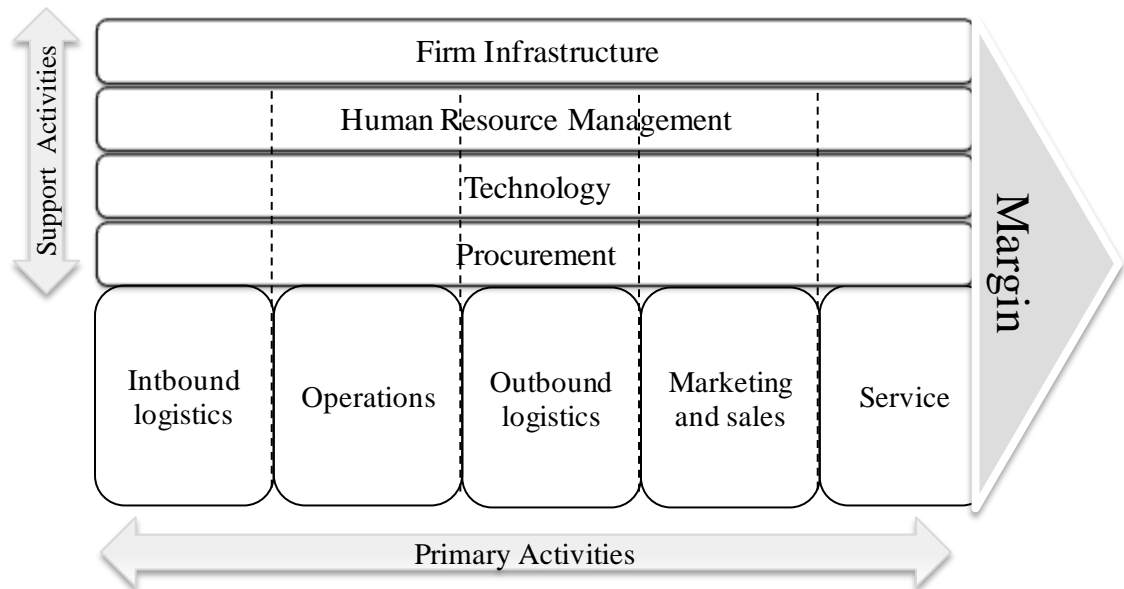
Figure 1: The Value Chain (Coyle al et. 2003, 15)[3]

With regards to the movement of product and information, there are two approaches in supply chain management that have been widely used namely, push and pull business models.

2.1 Push System

Push system is referred when raw materials are stored before production and products are produced to stock before orders are placed. The action is stimulated by demand estimation or demand forecast. Products and information flow the same way, from seller to buyer. Communication carried out in the supply chain of this approach can be either interactive or non-interactive since customers or buyers do not always response to messages sent by producer or sellers. For example, there is no direct feedback from customers after message in advertisement was sent by vendors through media channels. Push system, typical and traditional, is still widely utilized by many firms in different industries.

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[3] Original source: Porter, M. 1985. *Competitive Advantage*. New York: The Free Press. p.37

2.2 Pull System

Pull system, on the other hand, is used in response to confirmed orders. Products are produced after or at production planning stage. Therefore, stock does not contain finished goods, but semi-finished materials. Customers send their requirements and place orders to producers or sellers. The requested product is pulled through the delivery channel. Communication carried out in pull system is usually interactive. Pull model is also widely used inside the same firm, for instance, a department sends an internal order to the other department to manufacturer an item that is needed in their work process.

Pull system includes just-in-time (JIT) which is an inventory strategy to improve to improve business' inventory turnover by bringing inventory to a minimum. JIT strategy considers inventory as waste, its emphasis therefore is ensure that supplies are delivered at when and to where they are needed.

3 Inventory Control

Inventory control is challenging in business. Managing inventory control can directly affect business performance. The reason for having inventories or stocks is to buffer against demand and supply. Having too much inventory on hand means high holding cost, and having too little leads to a rise in ordering cost. Therefore, inventory management should be well planned in order to achieve the lowest possible total cost.

Even though inventory is considered as a negative impact in business since large proportion of total expenses is generated here, but having inventory is still a must for many kinds of business. Managing and controlling inventory are compulsory practices for firms that seek for profitability. The goals for controlling inventory are minimizing the total cost and maximizing service level by balancing demand and supply. There are several approaches involved in managing inventory. Businesses are characterized by two distinguished systems, push and pull. JIT is a pull system while EOQ (Economic Order Quantity) includes elements of push strategies in proactive manner.

When it comes to hospital pharmacy, being proactive is the most crucial qualification. Generally, order or demand is not confirmed beforehand since number of patients is really difficult to predict. However, it is predictable in some cases, for instance, diabetic and HIV patients who must regularly get treatments and constantly require particular medicines. Hence, push system is mostly used in hospital pharmacy and some other healthcare facilities since drugs must be available when they are needed.

Medicinal products are really unique compared to the other commodities since they deal with illness and life saving. It is common for warehouse managers to try to reduce inventory level and minimize the total cost. Sometimes, this leads to falling in service level. Inventory management in hospital is handled differently compared to some other organizations in healthcare industry since hospitals do not seek for a big margin from drug sales. Inventory in hospitals should be therefore managed a bit differently. Service level should be the first priority, then minimizing costs and losses.

3.1 Rationale for Having Inventory

- Economies of scale can be obtained by purchasing large volumes which allows cost reduction of per unit fixed cost. Also, transportation can get economies of scale through utilization by moving larger volume of products.

- Balancing supply and demand is another important reason for having inventory. If supply is seasonal, inventory can help meet demand when materials or products are not available. Vice versa, if there is an occurrence of seasonal demand, firms must accumulate inventory in advance to meet demand in the future.

- Specialization can bring economies of scale to manufacturers by long production run. Instead of producing a variety of products, each plant can product a product and ship to customers or other warehouse.

- Protection from uncertainties is a primary reason for holding inventory. Having stock on hand can reduce risk of shortage or stockout situation which might lead to lost sales and lack of reliability. Customer can possibly buy products from competitors instead.

3.2 Inventory Costs

Inventory is associated with three major costs as follows.

- Ordering Cost covers all costs occurring during the ordering processes of one order regardless of volume or quantity ordered. It includes costs and time spent on requesting for quotations, entering purchase order, approving order, checking received order, invoicing, making payment and reviewing order report. Ordering cost might not be a big component of the total cost for firms but considering time spent on one order and management efforts, ordering cost should be therefore properly reduced. Not only can saving in ordering cost bring the total cost down, some other costs such as wages (less staff required) is also cut.

- Holding Cost is divided into three categories namely risk costs, storage costs and finance costs. Risk costs include deterioration, obsolescence, damage and theft. Storage costs are associated with renting, building, racking, special storage such refrigeration, and handling costs. Finally, finance costs include interest on money invested in inventories and insurance.

- Stockout Cost is the cost of not having products available or enough when they are demanded by customers. It might be difficult to calculate this cost. For example, stockout cost causes losing in sales both current and future since customers might turn to competitors. Stockout cost in some organization such as hospital might be greater than the other types of organization.
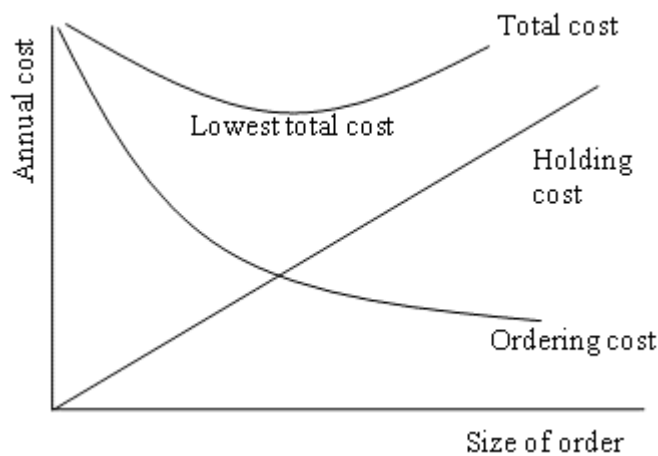
Figure 2: Cost Trade-offs

Figure 2 illustrates the general relationship of holding cost and ordering cost. The tendency of holding and ordering costs are generally opposed to each other. Different sizes of order have a significant impact to the total cost. The lowest total cost can be obtained at the most suitable order quantity which can be determined by balancing holding and ordering costs. However, the other types of costs can also affect the total cost depending on different logistic processes such as, transportation, shortage, or in-transit inventory carrying costs.

4 Classifying Inventory

Different inventory procedures have been developed to enhance inventory management in different purposes. With multiple product lines a firm has, inventory needs to be classified before making decision about inventory methods. When it comes to pharmaceutical products, there are several procedures to classify the inventory with regards to different basis, for example, value of consumption, criticality, consumption pattern and source or supply. Two types of classification that can be utilized for drug inventory are described below.

4.1 ABC Classification

ABC analysis is one the most widely used tool for materials management. It is also known as Pareto's Law or "80 – 20 Rule" (Coyle et al. 2003, 208). This classification has been conducted and developed by Vilfredo Pareto, an Italian philosopher and economist. He observed that a very large percentage of total national income and wealth was concentrated on a small percentage of population. This rule of thumb expresses that 80 % of total value is accounted by 20 % of items. This analysis is considered a universal principle. It is therefore widely used in many situations of businesses.

- Class A represents 20 % of materials in inventory and 75 % of the inventory value.
- Class B represents 30 % of materials in inventory and 15 % of the inventory value.
- Class C represents 50 % of material in inventory and only 10 % of inventory value.

According to ABC classification, it suggests that the more analysis should be applied to materials with high inventory value. Class A should be most extensively handled and Class C is analyzed little (Gaither & Grazier 1999, 566). Advantage of ABC classification is that controlling small numbers of items amounting to 10-20 % will result in the control of 75-80 % of the monetary value of the inventory held.

If items in the inventory are not classified, managing and handling materials would be very expensive since equal attention is given to all items. Having classified the inventory, different levels of control can be assigned to items in the different classes. V. Venkat Reddy (Managing a Modern Hospital. 2008, 151) has explained the selective

control procedures for ABC classification used in hospital pharmacy as follows.

Very strict control procedures should be used with A items and the controller should have great authority. Inventory held in safety stock should be very low or none compensated with more frequent order placements. Consumption control and product movement should be reviewed regularly – weekly or daily. Number of sources for high valued items should be increase in order to ensure good supplier performance and reduction in lead time. Purchases of items should be centralized.

Class B can be controlled by middle management. Low safety stock policy is applied to this class with quarterly or monthly orders. Past consumption can be used a basis for calculating order quantity. There should be two or four reliable suppliers to ensure that lead time is reduced.

Power can be delegated to user department to determine stock level. Class C items do not need to be highly controlled. Since the items have the lowest value compared to the class A and B, orders can be placed at a greater volume to take advantage of quantity discount. Rough estimates are sufficient to manage class C materials.

Although ABC analysis suggests putting great clerical effort on class A items, importance of class B and C however should not be overlooked. Especially in hospital pharmacy, there might be medicines from A, B and C in one prescription. Short of class C drug can lead to a failure in medical treatment if it is vital for the illness.

4.2 VEN Classification

VEN classification is a method that pays attention to criticality of drugs. Drugs are categorized into three groups based on basis of priority and importance to patients' health.

- ▪ V – Vital drugs potentially involve lifesaving. They have significant withdrawal side effects. Drugs that are crucial to providing basic health services are included in this group as well.

- E – Essential drugs: An effectiveness of this group is less severe when compared to vital drugs but they are significant for illnesses.

- N – Nonessential drugs: They are used for minor or self – limited illness. Drugs that are still questionable about their efficacy also belong to this class. High cost drugs for marginal therapeutic advantage are also an addition.

To identify drugs by using this approach, a panel of pharmacists, doctors with different specializations should be set up since opinions can differ. Drugs which appear in all categories are identified as vital. Items which fall into vital and essential are marked as vital and ones which appear in essential and nonessential are classified as essential. This technique allows staff to be able to manage different degree of management to control inventory. The degree of importance of procurement and control procedures reduces from vital to nonessential drugs.

5 Methods of Inventory Control

Many approaches are used in order to control inventory. Choosing a method to use in business must be carefully considered and analyzed based on its comprehensiveness. In healthcare facilities, there are several methods employed to control inventory and to facilitate procurement's policy. Each method has different objectives and procedures. Selecting and utilizing methods of inventory control depends on feasibility and suitability. Several factors are involved in making decision regarding utilization of inventory methods such as, budget, technology and personnel. In a hospital pharmacy, a combination of different methods is recommended because of numerous drugs in the inventory. Methods of inventory control are summarized as follows:

5.1 Open-to-Buy (OTB) Budget

Open-to-Buy (OTB) Budget Method is an inventory control method with regards to purchasing policy. It limits purchases to a specific amount of fund available at a specific period. The emphasis of OTB method is financial control of pharmacy inventory. The monthly amount of fund provided for expenditure is approximately equal to the best estimate of previous month's use. Although, it is useful in monitoring and adjusting the financial value of the inventory, it is recommended to combine other methods for a total inventory management system.

5.2 Short-List Method

Short-List Method's emphasis is to provide accurate and timely inventory information to the person who is responsible for order placement. Items with short supply are identified and added to the list when the inventory level reaches the reorder point. This method works well when there is a duplicate of stock maintained and monitored by other inventory control methods.

5.3 Stock Record Card

Stock Record Card Method is used to record information about movement of products in the storage area. It is also used to monitor inventory level and facilitate order

initiation. Stock record card usually contains essential information with regards to receiving and issuing drugs.

5.4 Fixed Order Quantity Approach

(Under the Condition of Certainty)

Under the condition of certainty when lead time and demand are certain, fixed order quantity approach can be applied to determine order quantity. As the name implies, order is placed at a fixed quantity which is calculated based on product cost and its demand characteristics. Inventory carrying and ordering costs are the main components of this equation. Two systems to determine fixed order quantity are discussed.

5.4.1 Two-Bin System

The two bin system, one of fixed order quantity approaches, allows firms to develop minimum stock level and determine reorder point. It works so that products are placed into two bins, when one is empty a new order should be placed. The amount of product in the second bin is the fixed quantity that should be ordered. Volume in each bin can be determined by knowing an average usage per day and lead time of a particular product.

5.4.2 Simple Economic Order Quantity Model

Economic Order Quantity (EOQ) is one of the most popular formulas used for calculating quantity of order placement. EOQ is formulated to get trade-off point on basis of regular relationship between ordering cost and carrying cost. Before employing this method to determine an order quantity, there are several assumptions that should be taken into account as follows:

- There is a continuous, constant, and known demand rate.
- The lead time cycle is known and constant.
- The constant purchase price is independent of the amount ordered.
- Transportation costs are constant no matter the amount moved or the distance traveled.

- There is no inventory in transit.
- All inventory parts are independent of each other.
- The planning horizon is infinite.
- There is no limit of the amount of capital available (Bloomberg, LeMay & Hanna, 2002, 149-150)[4].

$$Q = \sqrt{\frac{2RA}{VW}}$$

Where:

Q order quantity

A ordering cost/one order

R annual demand for the product

W annual inventory carrying cost expressed as a %age of the product's cost

V average cost or value of one unit of inventory

According to Coyle, Bari & Langley (2003, 229), some may feel that simple EOQ model is too simplistic and it might lead to consequent inaccurate result. However, they have mentioned that the simple EOQ method is chosen to use instead of the complex one for several reasons:

- Adopting more complex analysis would cost more since demand variation is so small.
- Data is too limited to formulate sophisticated methods for firm that just develops inventory models.
- Changes in input variables will not significantly affect simple EOQ's result.
- It is also suitable for products with constant price or discount is not offered.

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[4] Original source: Coyle, John J. Bardi, Edward J. & Langley Jr., C. John. 1992. *The Management of Business Logistics, 5th ed.* St. Pual, M: West publishing Company

5.5 Fixed Order Quantity Approach

(Under the Condition of Uncertainty)

An existence of uncertainties seems to be a very common and regular situation in business. Uncertainty includes change in demand, damage during transportation and delay delivery, for example. If there is an uncertainty of demand, EOQ therefore has to be adjusted to buffer against uncertain business atmosphere. Reorder point (ROP) also needs to be taken into account when both demand and lead time vary. ROP calculation is not anymore straightforward when there is an occurrence of delay in delivery and fluctuation in demand. Safety stock is also discussed and analyzed to protect shortage supply and response to fluctuated demand during lead time.

5.5.1 Adjusted Economic Order Quantity

In a business environment, fluctuation in demand is a common situation. Especially in healthcare industry where demand cannot be accurately forecasted since it depends on several external factors. Regarding hospital pharmacy, there are several key factors, both internal and external, that affect inventory level in the pharmacy store. During the observation at premise, factors affecting demand and usage of medicines can be illustrated in figure 3. All of these factors can influence fluctuation in drug consumption rate in hospital pharmacy, some internal factor, for instance, prescribers' preference, can be controlled, but it is impossible to control some external factors.
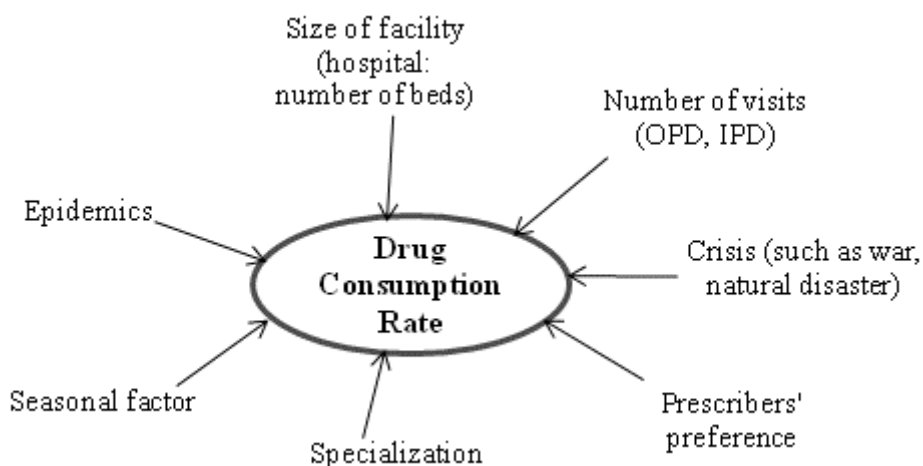

Figure 3: Factors Influence Pharmaceutical Consumption Rate in Hospital Pharmacy

As previously noted regarding the restrictive assumptions of simple EOQ model, the situation that would meet all the assumptions is an ideal. Since uncertainty in demand seems to be the situation encountered the most, EOQ model should be fixed to cope with this uncertainty. As the emphasis of this adjusted formula is demand, the other assumptions applied to simple EOQ therefore still exist.

$$Q = \sqrt{\frac{2R(A+G)}{VW}}$$

Where:

Q order quantity

A ordering cost/one order

G expected stockout cost per cycle (expected shorts in units*stockout cost per unit)

R annual demand for the product

W annual inventory carrying cost expressed as a %age of the product's cost

V average cost or value of one unit of inventory

5.5.2 Reorder Point

When there is an existence of demand fluctuation, EOQ formula is adjusted to get the most appropriate order quantity. However, many firms do not find constant and promising lead time so common. Hence ROP model which helps protect service level and prevent stockout should be reformulated as well.

In an organization like hospital, medicines and other health supplies must be on hand at all times so that treatments and life saving can be handled. Stockout is a great penalty and it should not happen. Thus, ROP should be carefully determined.

Reorder point = Cycle stock + Safety stock

Two types of stocks are taken into account when it comes to determination of ROP.

Cycle Stock

Cycle stock is the estimate quantity of an item that will be sold or used during the time that takes until the new order arrives from the supplier (lead time). When lead time and demand are known and constant, firms can simply calculate cycle stock by multiplying daily demand by lead time in days. However, when length of lead time is not promised, cycle stock can be formulated as follow:

$$\overline{X} = \overline{R}\left(\overline{X}_{LT}\right)$$

Where:

$\overline{X}$ mean (average) demand during lead time

$\overline{R}$ mean (average) daily demand

$\overline{X}_{LT}$ mean (average) lead time length

Safety Stock

Safety stock is added to the method of ROP to reduce risk when a delay in delivery and fluctuation in demand during lead time take place. A simple Two-bin System is used to decide reorder point. The new order is placed when the first item in the second bin is used. This method is suitable in the situation when demand and lead time are constant. Most of cases, the situation might not be promising, hence safety stock is considered as the third bin to protect business from uncertainty. When comparing to cycle stock, safety stock is a bit trickier to calculate since there are several methods to determine safety stock. Results from different methods can vary. It therefore depends on how much we would want to have on hand during the replenishment cycle.

A simple method used to determine safety stock is (Guan, Hansen & Mowen 2009, 764):

Safety stock = (Maximum usage − Average usage)* Lead time

However, this method might give an exaggerating result if there is a big gap between

maximum usage and average usage. One can end up holding too much inventory on hand more than required. This formula is thus suitable for items whose demand rate is more constant.

Another way to determine safety stock which is a bit more sophisticated than the previous one is standard deviation method. It also takes standard deviation of demand and lead time into account. The equation of determining safety stock is as follow:

$$\sigma = \sqrt{\overline{X}_{LT}\left(\sigma_R\right)^2 + \overline{R}^2\left(\sigma_{LT}\right)^2}$$

Where:

σ standard deviation of demand during lead time

$\overline{X}_{LT}$ mean (average) lead time length

σ_R standard deviation of daily demand

$\overline{R}$ mean (average) daily demand

σ_{LT} standard deviation of lead time length

Associated with cycle stock and safety stock, ROP can be determined by combining cycle stock and safety stock at the required service level. Equation of ROP is formulated below.

$$\text{ROP} = \overline{X} + n\sigma$$

n variable value of standard deviation

According to the normal distribution, if 'n' is 1, the probability that demand during lead time will not exceed the available inventory is approximately 84.13 %. At 2 and 3 standard deviations, the stockout protection level reveals at 97.72 % and 99.87 % respectively.

5.6 Fixed Order Interval Approach

Fixed order interval approach or also called fixed period approach is a technique that order is placed at fixed intervals. The inventory level must be first determined. How

much to order is based on the outstanding of inventory on hand, and then an order is placed to bring up the stock level back to the predetermined inventory level. With an assumption that demand and lead time are constant and known in advance, order will be placed at the same quantity every time. On the contrary, if either demand or lead time varies, the quantity of each order placed will be different as well.

This technique is not costly since it does not require a close control of inventory level. This method is good with low-valued products that can be ordered infrequently and at large quantity. But it might not be the best approach for high-valued items or items with seasonal demand.

According to Handbook of Supply Management at First-Level Healthcare Facilities (WHO 2006), the method suggested to use in healthcare facility is pretty similar to fixed order interval approach. The inventory level is determined by calculating an average of monthly demand using past consumption record. Then, the frequency of received deliveries must be decided, once a month, every three months or every six months. Finally, multiplying item's average monthly consumption by suggested reorder factor to determine inventory level. Order is placed at a quantity that will bring the inventory up to the desired level. Therefore, the order volume varies at times depending on how much the current inventory on hand is.

The reorder factor is 2 if supplies are delivered once a month, 6 if supplies are delivered every 3 months and the reorder factor is 12 if supplies are delivered every 6 months.

If the healthcare facility decides to receive delivery every month, then the reorder factor is 2. If an average monthly consumption of a medicine is 15 packages a month, it means that the inventory level of this item is set to 30 packages (15*2). When the inventory level falls down at, for instance, 6 packages, hence the order is placed at 24 packages to bring inventory back to the predetermined level.

6 Relevant Research Works

V. R. Thawani et al. (2003) have studied about economic analysis of drug expenditure in Government Medical College hospital, Nagpur, India. The research was conducted for a public hospital whose allocated budget is quite limited. ABC and VEN classifications have been successfully implemented in the studied hospital. They derived the matrix of drugs prioritization by coupling ABC and VEN classifications. Different management procedures are used with the different categories. For example, they have suggested that CV group can be procured once a year and stored to save management efforts. AD drugs which consumes significant budget should be controlled by using EOQ method to determine order quantity. After these methods have been introduced to the hospital, there are noticeable improvements in many ways such as financial management, drug availability and reduction in expenditures and emergency local purchases.

Chungsiwapornpong (2007) has conducted her master thesis regarding drug inventory control process and performance among hospital pharmacy departments in Thailand. The survey has been responded by 309 respondents which accounted for 42.92 % of the total of 720 hospitals. The survey results were presented based on 9 important indicators with regards to drug inventory process and drug inventory performance. Based on her findings, ABC and VEN systems were the powerful and effective tools for hospital pharmacies. The survey results showed that hospitals that adopted ABC and VEN approaches have better performance than the ones without. The percentage of stockout situations at private hospitals using VEN analysis (0,99 %) was less than private hospitals without this inventory classification (3,94 %). Also the average months of drug inventory in the hospitals with ABC and VEN was less than the hospital that did not utilize these methods. In addition to this, the hospitals that used minimum-maximum stock level, EOQ and reorder point methods have lower inventory level. In conclusion, it is recommended for hospitals to determine the format of inventory management reports and develop useful methods of inventory control such as, EOQ, ABC, VEN and JIT.

III Case Study

1 Organization profile

Thai International Hospital Mahasarakham is a medium-size private hospital located in Mahasarakham, a small province in the north east of Thailand. As of December 2009, the hospital has 50 beds with 3 full-time doctors, 20 part-time doctors and 104 employees.

With 936.854 in habitants, Mahasarakham is relatively small compared to the other provinces in Thailand. There are two hospitals in the province, Thai International Hospital Mahasarakham and Mahasarakham hospital which is the main public hospital. Since the public hospitals alone cannot accommodate and cope with numerous patients, the private section plays important role in Thailand's medical services. With advantages of fast and friendly service as well as high standard medical treatments, an increasing numbers of both Thai and foreign patients are seeking for healthcare in private sector.

The hospital was founded in 1995 under its old name, Mahasarakham Medical Centre Hospital. In March 2009, it was acquired and changed the official name to Thai International Hospital Mahasarakham. The new management team has operated since then with the aim of improving both core and support services of the hospital. During the operational year of 2008, there were 28.823 visits of OPD (outpatient department) patients, 1.688 visits of IPD (inpatient department) patients. There are eight departments for medical services division namely:

- Surgery
- Medicine
- Obstetrics and gynecology (OB/GYN)
- Paediatrics
- Dentistry
- Anaesthesia
- Eye
- Ear, throat and nose

1.1 Pharmacy Department

Pharmacy department of Thai International Hospital Mahasarakham is an essential department of medical support service. The main responsibilities are ensuring the delivery of safe, high quality and cost effective medicines to customers (patients). The major roles of the department include procurement, storage, dispensing, and controlling inventory.

1.2 Pharmacy Store

The pharmacy store is served as a main warehouse for pharmaceutical commodities. It is set up to facilitate order initiation by delivering required medicines to outpatient and inpatient units. Outpatient dispensing unit is open 24 hours to support the clinical service for outpatients, and inpatient storage handles internal requirements of medicine requested by different wards in the hospital.

1.3 Categorization of Drugs Items

There are approximately 730 types items in pharmacy store. All commodities are categorized based on their substantial forms as follows.

- Tablets
- Capsules
- Injections
- Liquids
- Ointments
- Drops
- Powders
- Fluids
- Miscellaneous
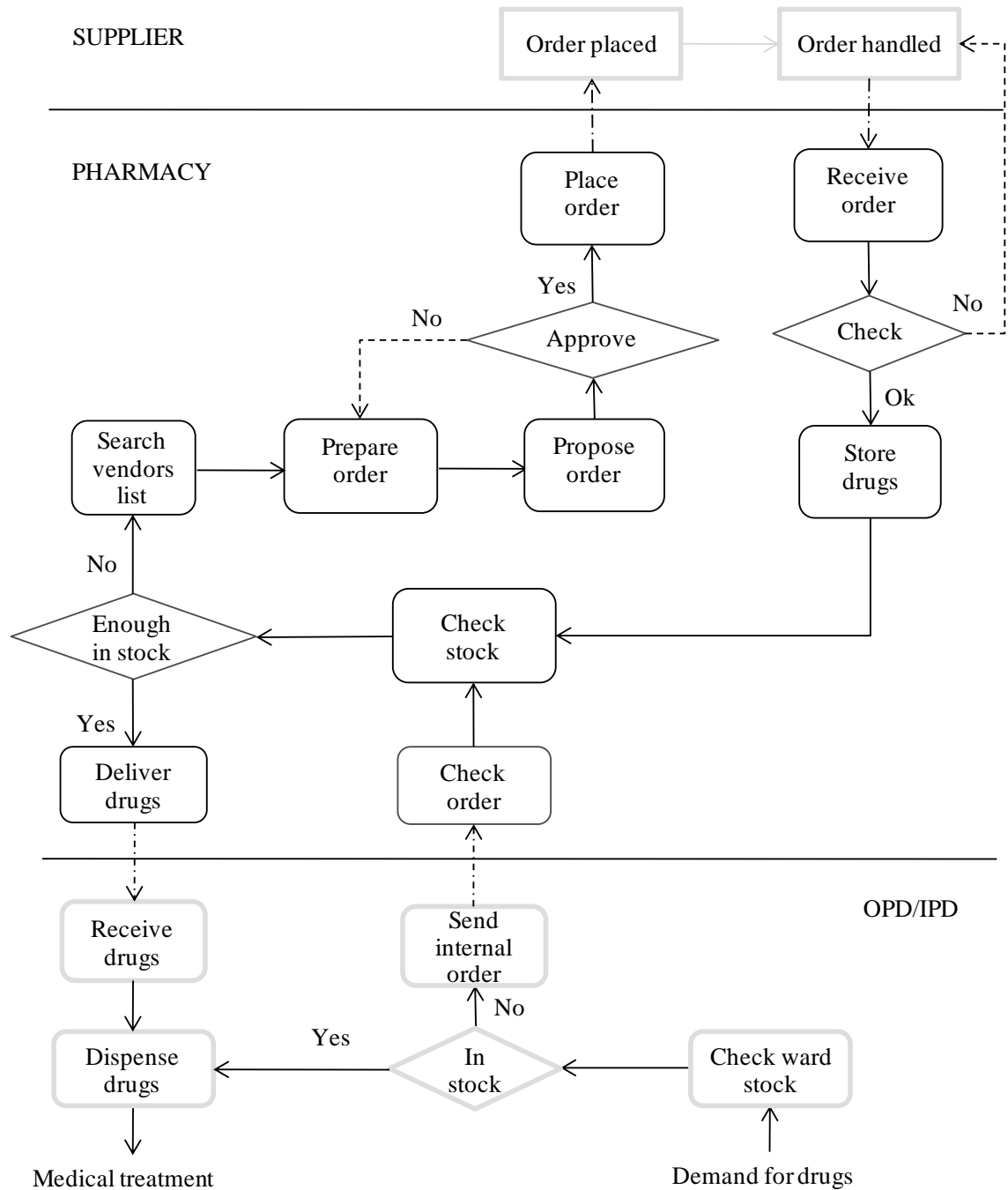
2 Current Processes

Figure 4: Regular Inventory Routine

In order to identify difficulties and find a room for improvement, the current process of drug inventory management must be observed and analyzed. To better understand the whole process that the pharmacy department has to function regarding inbound and outbound logistic activities, the flow of activities of regular ordering routine is summarized and illustrated in figure 4.

The pharmacy department acts as a middle party between suppliers and distributors (OPD and IPD departments). The main responsibilities that the pharmacy has to perform are engaged with procurement process and inventory management, in which several activities are involved. The major activities regarding regular inventory process are purchasing, receiving, storing, issuing, monitoring, reporting and waste management.

2.1 Purchasing

In the pharmacy department of Thai International Hospital, pharmacists also perform as purchasers, and store keepers. When the on hand inventory level cannot fulfill the estimated internal orders, purchasing process must be performed. The responsible persons decide when to reorder an item by roughly estimating usage during the replenishment cycle. There is no standard policy to determine the reorder point. Instead, the purchasing activity can be done since the pharmacy staff are accustomed with the current process and demand. Purchasing process is comprised of confirming quotation, preparing order document, and placing order.

In addition to the database of hospital information system, there is also an excel format of complete drug list which includes all the updated quotations. However, an existing quotation is sometimes confirmed again by telephone before preparing order documents to ensure that the price is still valid. Regarding the quotations, most of them are offered at fixed price regardless of order size. There is only a small number of items where discount is offered at a larger quantity, for instance, every purchase of 10 packages receives 1 package extra. Moreover, almost every vendor has a minimum price of 1000 baht per an order. In another word, several items can be consolidated in the same order so that the sum amount can reach the requirement of minimum order.

After the quotation is checked or confirmed, the order documents must be prepared for approval. Determining order quantity which is one of the most crucial decisions in managing inventory happens at this stage. As earlier described in section II, there are several methods to determine order quantity with different purposes. However, it is found that the order quantity is managed based on arbitrary policy, but it somewhat relies on recent past consumption.

After preparing the order documents, the order will be proposed for approval. If selected item and quantity are agreed, the order will be approved by the medical director and placed by the responsible pharmacist. In case of disagreement for any reason, the proposed order will be sent back to pharmacy department for reconsideration and modification.

Records of order placements are input into paper-based order status which contains information of date of placement, date of receive, item list, price, amount, supplier contact information.

2.2 Receiving

After gathering the history of order placements for 4,5 months back (17 July -1 December 2009), it was found that lead times vary from 1 to 30 days, depending on items and suppliers. It is noticeable that lead time of some smaller suppliers is more fluctuated than the bigger vendors'. However, those sources whose lead time is worse offer more competitive price.

Delivery and transportation are carried out by suppliers. When an order arrives at the premise from supplier, it is usually accompanied with invoice and packing list. The responsible staff will check the order to ensure that quantities, prices, and conditions of products meet the requirements. Then, medicines or vaccines will be shelved. At this stage, the order placement report is marked as received in the order placement report and the information of the received order is input in the database and stock record card.

If there is any item that is damaged or expired, the pharmacy staff will contact the sales representative to handle the expired stock. The replacement process will be organized

by supplier by delivering new items and picking up the unwanted ones.

2.3 Storing

Storing process of the pharmacy store follows the policy recommended by WHO. Products are arranged in the storage area to facilitate first expire-first out procedure (FEFO). Drugs with earlier expiry date will be placed first in front of products with later expiry date so that it is easy to pick up.

There are approximately 730 items (as of December 2009) including vaccines. All the medicinal products are stored on shelves in alphabetical order with their generic names. Items that require low temperature are stored in the refrigerators. Every single item is accompanied with its stock record card which serves as a tool to control the product flows. Stock record card contains information of quantity received, quantity issued, present balance and signature of responsible person. In addition to the attached stock record card, the inventory is also classified by yearly shelf life by using color codes. The expiration periods are symbolized by using stickers in different colors attached to the location of each item. .

2.4 Issuing

Prescribing and dispensing medicines are separate activities. Medicines are prescribed in clinical area and prescription document is brought to dispensing area to withdraw medicines. The hospital's operation is divided into two divisions, inpatient and outpatient departments. In order to facilitate the operation, each department has its own medicine storages. When a demand for a drug occurs, the nursing staff will check if there is availability in the sub-store. If it is not available, an internal order will be placed to the pharmacy department. Then, requested commodity is transferred from the main warehouse to OPD and IPD storages to start medical treatment. All the medicines are dispensed based on FEFO policy. Whenever an item is taken from the main store, the stock record card of that item must be updated by filling the information about date of issue, quantity issued, current outstanding balance, and signature of responsible person. Usually, medicines are delivered to OPD and IPD storages in a bigger measurement unit such as box, there are for example 200 tablets in a box. The pharmacy store, OPD and

IPD storages are separate and the pharmacy store does not know the current inventory level of the sub-stores. This sometimes brings a difficulty to the pharmacist when determining order quantity.

2.5 Monitoring

There is no such a position of store keeper being responsible for inventory management. Inventory control is handled by pharmacists and nursing staff. Combination of inventory control methods used for monitoring inventory. In addition to stock record card method, computerized information system is also used so that the overwhelming information can be stored and more accurate reports can be generated. Another important activity that must be performed regularly is physical inventory.

As previously mention that stock record card is used for controlling inventory when drugs are received and issued. Updating stock record card is done manually, so it is possible that an error might sometimes occur. Hence, physical inventory process is planned to double check the inventory level and also to separate expired medicines from the store area.

Physical inventory is a process of manual counting in order to ensure that actual inventory is consistent with the numbers recorded in the stock cards. There are two types of physical inventory performed at the pharmacy store as follows:

- Complete physical inventory: the responsible persons will count all the items in stock once a year.

- Random physical inventory or cycle counting is a daily activity. Selected products will be counted and checked against information on stock record card. The activity helps ensure that shortage supply will not happen and expired or damaged product are located to the separate area.

Apart from paper-based inventory methods done manually, technology is extremely important in inventory management. The management team realizes about the importance of pharmaceutical management and inventory control, the budget for

implementing the application of Pharmacy Information System has been approved. The current technology used in the hospital is Hospital Information System which is used to collect, store, retrieve, and communicate patient care and administrative information for all hospital activities. The existing technology has facilitated the pharmacy department by storing information and providing reports. However, most of activities with regards to procurement and inventory control are still performed manually since the existing program was not designed to fully facilitate inventory control but general administrative operations.

2.6 Reporting

Reporting is another important process for inventory management. The reports that are regularly generated concentrating on consumption rate and inventory level. The top 50 consumed drugs are monthly reported separating into consumption of OPD and IPD departments. Consumption pattern of medicines in OPD and IPD are different. Regarding the demand size of an item, demand for the same item from outpatients seems to be far bigger than inpatients' demand.

In addition to the regular monthly report, drug sales and inventory level reports are also provided and can be retrieved from the database. Inventory level and order placement report are manually handled and updated. Nevertheless, some other types of reports that can be essential for inventory control have not provided, for instance, wastage, vendors' lead times, and stockout reports.

2.7 Waste Management

For pharmacy department, waste means cost. Unwanted and expired medicines rate is an indicator for measuring performance of pharmaceutical inventory management. Minimizing waste is one the primary goals which allows the department to achieve its objective of cost-effective product utilization.

Thanks to the state regulations that have been addressed to protect consumers, unwanted medicines can be returned to suppliers and new items will be replaced. Value of

returned items is issued based upon agreements. For instance, drugs with 6 months before the expiration will get 100 % of the returned value. This policy benefits the hospital in such a way that it can reduce waste and loss. Drugs with slow consumption rate can be also returned for some others that might have more use for the hospital. Unwanted or expired medicines that cannot be returned are destroyed according to the standard waste management of medical and pharmaceutical supplies.

3 Problem Statement

Purchasing and controlling inventory are the key activities in procurement process. One cannot be effective without the other. Purchasing includes selection of the right quality products and knowing the right quantity, when to order, at what price and from which source. Inventory, which is a result of the purchasing process, must be well controlled. However, based on daily activities performed in the hospital pharmacy, the main concerns regarding managing inventory occur during purchasing process. It is problematic and time consuming to decide when and how much to order.

Deciding the time to make an order, from now on referred to as the reorder point (ROP), takes two major factors into consideration – the length of lead time and demand during lead time. Nevertheless, determining ROP for the hospital pharmacy is not simple, as the demand is difficult to accurately forecast and lead time is fluctuated, depending on suppliers. Due to fluctuation of demand and lead time, ROP is therefore really crucial.

The regular ordering routine reveals that ROP is determined somewhat based on past usage. Yet, there is no specific policy to facilitate the determination, but it is done based on the staff's familiarity of the process. If ROP is not carefully handled, unexpected situations of stockout and overstock might occur. Shortage of vital medicines used for severe illness is a great cost for the hospital since some medicines are scarce and they are not always available in the markets. In response to stockout situation, local emergency purchase must be made which is costly to the pharmacy department.

Another difficulty the staff have to encounter when performing purchasing process is how much to order. Based on the basic knowledge of inventory management, ordering too much will bring up carrying cost and ordering too little will lead to higher ordering cost. But the current purchasing process has not taken these matters into account and arbitrary policy has been used when determining order quantity.

A lesson has been learned from too large orders the past - some overstocked items have been found after the acquisition of the hospital. It has been therefore agreed that the pharmacy store aims to carrying inventory for one month. The new pharmacy team wants to implement an effective policy that helps balance demand and supply in order

to prevent stockout and overstock situations and to improve inventory turnover.

To conclude, there are currently two major concerns regarding drug inventory control in the pharmacy department – when an order should be place and at what quantity. This research concentrates on analyzing the major problems and suggesting the possible solutions, which are discussed in the next chapter.

It is challenging to archive drug procurement objectives with regards to costs, quantity, quality, and delivery. However, considering the hospital's potential of personnel and technology, the implementation of rational policy for drug inventory control can be successful. Additionally, the hospital business is still at the beginning of growing period, implementing efficient and effective inventory management now can be a good start for the expanded business in the future.

IV Analysis

As explained previously regarding the encountered problems of inventory control in the pharmacy department, reorder point and order quantity are the most common issues for inventory management. Identifying and analyzing these problems lead to the practical solutions. Several inventory control methods can be utilized to determine reorder point and order quantity. However, before selecting any approach to use, drug inventory must be first classified. In order to improve inventory performance of the hospital pharmacy, action plan can be divided into two phrases – classifying drug inventory and selecting inventory control methods.

Classifying inventory must be performed when handling great number of product types. Several classification models can be used to group the inventory. One of the most common and effective approaches is ABC model that categorizes product based on its value. When it comes to medicinal commodity, not only does value matter, but also criticality. Thus, ABC and VEN approaches are selected for classifying drugs. Combination of these two models allows importance and priority of each product group visible.

Having classified the inventory, the next step is to select inventory control methods. In order to put the right method in the right place, it must be remembered that different methods serve different purposes and they require different levels of management. Selection of inventory control methods are explained in the next section. No matter what method used for inventory management, it should be in place.

In conclusion, activities that must be performed to solve the problems about ROP and order quantity are inventory classification and selection of inventory control methods. However, it is important to note that the result in this final thesis does not necessarily provide the final solution for drug inventory control, but some possibilities to improve drug inventory control in a hospital pharmacy.

1 Classifying inventory

1.1 ABC Classification

Since there are approximately 730 items in the inventory to handle, there should be some methods to categorize and organize them so that it is easier to manage and handle. In this case, ABC classification which is a powerful tool to prioritize and classify items according to inventory value can be considered. The contributions to inventory value of class A, B and C are 75-80 %, 15 % and 5-10 % respectively.

Performing an ABC Analysis

- Listing all medicinal supplies in the inventory
- Entering annual consumption of each medicine
- Calculating percentage of total annual sales contributed by each drug
- Sorting the list by value of each item
- Deciding cut-off points to group inventories to A, B, and C classes

Having performed ABC approach, all items are classified. This brings advantages in both inventory and financial aspects. Utilizing ABC analysis makes managing inventory and taking surveillance easier. With high inventory value, items appearing on top of the list are the ones that need special attention. Cost cutting is also smoothened by concentrating on small number of items whose value contribution is high.

In principles, class A items can be purchased more frequently in order to decrease the inventory level and increase inventory turnover by stocking less but purchasing more often. Class B requires moderate attention and analysis, and class C can be ordered in a large quantity in order to obtain advantage of quantity discount.

ABC analysis works well in some industries. Nonetheless, this approach has some limitations especially in hospital pharmacy. ABC classification does not tell anything regarding importance and criticality of drugs. Some drugs with high consumption that contribute high value to the inventory might not be as vital as some others in class B and C. Due to this fact, utilizing only ABC analysis in hospital pharmacy can lead to

overlooking of some items whose high importance and criticality but low consumption rate. Therefore, ABC analysis should be accompanied with VEN classification which concentrates on the criticality of drugs.

1.2 VEN Classification

ABC analysis alone is not effective enough to be applied in the hospital pharmacy since it is not only about values that matters in hospital operation. Vital, essential and nonessential drugs should be also classified. In order to perform VEN analysis, collaboration from pharmacists, doctors with different specializations is needed. VEN analysis should be conducted based on commitment of a panel of doctors and pharmacists since it is a fundamental of inventory management models that will be implemented. Below is an example of conducting VEN and ABC classifications.

VEN Category (VEN)	Drug Name Strength Package Size	Dosage Form	Price Per Package US$	Quantity Dispensed in 1995	Total Cost US$	Total Cost %	Cumulative %	
N	Inosine 200 mg N100	tab	$20.00	800	$16,000.00	16.5%	16.5%	
N	Solcoseril 2 ml N25	inj	$20.12	700	$14,084.00	14.5%	31.0%	
V	Insulin HM 10 ml 40 IU/ml	inj	$5.50	2000	$11,000.00	11.3%	42.3%	
N	Drotaverine Hydrochloride 0.04 N100	tab	$2.15	5000	$10,750.00	11.1%	53.4%	A
E	Isradipine 5 mg N30	caps	$16.21	600	$9,726.00	10.0%	63.4%	
V	Verapamil Hydrochloride 80 mg N100	tab	$5.00	1200	$6,000.00	6.2%	69.6%	
V	Cefotaxime Sodium 1 g	inj	$2.40	2000	$4,800.00	4.9%	74.5%	
N	Inosine 2% 5 ml N10	inj	$1.57	3000	$4,710.00	4.8%	79.4%	
E	Ranitidine Hydrochloride 150 mg N100	tab	$8.00	500	$4,000.00	4.1%	83.5%	
N	Bendazol 0.5% 2 ml N10	inj	$0.50	5000	$2,500.00	2.6%	86.0%	
V	Prednisolone 30 mg N3	inj	$1.21	1900	$2,299.00	2.4%	88.4%	B
E	Nystatin 500,000 U N25	tab	$0.73	3000	$2,190.00	2.3%	90.7%	
E	Metoclopramide Hydrochloride 10 mg N40	tab	$1.67	1200	$2,004.00	2.1%	92.7%	
V	Ampicillin 250 mg N24	tab	$1.25	1500	$1,875.00	1.9%	94.7%	
E	Nandrolone Decanoate 50 mg 1 ml	inj	$1.74	800	$1,392.00	1.4%	96.1%	
N	Cocarboxylase 50 mg 3 ml N3	inj	$1.25	1000	$1,250.00	1.3%	97.4%	
E	Metamizole 50% 1 ml N10	inj	$0.30	2000	$600.00	0.6%	98.0%	
V	Digoxin 0.25 mg N50	tab	$1.00	600	$600.00	0.6%	98.6%	C
E	Allylestrenol 5 mg N20	tab	$1.63	300	$489.00	0.5%	99.1%	
E	Nitrofurantoin 100 mg N10	tab	$0.15	3000	$450.00	0.5%	99.6%	
E	Chlordiazepoxide 10 mg N50	tab	$0.56	800	$448.00	0.5%	100.0%	
TOTAL					$97,167.00	100.0%		

Table 1: Example for Conducting ABC/VEN Analyses (Moore, Bykov, Savelli & Zagorski 1997, 39)

According to an example of conducting ABC/VEN analyses in table 3, contribution of 79,4% of the total cost spent on class A. The rest of 20,6% was spent on class B and C.

Class A revealed that four out of eight drugs are in nonessential category which contributed 46,9% of total budget. Limiting use of nonessential drugs whose marginal therapeutic advantage in class A can significantly reduce hospital's expenditure.

	V	E	N
A	<u>AV</u>	AE	<u>AN</u>
B	BV	BE	BN
C	<u>CV</u>	CE	<u>CN</u>

Table 2: Matrix of Coupling ABC/VEN Models

A combination of ABC and VEN classifications provides a matrix comprises of nine categories. According to the matrix of ABC and VEN analyses conducted in table 2, there are four outstanding groups at the corners that should be bolded with regards to inventory policy and safety stock level. Each group requires different level of management and inventory control policy.

- AV represents drugs which have vital criticality and high consumption rate. Items in this group require special attention and comprehensive analysis. It is recommended to stock less but purchase more often for class A, on the other hand, a contradictory policy given to vital drugs that they should be always available in stock to meet emergencies. An occurrence of shortage for vital drugs has a great negative impact on medical service. Hence, this class must be carefully analyzed by constantly controlling and regularly following up the inventory. EOQ or more complex method can be utilized to control the AV group. Safety stock should be sufficient to meet fluctuated demand and emergency cases. There should be more than a few suppliers for each medicine in order to gain better quality, price and lead time. An effort should be put to enhance suppliers' performance. The pharmacy staff should try to shorten lead time.

- AN includes medicines with high valued contribution to total inventory but they are considered as nonessential drugs. Efficacy of some nonessential drugs is still questionable and some of them can be substituted by some other medicines. Taking a close surveillance regarding a necessity of having those drugs in the inventory can

ease up stock handling process. Limiting use of AN group can significantly reduce inventory level and enhance the financial performance. Stock should be shelved at low level. However, some medicines whose therapeutic advantages are still required and prescribed, moderate level of inventory control should be applied to those drugs.

- CV includes vital medicines that should be always available in stock but they do not have a huge impact on financial aspect. Order placement of this group can be placed at large quantity to obtain quantity discount and to save management efforts. When determining order quantity, shelf life should be also taken into consideration. Monitoring inventory can be performed once or twice a year. Considering a great number of medicinal products in the pharmacy store, it is worth to place an order at a greater volume for CV groups. By doing so, the pharmacy staff can narrow down the number of medicines that they have to handle.

- CN is the least essential and important group based on both ABC and VEN explanations. The pharmacy staff can review all items in this group and analyze demand for those drugs. It is possible that some drugs do not anymore have use for medical treatments. The staff can possibly leave out some items that belong to this group from hospital drug list to reduce number of product lines in the inventory. Safety stock should be determined at low level. Some items that are still in need in this category should be controlled by using inexpensive method and low level management. Authority for controlling this group can be delegated to the pharmacy users.

- AE and BV groups cannot be overlooked since AE is important regarding its value and BV is important for medical treatment. EOQ method can be utilized to determine order quantity of items in these groups. Regarding handling safety stock, slightly different policies are applied. AE, essential medicines with high value, can be stored at a lower level but more frequently purchased. BV group which includes vital drugs with lower inventory value can be stored more than AE items.

- BE, BN and CE can be controlled by utilizing medium level of inventory management. Analysis based on past consumption is sufficient to control these classes. Moderate safety stock is applied to these categories.

The coupling matrix of ABC and VEN models has proved to be a useful procurement tool for drugs prioritization of hospital pharmacy, especially when the budget of expenditure is limited to cover all medical requirements. ABC/VEN models can be simply categorized and sorted in normal spreadsheets. Alternatively, ABC/VEN software which is developed by MSH[5] can be downloaded for free. Users can input data of each drug used in the organization and the program can generate, for instance, ABC/VEN analysis, VEN comparison chart, therapeutic summary and drug master list.

By realizing the importance of the pharmacy and its operation, budget has been approved for implementation of computerized drug inventory control system. One of the primary features that the system should be able to function is drug prioritization since classifying inventory is extremely important in inventory control.

Two important phrases at the first stage of improving inventory are classifying inventory and determining inventory policy. There is another important point to note is that performing these activities require high level of commitment from involved parties such as pharmacists and doctors with different specializations. To be on the safe side, if drugs appear in more than one category regarding VEN, drugs are always identified as higher criticality.

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[5] Management Sciences for Health (MSH) is a nonprofit international health organization whose mission is to save lives and improve the health of the world's poorest and most vulnerable people by closing the gap between knowledge and action in public health.

2 Selecting Inventory Methods

2.1 Reorder Point

After exploring past consumption record of some medicines, it is found that demand varies and lead time is not curtain. When both crucial factors are uncertain, taking safety stock into account when determining ROP is a must. There are different methods to calculate reorder point. The reorder point calculation involves predetermined demand during lead time (cycle stock) plus safety stock that buffers against fluctuated demand during lead time.

Referring to ROP formulas discussed in the previous part, there are two methods to calculate safety stock. Let's take Amoxicillin[6] 500g (capsule) as an example to demonstrate these two methods and to compare the results. Past consumption of Amoxicillin 500g (capsule) 1st January –30th June 2009 provides required values as follows:

Average daily demand	= 30,96
Standard deviation of daily demand	= 23,18
Average lead time	= 7,83
Standard deviation of lead time length	= 3,98
Maximum daily usage	= 112

2.1.1 Cycle Stock

$$\overline{X} = \overline{R}\left(\overline{X}_{LT}\right)$$
$$= 30,96(7,83)$$
$$= 242,42 \text{ rounded to } 243$$

An average demand at 243 capsules is needed during the replenishment cycle when lead time varies from 4 to 15 days. Having now determined cycle stock (average demand

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[6] **Use** – Treatment of otitis media, sinusitis, and infections caused by susceptible organisms involving the respiratory tract, skin and urinary tract; prophylaxis of bacterial andocarditis in patients undergoing surgical or dental procedures; as part of a multidrug regimen for H. pylori eradication.

during lead time), an additional safety stock to this value can suggest the reorder point. Another thing to remember when calculating is whenever result gives any part (½, ¾, etc) of a whole number, it is always rounded up to the next whole number since part of a tablet or capsule cannot be purchased.

2.1.2 Safety Stock

<u>Method 1</u>

Standard deviation of demand during lead time (Safety Stock)

$$\sigma = \sqrt{\overline{X_{LT}}\left(\sigma_R\right)^2 + \overline{R}^2\left(\sigma_{LT}\right)^2}$$

$$= \sqrt{7,83\,(23,18)^2 + 30,96^2\,(3,98)^2}$$

$$= \sqrt{19390,52}$$

$$= 139,25 \text{ rounded to } 140$$

Reorder Point	Customer Service Level	Stockout Situation
243 + 140 = 383	84,13 %	15,87 %
243 + 280 = 523	97,72 %	2,28 %
243 + 420 = 663	99,87 %	0,13 %

Table 3: Comparison of ROP Results at Different Customer Service Levels

The result shows that an 84,13 % of customer service (1 standard deviation, or a 15,87 % of stockout level) requires 140 capsules in safety stock. At 97,72 and 99,87 % of customer service level, 280 and 420 capsules are needed in the inventory respectively.

<u>Method 2</u>

Safety stock $= (\text{Maximum usage} - \text{Average usage})\ast \text{ Lead time}$

$$= (112 - 30,96)\ast 7,83$$

$$= 634,54 \text{ rounded to } 635$$

Reorder point $= 243 + 635$

$$= 878$$

Method 2 shows that Amoxicillin 500g (capsule) should be reordered when the inventory level falls to 878 units.

Previously demonstrated, the calculations are done based on information collected during 6 months. The first method gives a few suggestions for reorder point at different levels of stockout protection, while the result of the second method is obtained by taking maximum usage into consideration. The final decision will be made by the staff to ensure that stockout situation, which is unacceptable for a hospital, will not be happened. On the other hand, controlling holding cost should be also taken into consideration. How much holding cost the pharmacy is willing to carry? By balancing these two factors, staff will be able to determine the most realistic ROP.

Regarding medicines whose demands might be seasonal, it is recommended that information used for calculation should be reviewed in an annual cycle. This will give a clearer picture of consumption's trend in one year, when the demand is decreased and increased. No matter what method is chosen to determine ROP, it is necessary to always annually update the information since the consumption rate differs every year.

Determining reorder point of each item should be done either manually or automatically. This can be a time consuming process if it is a manual work but it is worth it in the long run. As mentioned previously that Pharmacy Information System is still in the process of implementation, the program should be able to automatically calculate and update ROP of each item. After determining ROP, it should also be written on the stock record card which is another effective tool used for inventory control in the hospital pharmacy. The stock record cards are placed on the shelves so that they can be monitored when performing physical inventory process.

An additional recommendation regarding order placement, medicines whose inventory levels are close to ROP can also be sorted by suppliers so that the staff can purchase them at once in one order. Instead of spending valuable working hours on placing several orders which will be anyway sent to the same supplier, the staff can consolidate and send them all at once to the supplier. Not only can it save time, but also there is an opportunity opened for negotiation to get the better price or quantity discount.

2.2 Determining Order Quantity

Having classified all items in the inventory, it is now clearer which items categories require more attention and complex analysis. Explained in the previous section, there are several methods for inventory control. Two approaches can be used to determine order quantity, fixed order quantity approach and fixed order interval approach.

2.2.1 Simple EOQ Model

EOQ model of methods used in fixed order quantity approach. With highly restrictive assumptions for utilizing simple EOQ model, its usefulness is quite limited. Considering some situations, for instance, new items or ad-hoc request of a particular medicine that is not available in hospital drug list, this simple but effective method is nevertheless suggested to use in hospital pharmacy. There is no objection not to employ this tool because the demand must be known in advance and lead time should be promised before placing the order. As well as purchase price and transportation cost are known and there is no inventory in transit.

The simple EOQ formula is armed with two important values namely, ordering cost and carrying or holding cost. Ordering cost, which is the cost occurred per one order regardless of order volume, is not so complicated to estimate. On the contrary, carrying or holding cost is really difficult to determine and experienced staff is required to calculate this cost. Although carrying cost is not obviously written as some other costs such as product cost, it must be remembered that it really exists.

The responsible person should be able to answer the questions regarding labor cost, space rent, taxes, insurance, obsolescence and opportunity cost. Since inaccurate inputs added to the formula can distort the answer, the in-charge person must be experienced and accustomed with organization's financial activities as well as procurement processes in the hospital pharmacy. Thus, collaboration between pharmacist and accountant is needed to estimate carrying cost of simple EOQ method.

In conclusion, not only can this method be used with new items or ad-hoc requested

medicine, but also some other drugs whose qualifications matched with the criteria of EOQ formula. However, implementing EOQ can be complex and time consuming, it is hence recommend using with expensive items.

2.2.2 Adjusted EOQ Model

As number of patients and their demand cannot be accurately predicted, using simple EOQ is not the answer of inventory control when fluctuation in demand takes place. More importantly, the pharmacy department most of the times encounter this sort of situation. Therefore, the simple EOQ formula has been adjusted to cope with the situation of uncertainty in demand. This modified model is considered the most complex and costly method when comparing to the other methods discussed in this research. Analyzing every single item by using adjusted EOQ model can be really expensive.

Again, this adjusted formula is associated with ordering and carrying costs. In addition to this, shortage or stockout cost is also taken into account when fixing the simple EOQ model under the situation of uncertain demand. There are several approaches to estimate shortage cost, for example, multiplying expected shorts in one cycle by unit cost.

Since it is not necessary to utilize this method with every single pharmaceutical product, this model is best suited for expensive items that need special attentions, for instance AV class drugs. Those that contribute significant value to the inventory and have vital criticality to medical treatment are deserved to be carefully analyzed.

2.2.3 Fixed Order Interval Approach

Fixed order interval approach is performed by predetermining required inventory level of an item and placing the new order at quantity that will bring stock on hand back to desired inventory level. This method is not costly since it does not require complex procedures.

Determining the inventory level by multiplying average monthly consumption with

reorder factor can be an option. Although this method is not widely used in big firms that have more amount of fund available invested in inventory control system. Considering several aspects of the hospital pharmacy and its operation, the concept of this approach can fit the requirements and available budget. This inventory control system works better with small and medium size-operations. Its concept allows system work better on items with independent demand than dependent demand.

As it is known medicines are not the main assets of hospital, investing on implementing complex methods to save half a euro might not make much business sense. This method is inexpensive, however it is not recommended to use this model for every item in the inventory since it can possibly lead to stockout or overstock situations. Therefore, this approach is suitable for lower valued items such as items in class B and C since they do not require high level of surveillance.

2.2.4 Two-Bin System

Two-bin system is the simplest and most inexpensive method discussed in this research. It does not require high level management and closely monitoring. This method can be used with low valued C class items whose priority of medical treatment is not severe.

Also this method can by employed by OPD and IPD storages since amount of medicines requested in the internal order is not big. Staff responsible for activities in those departments may not have enough time to review and monitor the inventory since they are usually engaged with their main responsibilities. By using two-bin method, nursing staff can save their management efforts in controlling inventory in the sub storages and the pharmacy staff can easily estimate the current inventory level of OPD and IPD department.

2.3 Important Note

There is another important issue when determining ROP and order quantity. Whenever placing an order of seasonal medicine, the information of the past usage should be reviewed and gathered at least 2 years back in order to ensure the best estimation of the next quantity ordered.
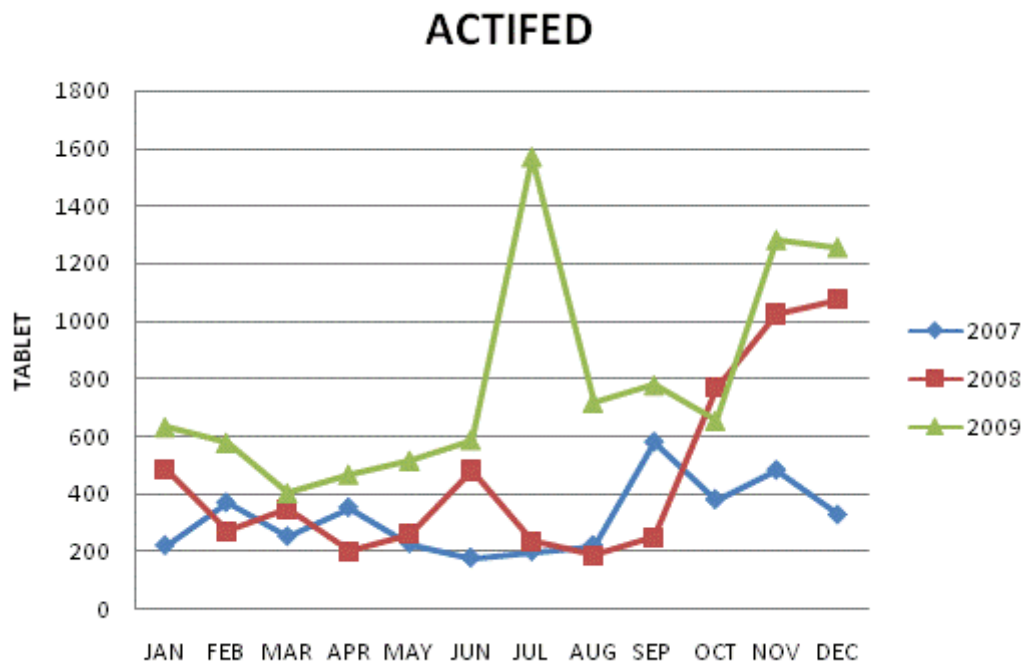
Figure 5: Past Consumption of an Example Medicine with Seasonal Demand

With an assumption that Actifed[7] is a seasonal demand item since it is used for common cold treatment, the demand can be possibly higher around the end of the year and the beginning of the next year which is the winter time in Thailand. To prove whether this assumption is true, the past consumption of this item is reviewed three years back as shown in figure 5.

The trends for the past 3 years proved that demand were increased during September until January. The remarkably high consumption rate in July 2009 was influenced by a significant rise of number of patients, this high rate also applied to the other drugs during the same period. As the graph shown, inventory staff can estimate the order quantity based on information of previous seasons.

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[7] Use – Temporary symptomatic relief of nasal congestion due to common cold, upper respiratory allergies, and ainusitis; also promotes nasal or sinus drainage. (Lacy, F. Charles, Armstrong, Lora L., Goldman, Morton P. and Lance, Leonard L. 2005)

Seasonal demand case can be known and predicted in advance. Therefore, medicines with seasonal demand should be listed for review to ensure that there would be enough supplies available when they are needed.

When inventory methods are put in their places and important numbers of ROP and order quantity are determined, it is important to remember that the results are just rational guidelines for making final decision. Practically, it is not compulsory to exactly follow the results obtained from calculation methods. To clarify it, assuming that the result obtained from EOQ method suggests that an order should be placed at 9 packages, the order can actually be placed at 10 packages to take an advantage of quantity discount if available. Another example regarding ROP level, drugs whose inventory levels are close enough to the reorder point can be purchased at once in order to reduce management efforts.

V Conclusions and Recommendations

Drug expenditure is considered the main component of hospital's spending. Focusing on healthcare premises at the community level, the relevant researches and information revealed that drug inventory management has not received enough attention as it deserves. This final thesis has been conducted for Thai Mahasarakham hospital which is a medium sized private hospital in Thailand. The purpose of this final thesis is to serve as a proposal suggesting the possibilities of improvements of drug inventory control. The research is conducted by observation at premises, interviewing involved parties and gathering primary and secondary information. Qualitative research method is mostly use in the thesis.

The current process of inventory control at the hospital pharmacy shows that there is room for improvement. The regular ordering routine has been observed and analyzed. It is found that there are two major concerns regarding purchasing process. Order quantity and reorder point are determined based on arbitrary policy. In order to propose suitable solutions for the difficulties that the pharmacists have to encounter, several inventory approaches are studied and analyzed. Two steps involved in improving inventory control are classifying inventory and selecting effective and efficient inventory control methods.

There are approximately 730 items in the pharmacy store. It is impossible and unnecessary to give equal attention to every single item. Therefore, inventory should be classified and prioritized. ABC and VEN analyses have successfully implement in many hospital pharmacies. The matrix derived by coupling ABC and VEN approaches can narrow down the number of items that needs to be strictly handled.

AV is considered as the most important group among the others in terms of value and criticality, comprehensive analysis and top level management should be applied to control AV items. Reducing or limiting use of N items (AN, BN and CN) whose therapeutic advantages are still questionable can reduce inventory level and enhance financial performance. In order to save management efforts, CV drugs can be purchased at a greater quantity at a time. AE and BV groups are important for the inventory with

regards to value and criticality, a complex analysis such as EOQ method can be utilized. BE and CE classes can be handled by employing moderate level of inventory management.

Regarding safety stock level and ROP determination, it is recommended to stock expensive items less than the inexpensive ones. On the other hand, vital drugs should be available at all times. Therefore, decision making regarding the inventory level should be done by balancing these two policies. There are two methods purposed to determine ROP, it is difficult to specify which method is better than the other since they are implemented to serve different purposes. For more expensive drugs whose demand is more constant, taking standard deviation method might be more efficient. It is also beneficial to sort out products by suppliers so that drugs whose inventory levels are close enough to ROP can be purchased at once.

EOQ method can be used to determine order quantity of high valued drugs and less expensive method such as fixed order interval can be utilized for lower valued items. OPD and IPD stores can adopt two-bin system to control the inventory since inventory size in these two storages is small. Regarding medicines whose demand is seasonal, past consumption should be gathered at least for 2 years to ensure best estimation of order quantity.

It is important to remember that methods used for order quantity determination just suggest rational guideline for inventory decision making. Final decision should be made based on practical purpose. Considering capability of personnel, budget and technology of Thai International Mahasarakham hospital, drug inventory management project can be successfully implemented.

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