APPICATION OF THE VMI SYSTEM TO REPLENISH MEDICINE AT RAMATHIBODI HOSPITAL

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Thesis
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APPLICATION OF THE VMI SYSTEM TO REPLENISH MEDICINE AT RAMATHIBODI HOSPITAL

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ABSTRACT

The objective of the study was to simulate and evaluate the proposed internal VMI system for the hospital supply chain at Ramathibodi hospital. Thirty drug samples were selected on the basis of having the most highly dispensed value, frequency of drug dispensation, and shortage problems. The replenishment volume was calculated, based on drug utilization on average of daily use or by summation during the week. Then we selected the best alternative to implement in all dispensing rooms to see the effect.

The results showed the best alternative is the summation during the week formula. It can achieve the hospital KPI's, reduced average inventory value up to 20 percent, days of stock of approximately 7 days and 100 percent service level. When it was implemented in all dispensing rooms it could save a budget of around 31,019661 to 36,209,721 baht at the dispensing unit and 70,780,840 to 92,928,603 baht at the warehouse.

The formulation to calculate the maximum stock level, replenishment volume, minimum stock level and re-order point should be embedded in the hospital IT system.

KEY WORDS: INTERNAL VMI SYSTEM / HOSPITAL SUPPLY CHAIN / REPLENISHMENT VOLUME

102 pages

การประยุกต์ระบบเติมสินค้าโดยผู้ขายเพื่อการเติมยาภายในโรงพยาบาลรามาธิบดี
APPLICATION OF THE VMI SYSTEM TO REPLENISH MEDICINE AT RAMATHIBODI HOSPITAL

นิติ โอสิริสกุล 5636680 PYSP/M

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อสร้าง และประเมินแนวทางในการเติมยาของคลังยาให้แก่ห้องยาภายในโรงพยาบาลรามาธิบดี โดยการสุ่มตัวอย่างยา10 อันดับแรกจากยาในกลุ่มที่มีมูลค่าสูง มีการจ่ายบ่อย และ มีการขาดคราวบ่อย จากนั้นนำมาคำนวนปริมาณการเติมยา โดยใช้วิธีการคำนวนที่ต่างกันโดยนำปริมาณการใช้มาคำนวน คือ การใช้ค่าเฉลี่ยต่อวัน และการใช้ผลรวมในหนึ่งสัปดาห์ เพื่อคำนวนปริมาณการเติมยา จากนั้นทำเลือกผลที่ดีที่สุด และนำไปใช้ในทุกห้องยาเพื่อดูผลกระทบต่อคลังยา

ผลการศึกษาพบว่ารูปแบบของการใช้ยานั้นมีผลต่อการเติมยา โดยแนวทางที่ดีที่สุดในการเติมยา คือ การใช้ผลรวมในหนึ่งสัปดาห์ เพื่อคำนวนปริมาณการเติมยา ซึ่งวิธีนี้ให้ผลการประเมินตามข้อกำหนดที่ตั้งไว้ คือ มูลค่าคงคลังลดลงมากกว่า 20 เปอร์เซนต์จากเดิม จำนวนวันค้างสต็อกประมาณ 7 วัน และมีระดับการให้บริการที่ 100 เปอร์เซนต์ และเมื่อนำไปใช้ในทุกห้องยาพบว่าสามารถลดมูลค่าคงคลังของห้องยาได้ถึง 31,019661 ถึง 36,209,721 บาท และที่คลังยาได้ถึง 70,780,840 ถึง 92,928,603 บาท

อย่างไรก็ตามการวิจัยนี้เป็นการนำข้อมูลย้อนหลังมาใช้เพื่อใช้ในการประมาณการ และนำมาทดสอบโดยการคำนวนนอกระบบ หากจะนำไปใช้จริงจะต้องมีการนำแนวทางการคำนวนนี้ใส่เข้าไปในระบบเพื่อให้ระบบคำนวนปริมาณการเติมออกมาโดยอัตโนมัติ เพื่อประโยชน์สูงสุดในการทำงานจริง

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VMI	Vender management inventory
VMS	Vendor management systems
TPN	Total parenteral nutrition
VEN	Vital, Essential and Non-Essential
FSN	Fast, Slow and Non-Moving
ThaiHP	The Association of Hospital Pharmacy (Thailand)
Msale	Monthly sale
OPD	Outpatients Department
IPD	Inpatients Department
ROP	Re Order Point
DOS	Days Of Stock
KPI	Key Performance Index
SKU	Stock Keeping Unit

CHAPTER I
INTRODUCTION

1.1 Background and Rationale of study

The Faculty of Medicine Ramathibodi Hospital has three buildings to serve 7,000 out-patients per day; first building, Main Building, mainly provides more than 1,000 beds for the tertiary care of complicated and severely ill patients in various specialist departments and units. The second building, the Sirikit Medical Center, serves as a center for modern research projects, namely, the bone marrow transplantation project, the project of Advanced Diagnostic Imaging and Imaging-guided Minimal Invasive Therapy Center (AIMC). It also houses modern operating rooms and intensive care units. And the latest and state-of-the-art medical center named "Somdech Phra Debaratana Building" which will be completed in the near future will serve as the most excellent service complex for thousands of out-patients. The building will have well-equipped facilities to perform high standards of healthcare in the Southeast Asian region. It will provide 350 beds, 16 operating rooms and 14 Intensive Care Units, and also comprehensive service centers such as Stem Cell Transplantation, Minimal Invasive Endoscopic Surgery Center, Elderly Care Unit, Child Development Center and Complicated Diseases Service by specialized doctors.

The goals of the hospital are to educate and generate medical graduates and specialists who meet high international standards. To provide high quality medical care with modern facilities and technology to the public. To be the research center for medical innovations and public healthcare services.

In line with the mission of the hospital, medicines are important to meet the quality of the healthcare services. Internal supply chain for medicines is therefore important in the business process, especially the interaction between the pharmacy warehouse and the dispensing rooms. Currently, pharmacists in the dispensing rooms manage inventories by themselves and make decisions to replenish the stock based on their experience. The pharmacy warehouse is only responsible to collect the requests

from the dispensing rooms. However, the process that is to be developed will be designed in order to improve and run the process more effectively. In the new business process, the responsibility in the replenishment process at the dispensing room will be reallocated. Instead of waiting for the request from the dispensing room, the new process will enable the pharmacy warehouse to track the actual usage level and update the stock daily. A decision support system will also be implemented in order to provide information and suggest adjustments to the amount in reservation document. Due to the standard feature in the back office system, it will allow viewing of the stock level in each dispensing room. This means that the replenishment process will be decided based on the actual use and it will enable the central warehouse to obtain accurate demand information. (1, 2)

The supply chains in the hospital can be divided into 2 parts, material flow and information flow. The manual information flow between pharmacy warehouse to dispensing room has resulted in wrong predictions of medicine supply and utilization, drug shortage and overstocking. (3, 4) The current system is a passive system and leads to poor quality of service. This study will try to find a new system to solve the problems in the hospital supply chain. The active internal VMI system will be developed as a means to achieve this new system.

1.2 Objective of the study

1.2.1 General objective

The purpose of this study was to assess an application of a vendor management inventory (VMI) system to the internal hospital supply chain.

1.2.2 Specific objective

1. To simulate a VMI process for transferring of medicines from pharmacy warehouse to pharmacy dispensing units.

2. To assess the VMI performance at the pharmacy warehouse and pharmacy dispensing unit.

3. To show the effect of the internal VMI on the pharmacy warehouse

1.3 Scope of the study

This study focused on drug delivery from the pharmacy warehouse to the pharmacy dispensing unit at Ramathibodi Hospital. The data collected from the electronic database of the hospital and by observation of the activity in each step of the medicine transfer process. Drug transfer included 6 processes; checking the stock, forecasting, invoicing, picking, and packing and delivery. This research simulated an internal VMI process for transferring of medicines from pharmacy warehouse to pharmacy dispensing unit and to forecast the quantity of drug replenishment. In addition, this study also assessed the internal VMI model for its performance and the effect of the process on the pharmacy warehouse.

1.4 Definition of terms

1. Pharmacy warehouse is an inventory unit in the hospital that is responsible for receiving medicines from suppliers and distributing to each dispensing unit in the hospital.

2. Dispensing rooms are units that are responsible in receiving the medicines from pharmacy warehouse and dispensing medicines to the patients.

3. Internal supply chain or internal hospital supply is the supply between the dispensing rooms and the pharmacy warehouse in the hospital.

4. Inventory value is the value of medicines in the warehouse at the point of time.

5. Sale value is the value of medicines dispensed to the patients.

6. Forecast order is an order that is generated request order from the VMI model in the study.

7. Real order is a request order from the dispensing rooms at the time of the study.

8. Upstream is an information flow between inventory and purchasing unit.

9. Downstream is an information between flow inventory and dispensing units.

1.5 Expected outcomes and Benefits:

The results of the study will be used as a model to actively replenish medicines from the pharmacy warehouse to various dispensing units at Ramathibodi Hospital and to improve the performance of the internal supply chain in the hospital.

CHAPTER II
LITERATURE REVIEW

This research will study drug inventory control using the VMI model for simulation and to forecast the replenishment of drug quantity. A search of the relevant literature was carried out on the following subjects:

2.1. Hospital supply chain
2.2. Hospital Inventory management
2.3. Vendor management inventory (VMI)
2.4. Inventory performance indicators
2.5. Situation of drug management in the hospital

2.1. Hospital supply chain

The supply chain can be defined as "all the activities involved in delivering a product from raw material through to the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all of these activities." Supply chain management coordinates and integrates all of these activities into a seamless process. It links all of the partners in the chain including departments within an organization and the external partners including suppliers, carriers, third party companies, and information systems providers. Managers in companies across the supply chain take an interest in the success of other companies. They work together to make the whole supply chain competitive. They have the facts about the market, they know a lot about competition, and they coordinate their activities with those of their trading partners. It encompasses the processes necessary to create, source and to deliver to demand. They use technology to gather information on market demands and exchange information between organizations. A key point in supply chain

management is that the entire process must be viewed as one system. Any inefficiencies incurred across the supply chain (suppliers, manufacturing plants, warehouses, customers, etc.) must be assessed and remedied to determine the true capabilities of the process. (5)

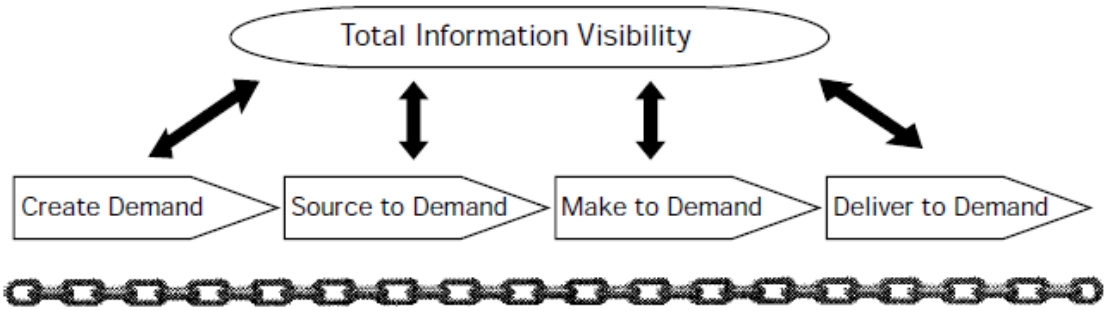


Figure 2.1 describes the total integration required within the supply chain. (5)

Hospitals are complex organization providing a multitude of service to patient, physicians and staff. These services include pharmacy, laboratory, surgery, dietary, linen, housekeeping, administration and others.(6) Moreover, each area has specific and often unique material and supply needs.(7)The hospital product line consists of high cost and low cost items as well as perishable and durable goods that are consumed in large and small quantities. Pharmaceutical components are often characterized as a large component of hospital's operating expenses. Any measures to control expenditure in this area can have a significant impact on the overall efficiency of the organization. The importance of effectively managing the pharmaceutical flow in the internal chain has been emphasized by many technicians and pharmacists.(8) Hospital supply chain, in terms of pharmaceutical products is primarily in providing supplies of medicine for the patients and it's a critical factor in ensuring a high standard of care.(9) Many challenges come up in handling hospital pharmacy. First, the pharmaceutical industry is influenced by strong institutional and regulatory pressures. The regulatory pressures have an effect in determining an accurate demand forecast. Second, hospitals are operationally different from other businesses, because

it’s extremely difficult to make forecasts about patients and their consumption of drugs. Third, hospital pharmacy often has to hold a large amount of safety stock to cope with uncertainty of demand, thus resulting in a high operational cost and having to deal with drug expiry problems.(10) Among several reasons why pharmaceuticals deserve extraordinary consideration in controlling inventory are that medicines are developed, manufactured and distributed according to strict regulatory requirements; there are fundamental differences between medicines and other consumer products; medicines are most often selected by a physician for a specific patient.(8)Hospital logistics, therefore, does not cover just support services such as purchasing, stores and the pharmacy, but also health care services such as patient care units and operating rooms. Hospital logistics can be defined as a large number of development, planning and implementation activities that subsequently facilitate more activities, such as purchasing, inventory management, transport management, the goods and services that form part of the overall medical service provided for the patients (Figure 2.2). (11) According to the definition of healthcare logistics, there are four major activities in hospital logistics:

1. Inventory Management activities such as purchase, receipt and inventory control of stock and supplies
2. Transport Management activities such as transport of patients to and into hospital, delivery of pharmaceutical and medical products
3. Production activities such as sterilization, preparation of TPN mixtures and reconstitution of chemotherapy products
4. Distribution activities such as delivery and sorting of bulk items into order requests for individual departments.

These activities have a target to ensure the right item, at the right place, at the right time, every time, in the right quantity, at the right costs.

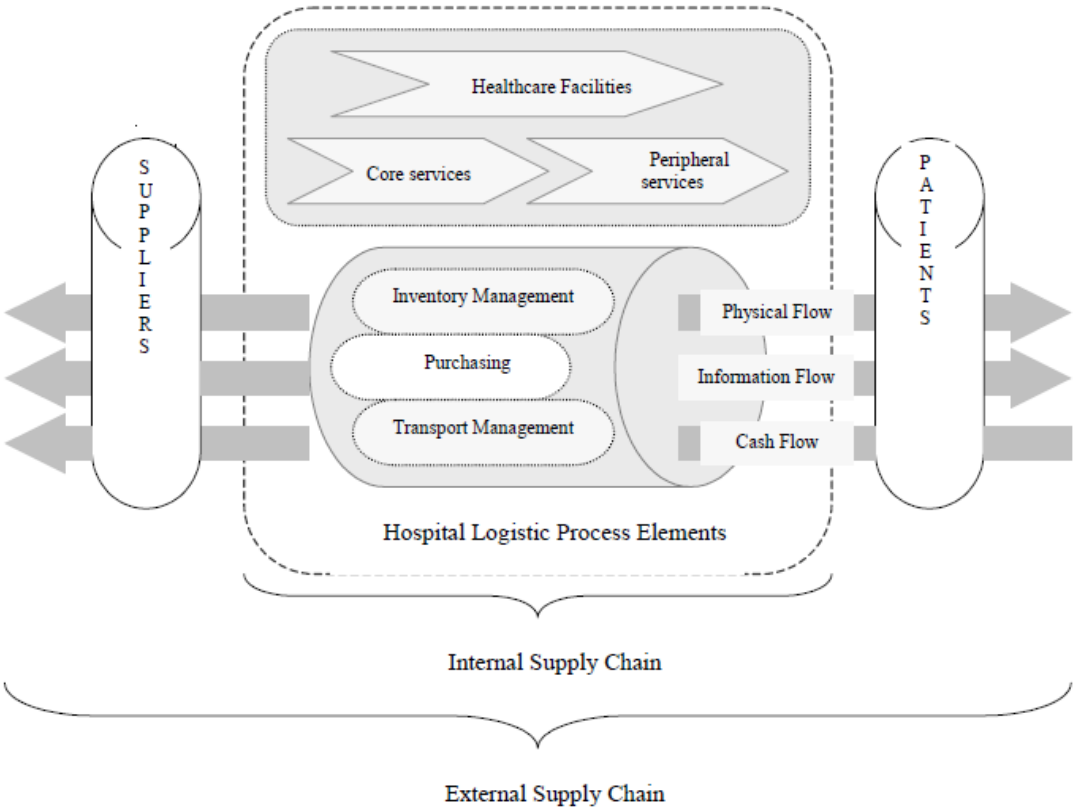


Figure 2.2 Hospital Supply Chain. (11)

Figure 2.2 shows the pharmaceutical supply chain in the hospital. There are 2 parts to the supply chain, internal and external. The external part starts from suppliers to hospital and then from dispensing rooms to patients. The internal part will supply medicines from the pharmacy warehouse to dispensing rooms. Collaboration and partnerships in the supply chain are needed to realize more value. Integration will realize great supply chain benefits which will have a further positive impact on relationships between the pharmacy warehouse and dispensing rooms through effective stock management, because warehouses are able to control inventory levels and eliminate waste, and on-site storage of products allows warehouses to offer vendor managed inventory (VMI) service to dispensing rooms. By tracking consumption at product/location/patient level, warehouse can identify sales trends as they occur and forecast more effectively. Effective management of the hospital supply chain has not just reduced costs but also provided major service enhancements throughout the supply chain such as a dedicated logistics teams and full audit trails and support.(11)

2.2. Hospital inventory management

Inventory Management is the scientific process by which an organization is supplied with the goods and services which needs to achieve its objectives at optimum cost. Inventory control can be viewed as the attainment of a cost balance between shortage and excess of stock. It is one of the modern management techniques of operations. Without proper control over the inventory, serious problems can precipitate, related to manufacturing, marketing, revenue generation and customer satisfaction. Likewise, availability of life saving drugs and other hospital supplies can be crucial to good hospital care and patient satisfaction. Hence, it helps in attaining the goal of a good hospital supply system by ensuring adequate stocks of required items for uninterrupted supply of all essential items. Inventory control deals with physical control of inventories. It is the process of deciding as to when, what and how much of each item is to be kept in stock, minimizing the ineffective stock and optimizing the various causes associated with the inventories. (12) Inventory management includes the management of quantities and storage locations, the control and planning of transport to control the system status and to choose an operating and optimization strategy. An efficient inventory control system can reduce costs, improve service delivery, increase return on investment, improve liquidity, improve service conditions, increase efficiency of man and machine and improve patient's satisfaction.

Inventory control methods can be divided into 4 parts

1. Purchase cost: It is the actual cost of materials. It is an apparent type of cost which is easily understood. The effort should be to reduce this as much as possible by following the simple techniques like bulk buying, using generic names and at negotiated rates.

2. Carrying cost: It includes the cost incurred on storage space, capital borrowing, additional manpower, obsolescence, deterioration and pilferage.

3. Ordering cost – It is the cost of placing an order like the cost involved in stationery, postage, telephone, fax, manpower etc.

4. Shortage cost – It deals with the cost of not having a particular material. The direct cost is the higher price we pay for procuring a substitute from an alternate source.

The types of Inventory control analysis, which are carried out for classifying materials so that materials and processes can be treated differently, are mentioned here as follows:

1. A-B-C Analysis (13)

A-B-C analysis is a basic analytical management tool. It is based on value of consumption of an item per year.

A is a highest annual usage around 10 – 20% of the drugs would account for 70 - 80 % of the resources.

B is a moderate annual usage 10 - 20 % of the drugs generally consumes 15 - 20% of the resources.

C is a low annual usage where the remaining 60 - 80% of drugs would consume just about 5 - 10% of the resources.

2. V-E-D Analysis (14)

V-E-D Analysis is based on critical values and shortage costs of the items. Items can be classified into one of three categories: Vital, Essential and Desirable.

Vital Items are items in the inventory of a hospital which could make the difference between life and death. There can be serious functional dislocation of patient care when such items are not available, even for short periods, adversely affecting the image of the hospital. Such items should always be stocked in sufficient quantity to ensure their constant availability. This group of items should be controlled by top management.

Essential Items are the items that if not available for a few days or a week, then functioning of the hospital can be adversely affected. These items should preferably be controlled by top/middle level management.

Desirable Items (Non-Essential items) will not affect patient care or hospital functioning, even if the shortage is prolonged, and include items like vitamins. Desirable items should be controlled by middle/ lower level management.

3. FSN Analysis

FSN analysis is an analysis of classification of materials based on movement such as fast moving, slow moving and non-moving medicines. FSN analysis materials can be classified based on their movement from inventory for a specified period. Items are classified based on consumption and average stay in the inventory. The longer the stay of an item in the inventory, the slower would be the movement of the material.

Inventory controlled models are important in estimating the level of safety stock required to achieve the service levels. Figure 2.3 shows an ideal inventory control model, where pharmaceuticals are issued in response to demand but stock outs are not permitted. The stock on hand steadily declines until the point at which an order must be placed. The stocks on hand consist of two components, the working stock and the safety stock. In the ideal model, the supplier performs according to plan, the shipments arrive on time, the quantity order is received and the inventory level is back to its starting maximum point. Working stock varies from zero to the quantity ordered and represents the stock used to satisfy demand between deliveries. To reduce the average inventory and reduce the inventory-holding cost, the working stock, the safety stock or both should be lowered. When medicines are used at a constant rate, the average working stock can be reduced by placing smaller orders but more frequently. The average inventory can also be reduced by cutting the safety stock but this method can increase the chances of stock outs. The inventory control model used to manage the order must consider safety stock, of how much stock to be kept in reserve to prevent out of stock and reorder frequency, which is the period of time between each order for an item (also known as the ordering period). Finally, reorder quantity is the number of units specified when an order is placed.

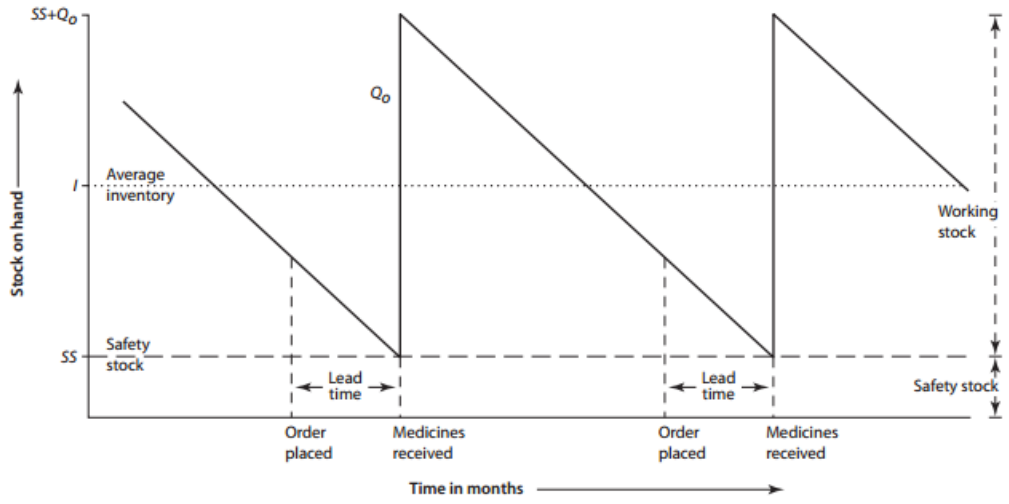


Figure 2.3 Ideal inventory control model.

2.3. Vendor management Inventory (VMI)

Vendor Management Inventory (VMI) can improve supply chain performance by decreasing inventory-related costs and increasing customer service. Unlike a traditional supply chain in which each member manages its own inventories and makes individual stocking decisions, VMI is a collaborative initiative where a downstream customer (internal hospital supply chain in our study) shifts the ownership of inventories to immediate upstream supplier (pharmacy warehouse) and allows the pharmacy warehouse to access their demand information in return. The upstream pharmacy warehouse has ownership of the inventories. The inventories are shipped to the warehouse. (15-17)

The VMI structure promotes collaboration between the pharmacy warehouse and dispensing rooms through information sharing and business process reengineering. VMI is an alternative for the traditional order-based replenishment practices.(18) VMI changes the approach for solving the problems of supply chain in the hospital.(19) Instead of just putting more pressure on pharmacy warehouse's performance by requiring ever faster and more accurate deliveries, VMI gives the warehouse both responsibility and authority to manage the entire replenishment process. Dispensing rooms provide the warehouse access to inventory and demand

information and sets the target for replenishment. Therefore, pharmacy warehouse decides when and how much to deliver by agreement with dispensing rooms. The measure for pharmacy warehouse's performance is not just delivery time and preciseness, but it is availability and turnover. This is a fundamental change that will affect the operational mode for both pharmacy warehouse and dispensing rooms. In this system, the pharmacy warehouse controls the stock levels instead of the pharmacist. The new system allows the pharmacists to concentrate more on other patient-care activities and also creates the time available for the warehouse to plan a delivery. (16, 20)

The other problems faced in hospital warehouse management are the many different types of medicines. Each medicine is used by many doctors and may be used for different treatments. (21) It is very inefficient to manage all these products without a proper classification because it is not possible to make a contract for each of them. The decision about order quantity also cannot be predicted accurately either by the pharmacy technician or the pharmacist. Order quantities can be calculated by an information system based on demand forecasting and safety stock level of each product. A VMI system will use information produced by this information system to get order quantities. (2, 9, 15, 20, 22, 23)

The VMI can be divided into two layers which are internal VMI and External VMI. In terms of internal VMI, it focuses on processes inside the hospital and how they manage business process effectively in order to gain accurate demand information. In terms of external VMI, it emphasizes the process outside the hospital. This is particularly in relation to how the hospital shares accurate demand information with the suppliers, so that the suppliers are then responsible for replenishing and managing the hospital's inventory. This is summarized in figure 2.4. Not surprisingly, it was found that the key success factors for VMI implementation are gaining accurate demand information and information sharing between supplier and hospital.(1)

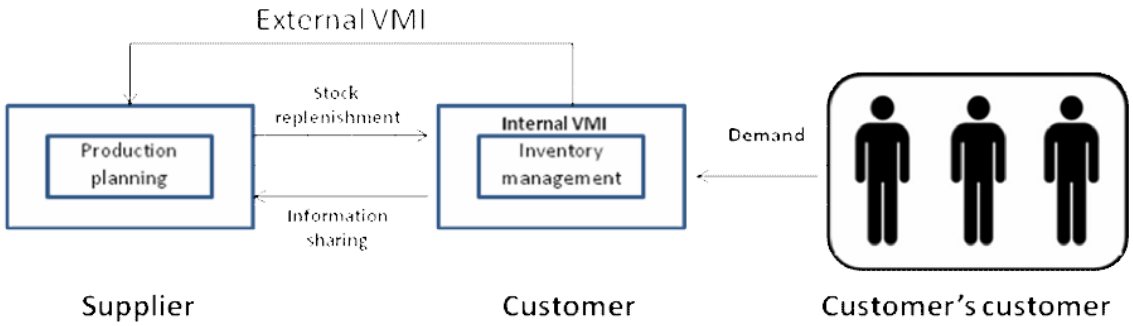


Figure 2.4 Processes of vendor managed inventory (VMI). (1)

The implementation of a VMI system can lead to significant stock reduction and other benefits. Through VMI, the flow of information and, as result, the flow of materials become seamless, improving service levels, inventory and transportation costs, the coordination of supply process and transport optimization.(24) The main goals of the VMI are to lower the inventory level and to improve the service level at the same time.(25) However, these two goals are compromised to some extent since both the warehouse and dispensing rooms hold a certain level of inventory in their own warehouses to secure medicine availability. Keeping safety stock is a traditional way to minimize the occurrence of stock outs. Inventory holding costs and customer service level are usually negatively correlated. Thus, lowering the inventory level and increasing the service level cannot possibly be achieved at the same time through any traditional management techniques. VMI overcomes this limitation of traditional management. In the VMI system, the retailer eliminates inventory holding costs. The vendor also reduces their inventory holding cost and increases the service level by controlling the dispensing room's inventory according to their best interest in scheduling delivery, warehousing, and replenishment in a win-win relationship. (26-29)

2.4. Inventory performance indicators

Several types of indicators have been developed to measure supply chain and logistics activities. Choosing the type of indicator to measure can be daunting, and it could be dangerous to simply focus attention on one area. For example, focusing only on cost containment could improve one area but may not affect the overall performance of the supply chain. For this reason, we adapted a model developed by Edward Frazelle will be adapted (30). This method is more holistic and consists of four types of indicators: quality, time, financial, and productivity. To complete the analysis, all indicator types need to be considered, and they need to work together. Quality**:** These indicators are often the simplest to implement and measure. Typically, it's tell about performance of a specific activity and common logistics indicator in this classification is accuracy including order accuracy, inventory accuracy, picking accuracy, etc. Time**:** These indicators focus on the time it takes to complete specific activities. They show where saving time during specific activities can improve the overall supply chain performance. Financial: These indicators help managers identify the supply chain cost drivers and help move toward a more efficiently managed supply chain. Productivity: These indicators examine how well resources are used. For example, filling vehicles to their capacity, instead of sending out vehicles half-full, could reduce costs and improve efficiency. (31)

As stated earlier, focusing on only one type of indicator may actually have a negative impact on product availability. For instance, a decision to send vehicles on a distribution run only when they are filled to capacity could cause stock outs at the next level down unless inventory policies are adjusted to compensate for reducing ad hoc shipments. It is very important to view these indicators holistically to make sure they are harmonized and not working against each other and to identify the tradeoffs required to strategically improve overall supply chain performance.(31)

Supply Chain Management Performance Measures Matrix by Function shown as table 2.1.

Table 2.1 Logistic performance indicators. (32)

Indicators / Activities	Cost	Time	Reliability
1.Demand forecasting and Planning	Forecasting cost per sales	Average forecast period	Forecast accuracy rate
2.Customer service and support	Customer service cost per sales	Average order cycle time	Delivered In-Full and On-Time rate of Customer service and support
3.Logistics communication and order processing	Information process cost per sales	Average processing cycle time	Order accuracy rate
4.Purchasing and procurement	Procurement cost per sales	Procurement cycle time	Supplier Delivered In-Full and On-Time rate
5.Material handling and packing	Demand value per sales	Average material handling and packing cycle time	Damage rate
6.Site selection, warehouse and storage	Warehouse cost per sales	Average inventory cycle time	Inventory accuracy rate
7.Inventory management	Inventory carrying cost per sales	Average inventory day	Inventory out of stock rate
8.Transportation	Transportation cost per sales	Average delivery cycle time	Transportation Delivered In-Full and On-Time
9.Reverse logistics	Returned cost per sales	Cycle time for customer return	Rate of returned goods

This table shows the activities for general logistics in the warehouse starting from demand forecasting to transportation and reverse logistics. In each activity, the three dimensions of cost, time and reliability can be evaluated to consider service quality of every step. These indicators are applied to assess both external and internal logistics. However, this research project will use some indicators to assess internal logistics between pharmacy warehouse and dispensing rooms i.e. Inventory carrying cost per sale, Average order cycle time, Average delivery cycle time, Average inventory day, Transportation DIFOT, Forecast accuracy rate and Rate of returned goods to assess the quality of logistics between warehouse and dispensing rooms.

As suggested by ThaiHP, this research will focus on inventory day of stock and how many items of drugs shortage. (33)

2.5. Situation of hospital supply chain in Thailand

Thailand, one of the rapidly growing manufacturing countries, also has a good reputation in the service industry. The cores of the hospital supply chain are input, process and output. Then material flow and information flow are analyzed. One of the significant input material flows in the hospital is medicines. It circulates across functions in the hospital. The information of this flow also needs to be distributed among functions in the chain. (34) The business process of the hospital model consists of material and product flow (Physical Flows) and information for material management (Information Flows). Medicine and its information flow across three major functions in the hospital. These are the medicine storeroom in each dispensing room, pharmacy warehouse and the purchasing department. When medicines are delivered by suppliers, it is sent to the pharmacy warehouse. The warehouse checks against purchasing order and store these medicines in their warehouse. Then the warehouse distributes medicines to each dispensing room according to the requests.

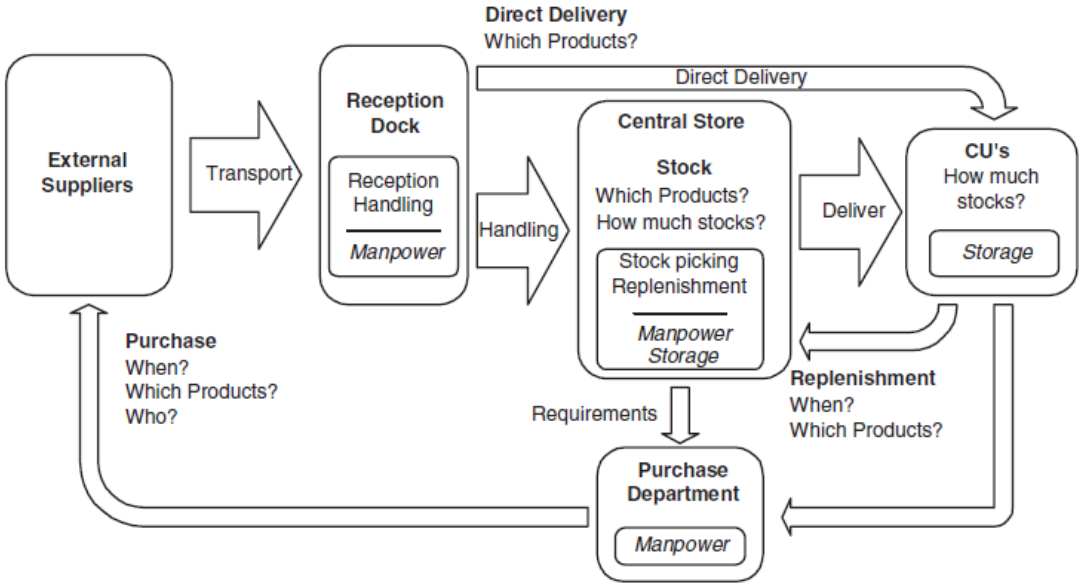


Figure 2.5 Medicine distribution systems. (35)

The medicine requisition from each dispensing room to the pharmacy warehouse is determined by the pharmacist in each dispensing room. The pharmacist determines the quantity of each medicine to replenish the stock in each dispensing room based on their own experience. This depends upon level of stock remaining in each dispensing room and other conditions such as seasonal diseases, emergency requests, new government regulations, etc. The pharmacist places an order to the pharmacy warehouse every day. The pharmacy warehouse collects all these requests and supplies the requested amount to each dispensing room daily, without examining the stock level in each dispensing room. The pharmacy warehouse also uses the amount requested by the pharmacists to calculate the reorder point level in the pharmacy warehouse. The amount of demand average using all historical data is set as "Month sale" or "Msale" value. The Msale is updated each month. When stock is less than 70% of this level, the pharmacy warehouse will request the purchasing department to replenish the stock up to 100-150% of the value. The information flow of the medicine supply chain is only a one-way communication. It is evidenced that the only information that the warehouse receives is the request form from each dispensing room. The pharmacy warehouse has no chance to see the demand from the patients' and the stock level at each dispensing room. As a result, the stock updating

information is not about the supply chain stock in the whole system but just the stock in the pharmacy warehouse. This results in an inaccurate calculation of the stock reorder point. This can affect the accuracy of the order amount based on patients' demand. (34)

In the pharmacy warehouse, any product information including usage level, inventory level, or transaction, is recorded in the front office system which is integrated with the back office system. This enables free flow of information from the warehouse to the dispensing rooms and the information is transferred back to the warehouse from the dispensing rooms via integrated systems. The hospital has two main systems for inventory management which are a back office and a front office. The back office system is used for managing inventory at the pharmacy warehouse. After the pharmacists at the pharmacy warehouse receive medicines, this information is recorded in the back office system. In the system, the supplier's code is not used in the hospital; instead the hospital creates its own code in order to identify medicines in the hospital. However, it still requires mapping the hospital's unique code and the supplier's code for purchasing purposes. Another system is the front office system. It is employed to manage financial and inventory data at the front office or the store rooms. Additionally, the dispensing room sometimes functions as a small production line, when physicians require the production of a medicine for a special case. The new product is prepared and a new code is also created and recorded in the front office system. Both systems are employed for different purposes but they are integrated in order to transfer information between the systems. (1)

To successfully implement a VMI strategy in the healthcare industry, the hospital is required to be concerned about two layers of VMI, internal and external. In terms of the internal VMI, it deals with the internal supply chain in the hospital, where the pharmacy warehouse acts as the supplier that delivers medicines to various dispensing rooms. Under the VMI concept, the supplier takes responsibility for managing the customer's inventory. To operate the customer's inventory effectively, the supplier has to have accurate information regarding the stock inventory and the actual demand. Therefore, for the internal VMI, the pharmacy warehouse has to see the stock inventory at all dispensing rooms in the hospital and monitor stock levels to be able to respond to the actual demand. The business process of particularly concern

is the interaction between the pharmacy warehouse and dispensing rooms. Currently, the pharmacists in dispensing rooms manage inventories by themselves and make decisions to replenish the stock based on their experience. The warehouse is only responsible for collecting the requests from the dispensing room. However, the process should be redesigned in order to improve and run the process more effectively. In the new process, the responsibility of replenishment of stock at the dispensing rooms is reallocated to the pharmacy warehouse. Instead of waiting for the request from the dispensing room, the new process enables the pharmacy warehouse to know the actual usage level and update the stock daily. A decision support system will be implemented in order to provide information and suggest adjusting the amount in reservation document. Due to the standard feature in the back office system, the stock level in each dispensing room can be viewed. Therefore, the system is able to create the reservation document by itself. This means the replenishment process is decided based on the actual demand and it enables the pharmacy warehouse to obtain accurate demand information. (4) Figure 2.6 shows the process flow and information flow along the supply chain.

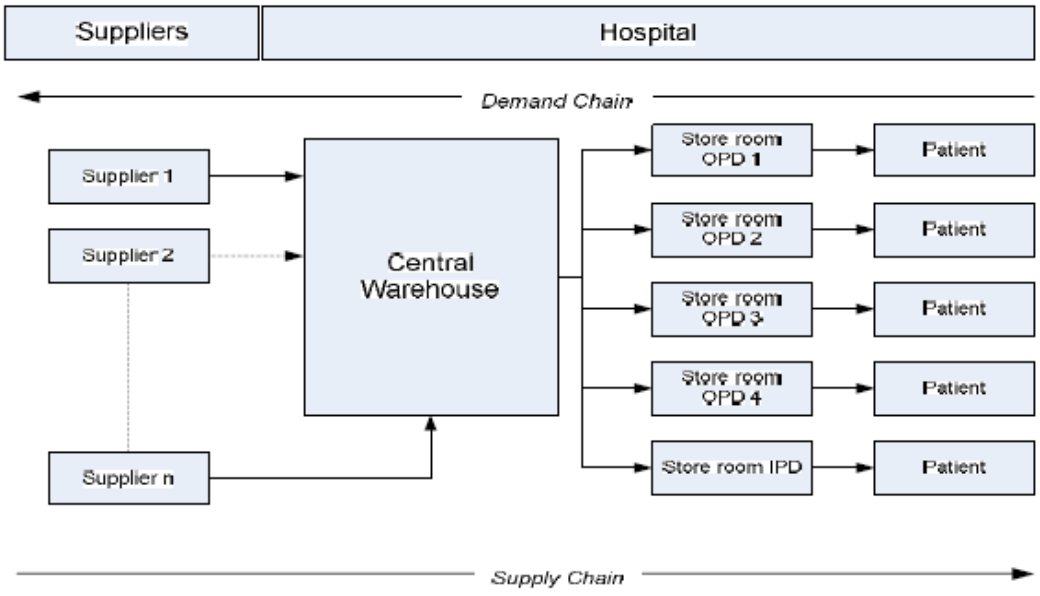
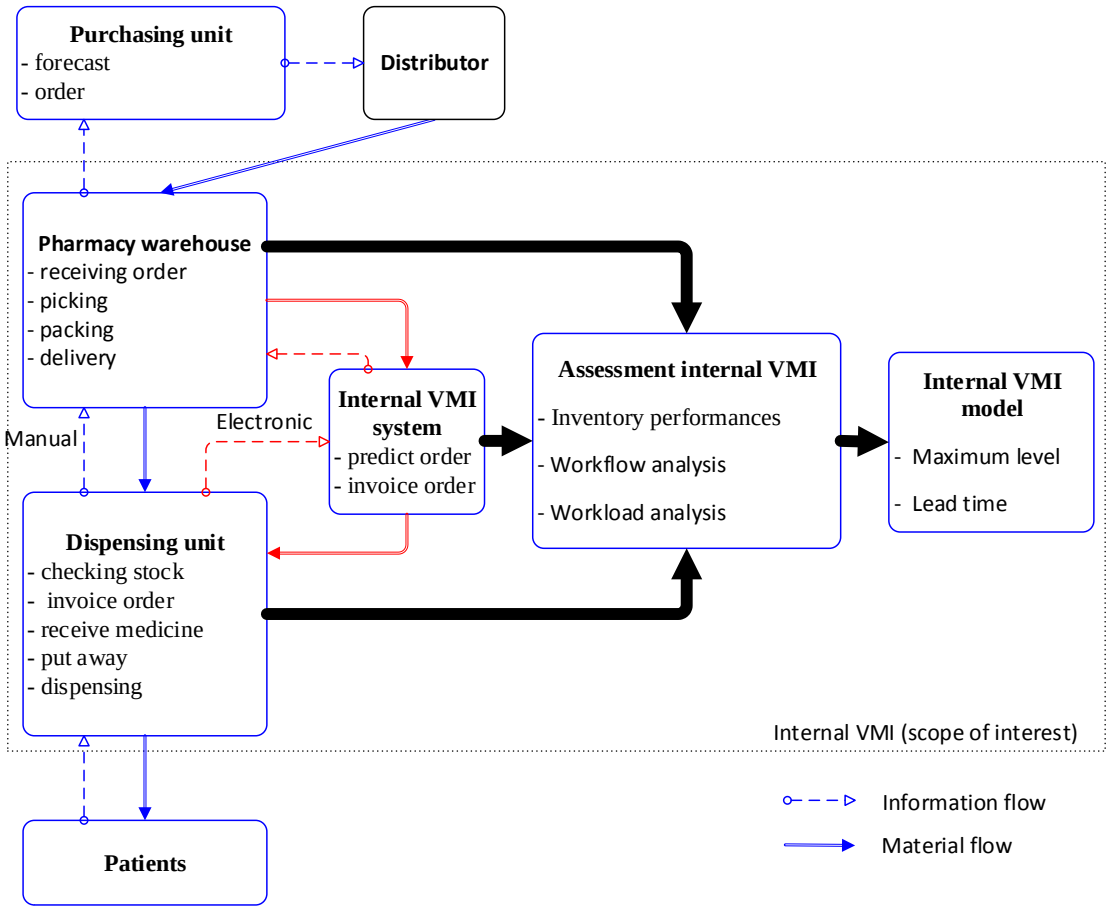


Figure 2.6 Medical supply chains of the VMI system. (1)

To implement VMI approach, there are three key success factors that should be taken into account. First, VMI should be divided into two layers which are internal VMI and External VMI. In terms of internal VMI, it focuses on processes inside the hospital supply chain, how they manage material processes effectively in order to gain accurate demand information. In terms of external VMI, its value is on processes outside the hospital. This particularly concerns how the hospital shares accurate demand information with the suppliers and the suppliers are then responsible for replenishing and managing the hospital's inventory. Secondly, shortening the ordering process is also required in order to succeed in implementing VMI. As this approach uses continuous replenishment, which aims to be more responsive to customer demand, shortening the ordering process enables the supplier to respond to the hospital's demand better. Lastly, it is necessary to have accurate demand information and adopt an enabler technology to run VMI smoothly. Inaccurate demand information is a great barrier and can lead to failure of VMI. Thus, it must be ensured that both pharmacy warehouse and dispensing rooms share accurate information. Additionally, the IT system is also an enabling factor that drives both trading partners to integrate and collaborate effectively for successful implementation of VMI. (1, 2, 4)

Conceptual framework



CHAPTER III
METHODOLOGY

This chapter provides information of the methodology that was used in this study. It consists of 5 parts: Study design, Study site, Study period, Study Population and Study procedure which are explained as follows;

3.1. Study design

This was a cross-sectional experimental study. Two internal VMI models were constructed; the first one between the pharmacy warehouse and a dispensing room floor 1, Somdech Phra Debaratana Medical Center and the second one between the pharmacy warehouse and all dispensing units. Suggestion of purchasing quantities after the application of VMI to the purchasing unit was proposed. Each model contained different alternative scenarios. Suitable logistic indicators were used to assess the alternative scenarios and the best alternative was selected. Drug dispensing and transferring electronic database from August 2013 to September 2014 were retrieved to run the model.

3.2. Study site

This study was conducted at the dispensing unit and the pharmacy warehouse at Somdech Phra Debaratana Medical Center, Ramathibodi Hospital.

3.3. Study period

This study began in October 2014 through May 2015.

3.4. Study Population and Sample

The dispensed medicines electronic data base was used to run the model and some information was collected to assess the performance of the model.

1. List of medicines to be selected as the study population. There were 3 groups:

1.1 Top 10 Class A drugs according to ABC analysis, as they represented the value of drug utilization.

1.2 Top 10 drugs that frequently faced shortage, as they represented the quality of the ordering and delivery system.

1.3 Top 10 most frequently dispensed drugs, as they represented the number of transactions.

Exclusion criteria for medicines in this study were drugs that were not available or that changed brands during the study period because this group could affect the stability of data collection. Among each 3 groups selected if any duplication were found only one item was included.

2. The alternatives in each VMI Model were assessed against the hospital KPIs; which were average inventory value, days of stock (DOS) and service level.

3.5. Study procedure

The study procedure composed of 5 parts; 1) Activity analysis, 2) Construction of the downstream internal VMI model to a OPD dispensing room 3) Assessment of downstream internal VMI model 4) Application of the the internal VMI to all dispensing rooms 5) Assessment of downstream to all dispensing rooms 6) Assessment of upstream of internal VMI model to the pharmacy warehouse 7) The effect of internal VMI along the supply chain

3.5.1. Activity analysis

The purpose of this part was to gain understanding in work activity. This was done by explaining flow of activities from the pharmacy warehouse to the dispensing units and; or downstream logistics, and from the warehouse to the

purchasing unit; or upstream logistics. Inventory management processes collected from interviewing staff and by observing the process, starting from creating the invoice until receiving the medicines from the pharmacy warehouse. The swim lane diagrams were constructed to show the processes and identify the persons responsible for each process.

3.5.2. Construction of the downstream internal VMI model

There were 3 steps as follow;

3.5.2.1 Analyze the drug utilization pattern.

All the daily utilization data of 30 drug samples were retrieved from the database to plot the scatter graph to demonstrate the differences of utilization pattern. Then the researcher grouped drug utilization patterns.

3.5.2.2 Two internal downstream VMI models were constructed (Constructed the models).

The first downstream model was between the warehouse and the main pharmacy unit, the second one was between the warehouse and all dispensing units. Within the downstream VMI model, 4 alternatives were generated to compare their performance. These alternatives came from varying the maximum level of inventory (7 days, 14 days, 1 week, and 1.2 week), methods in calculation of replenishment volume (average day formula and sum of week formula). The 4 alternatives are;

Alternative 1:

Calculation of the maximum level was done by the average drug utilization in one month, taking data from 2 consecutive months. For example, the level forecasted in May would come from the data in April and March. The maximum replenishment volume was 7 days, came from multiplying average daily utilization by 7. The stock was replenished twice a week, these days were the days before peak consumption during the week, notified from the drug pattern. The Re-Order Point (ROP) was set at 4 days of average drug utilization. The decision to replenish was done by 2 steps, first set the days to replenish and then looked at the

level of on hand if this level was below ROP the medicine would be fill up to the maximum level, but if not it would be skipped to the next round.

Alternative 2:

Calculation of the maximum level was done by the average drug utilization in one month, taking data from 2 consecutive months. For example the volume forecast in May would come from the data in April and March. The maximum replenishment volume was 14 days, came from multiplying average daily utilization by 14. The stock was replenished once a week, this day was the day before peak consumption during the week, notified from the drug pattern. The ROP was set at 7 days of average drug utilization. The decision to replenish was done by 2 steps, first set the days to replenish and then looked at the level of on hand if this level was below ROP the medicine would be fill up to the maximum level, but if not it would be skipped to the next round.

Alternative 3:

Calculation of the maximum level was done by the summation of one week drug utilization during the prior 2 months and then selected the highest volume of one week utilization. The replenishment was done once a week on a fixed day. The ROP was not set. The volume of drug replaced equal to the maximum level minus the on hand.

Alternative 4

Calculation of the maximum level was done by multiplying the summation of one week drug utilization during the prior 2 months and then selected the highest volume of one week utilization with 1.2. (Or 1.2 *alternative 3). The replenishment was done once a week on a fixed day. The ROP was not set. The volume of drug replaced equal to the maximum level minus the on hand.

3.5.2.3 Run the model

3.5.2.3.1. As it is model.

This model was run to show the present performance from the current data set. Started from finding the daily balance stock from the on hand volume of the previous day minuses by daily drug utilization pluses

the receiving amount from the warehouse. The volume of balance stock was used to calculate the KPI's; value of inventory, days of stock and service level.

3.5.2.3.2. To be model.

The daily consumption of drug was used in conjunction with alternatives 1 to 4. The performance of each alternative was assessed and KPI's were compared among alternatives.

3.5.3. Assessment of downstream internal VMI model to an OPD dispensing room

The data from the past was used to run the models and choose the best alternative; the models were evaluated by 3 KPI's as service rate, day of stock, and stock value, as following;

1. Average Inventory value is the cost of medicine storage in warehouse at the point of time. The goal of hospital aimed to reduce 20 % of inventory value.

Inventory value = balance stock in volume * value of medicines.

$$\text{Average inventory value} = \frac{\text{Summation of inventory value in every day}}{\text{Number of days}}$$

2. Average of Days of stock was the average amount of time that warehouse will hold inventory before the inventory was sold. The optimum days of stock should be less than 14 days.

$$\text{Average utilization per day} = \frac{\text{Summation of daily utilization}}{\text{Number of days}}$$

$$\text{Daily Days of stock} = \frac{\text{Daily balance stock in volume}}{\text{Average utilization per day}}$$

$$\text{Average Days of stock in a month} = \frac{\text{Summation of Daily Days of stock}}{\text{Number of days in a month}}$$

3. Service rate expressed the ability of the OPD dispensing rooms to serve the patients. The value of 95% service rate indicated an acceptable good performance.

$$\text{Service rate} = \frac{\text{Number of patients receiving medicines} * 100}{\text{Total numbers of patients were receiving the medicine.}}$$

Those KPI's were set by the hospital and selected the best alternative to be implemented to all pharmacy dispensing rooms.

The best alternative was selected by choose alternative that could provide the best of three hospital KPI's. The Average inventory value should reduce more than 20 percent; the average of Days of stock should be less than 14 days; and Service rate should be more than 95 percent.

3.5.4. Application of the internal VMI to all dispensing rooms and suggest purchasing volume.

After the conclusion of previous part, the selected alternative of the internal VMI was implemented to all pharmacy dispensing rooms to see the effect to the pharmacy warehouse. By this new VMI model, the ware house would calculate the replenishment volume and supplied the medicines to all the dispensing rooms. It should change the inventory value, days of stock and service level. The pharmacy warehouse was changed to be the manager to distribute the medicine to all dispensing rooms and suggested the purchasing volume to the purchasing unit. There are 5 step as follow;

1. Select one medicine from each group to be the sample, run the model to see the output to all dispensing rooms. The samples were distributed from pharmacy warehouse to many dispensing rooms.

2. The patterns of drug utilization in each room were analyzed in order to understand the behavior of drug dispensed in pharmacy dispensing rooms.

3. Applied the selected internal VMI model to all dispensing rooms, used the formula from the previous part to calculate the replenishment volume in each

room. The daily balance stock of warehouse was calculated after distribution volume of medicine to all dispensing rooms.

4. The medicines were issuing from the warehouse at different volume as follow;

4.1 Calculated the issuing volume from current situation. The requesting order from dispensing room were used to calculate by summation of all dispensing rooms are issuing the medicine from the warehouse (drug utilization from the warehouse)

4.2 Calculated the issuing volume from alternative situations. The replenishment volume from previous part was applied to all dispensing room. The data of receiving volume of medicine from the warehouse was collected to be the issuing data from the warehouse.

5. The purchasing volume was considered from the warehouse maximum level minus the on hand level. The purchasing lead times were set to be 7 and 14 days, thus created 2 scenarios.

5.1 The purchasing volume of lead time 7 days (scenario 1) was calculated by upper limit minus the stock balance of the warehouse in previous day. The upper limit was calculated by the maximum issue quantity from the warehouse in one week multiply by 2. The maximum issue quantity from the warehouse was calculated by maximum quantity issued per week during 8 weeks.

5.2 The purchasing volume of lead time 14 days (scenario 2) was calculated by upper limit minus the stock balance of the warehouse in previous day. The upper limit was calculated by the maximum issue quantity from the warehouse in one week multiply by 3. The maximum issue quantity from the warehouse was calculated by maximum quantity issued per week during 8 weeks.

3.5.5. Assessment of downstream to all dispensing rooms.

The selected internal VMI alternatives were implemented to all dispensing rooms. Three KPI's from part 3 were used to assess the performance of this alternative.

3.5.6. Assessment of upstream of internal VMI model to the pharmacy warehouse

This was the assessment of output of the upstream VMI model, or to compare the warehouse KPI's before and after application of VMI. After implementation of the internal VMI to all dispensing rooms the volume of drug issued from the warehouse to dispensing rooms would change. So the purchasing volume should be re-calculated to see the effect of VMI model between the warehouse and the purchasing unit. The summation of drug distributed from the pharmacy warehouse to all dispensing room was used to calculate the amount of medicine to be purchased. The assessment based on three KPI's, inventory value, days of stock and service level. Those KPI's should be better than current situation. The inventory value should be reduced; days of stock should be reduced and service level should be 100 percent in order to prevent drug shortage.

3.5.7. The effect of internal VMI along the supply chain.

After application the internal VMI model to all pharmacy rooms and the purchasing unit, the benefits from higher inventory performance should be cumulative. The whole drug supply chain was assessed.

CHAPTER IV
RESULTS

The results are composed of 4 parts as follow:

4.1 General profiles of the pharmacy warehouse, the main OPD pharmacy, and the purchasing department.

4.2 The VMI models for the pharmacy warehouse and the main OPD pharmacy.

4.3 The impact of VMI model to the pharmacy warehouse and the purchasing department.

4.4 The best alternative of VMI models along the supply chain.

The VMI models were applied at two places along the internal supply chain of medicines in the hospital. The first VMI model was applied between the pharmacy warehouse and the main OPD pharmacy. At this point, the pharmacy warehouse was the vendor and the main OPD was the customer. Four VMI models were constructed. The best alternative VMI model to solve inventory problems was selected. Then the selected VMI model was applied between the pharmacy warehouse and every OPD pharmacies in order to test the impact of application. This VMI model can have an impact on the workload of the pharmacy warehouse and the purchasing department. At this point, the pharmacy warehouse was the customer and the purchasing department was the vendor. The best VMI model was selected from three inventory criteria; the inventory value; the average days of stock, and the service rate. Details are demonstrated as follow.

4.1. General profiles of the pharmacy warehouse, the main OPD pharmacy, and the purchasing department.

4.1.1 Work flow along the medicine supply chain.

The medicine supply chain of the outpatient department is composed of the material flow and the information flow. The material flow starts from the distributors sends the medicine to pharmacy warehouse, the warehouse to the dispensing unit and the dispensing unit to the patients. The information flow starts at the dispensing room in the form of request order in paper to the warehouse. The amount requested comes from pharmacy assistants based on their experience. The warehouse then takes the information regarding the amount utilized from dispensing unit to forecast the purchasing volume. The purchasing order will go to the distributors, ordering to send medicines to the warehouse, as shown in the figure 4.1.

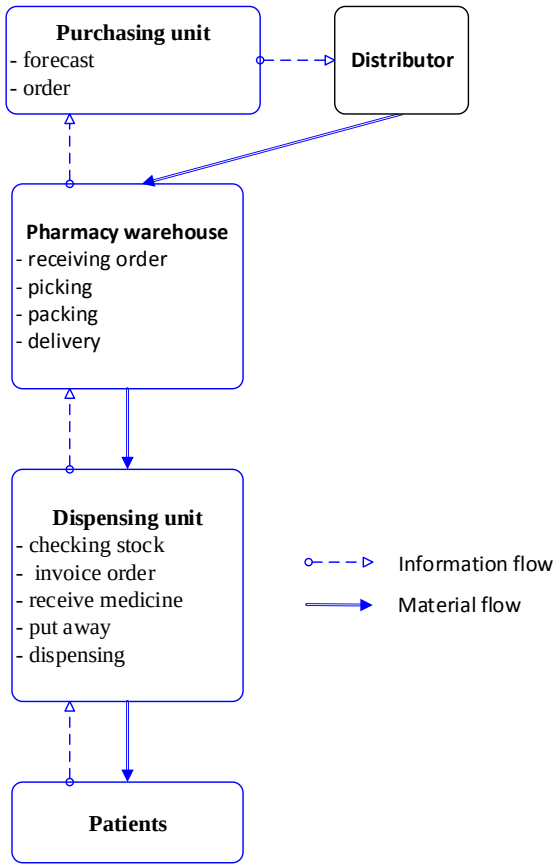


Figure 4.1 Work flow of the medicine along the supply chain

The detail work flow between dispensing unit and pharmacy warehouse is as follows:

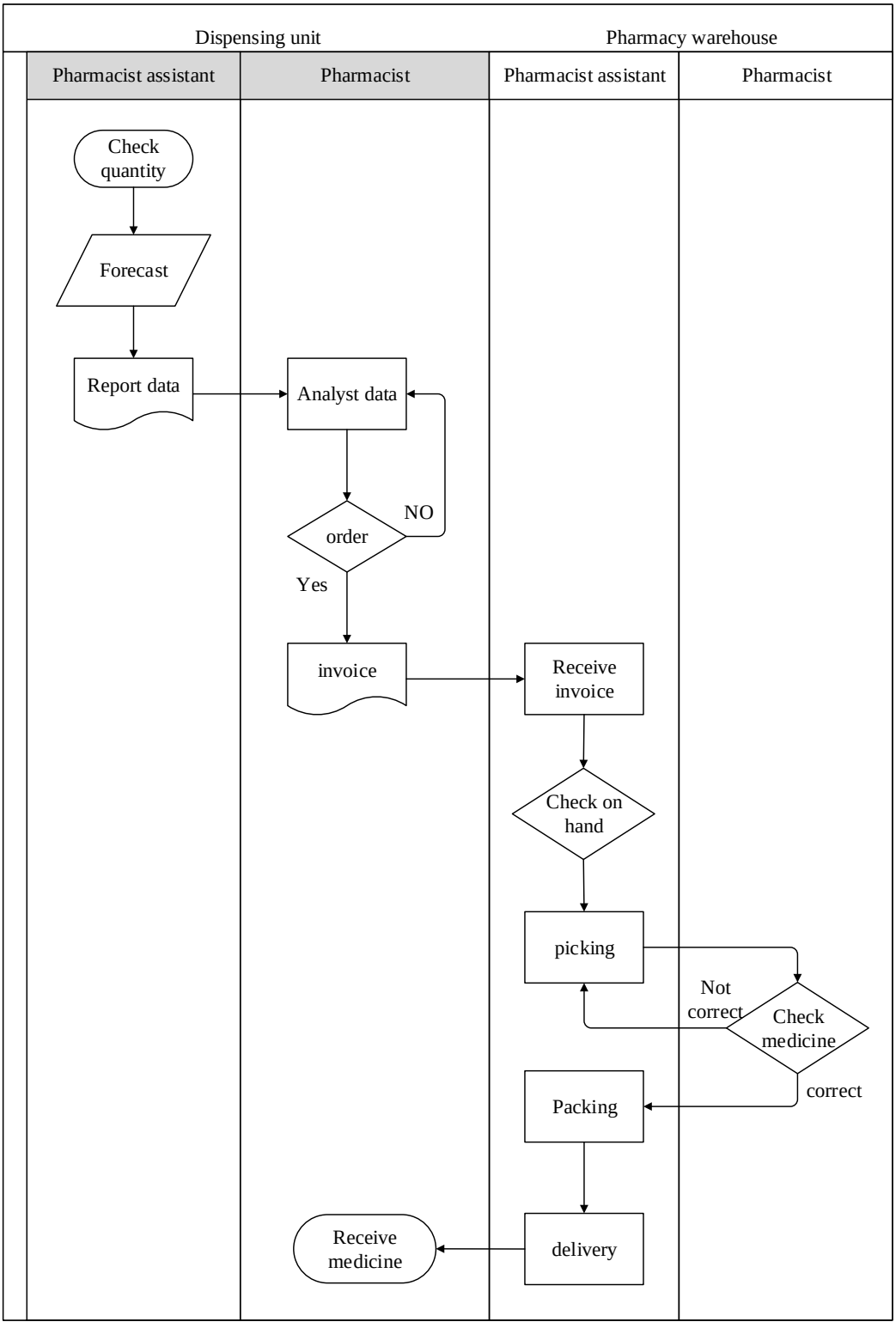


Figure 4.2 Work flow between dispensing unit and pharmacy warehouse

The purchasing unit used two types of information to calculate the purchasing volume; the consumption volume from the dispensing room and the on hand amount from the warehouse.

4.1.2 General profile of the pharmacy warehouse

There are 2,076 stock keeping units (SKU) in the warehouse during August 2013 to September 2014. The number of transaction per year is 198,960 averages per month 16,580, average per day 754.

The hospital KPIs of inventory output are; Average day of stocks, Average value of stock and Service level.

4.1.3 General profile the main OPD pharmacy

There are 1,547 stock keeping units (SKU) in the main OPD pharmacy during August 2013 to September 2014. The number of prescription per year is 265,848, average per month 22,154, average per day853. The number of pharmacy and pharmacy assistance are 44 and 74.

When classified the medicine by ABC analysis, there are;

Class A 96 SKU

Class B 195 SKU

Class C 1,252 SKU

At present, the service level of this main OPD pharmacy is 99 Percent and the Average of Day of stock is 10.28 days which does not exceed the levels set by the hospital at the service level of 95-100 Percent and the Average of Day of stock at 14 days. The total value of inventory is 13,472,512 Baht which is mandatory to be decrease by 20 Percent according to the hospital policy.

Table 4.1 Performance of the main OPD pharmacy and the hospital KPIs

Indicators	Current system	Hospital KPI
Service level	99 Percent	95 – 100 Percent
Average of Day of stock	10.28 days	14 days
Total value of inventory	13,472,512 Baht	decreased by 20 % from present

4.1.4 General profile the purchasing unit

There are two pharmacists and four pharmacy assistants in purchasing unit, responsible for 8,462 purchasing orders and 16,783 items per year. The lead time after sending the purchasing order to receiving the medicines into the warehouse was approximately ten days, as information from interviewing the head of pharmacy inventory unit.

4.2. The VMI models for the pharmacy warehouse and the main OPD pharmacy

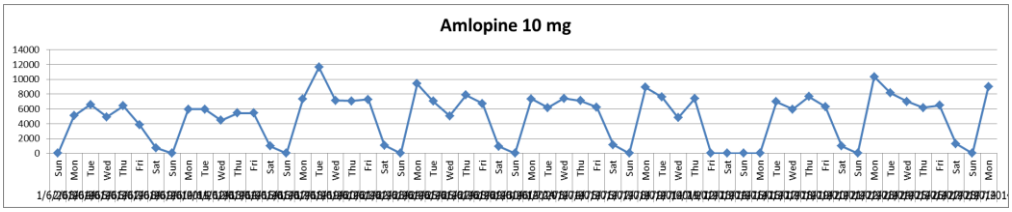
Models construction The overall model construction was composed of several steps as: identified drug dispensing pattern, generated inventory scenarios, created alternative choices of replenishment, assessed each alternative according to the hospital KPIs and selected the best alternative.

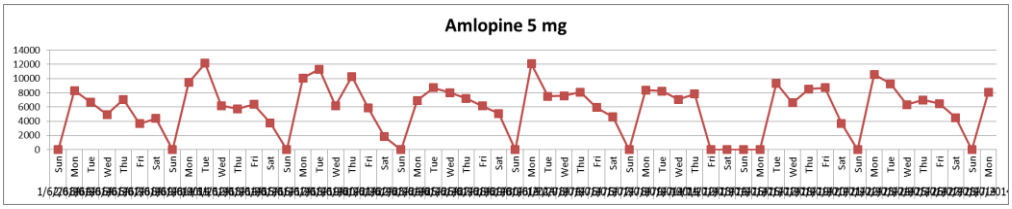
4.2.1 Patterns of drug dispensed to patients at the OPD pharmacy room.

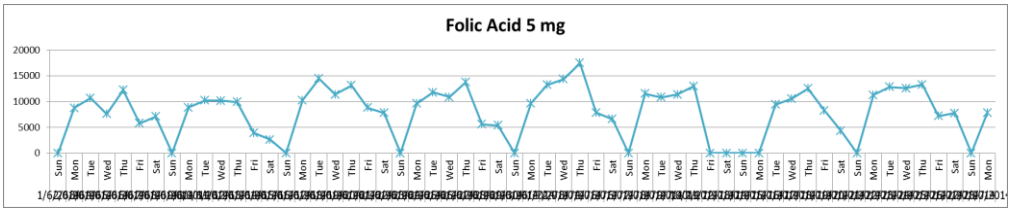
The daily rates of utilization of each drug sample were retrieved and plotted by days. It was found that the patterns could be grouped in to 3 types; a) regular pattern b) irregular pattern and c) by patient case pattern. The figures of each pattern are demonstrated in the figures 4.3 to 4.5.

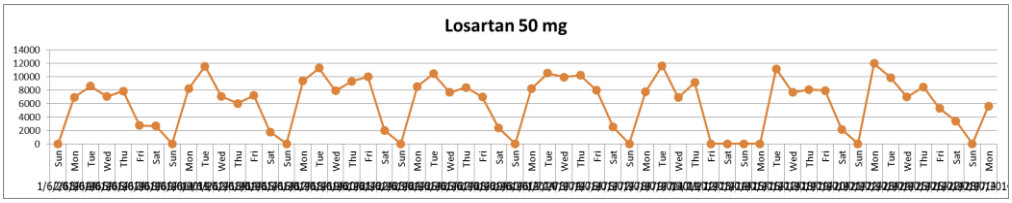
a) Regular pattern

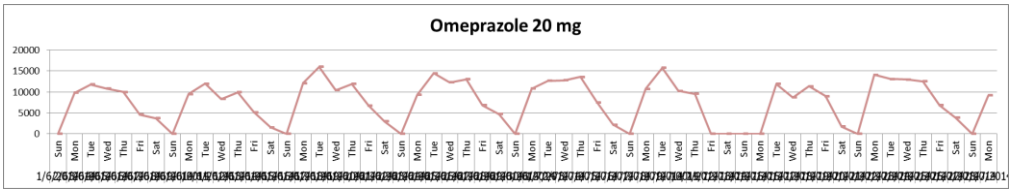
The characteristic of this pattern is the utilization during the week was almost repeated.











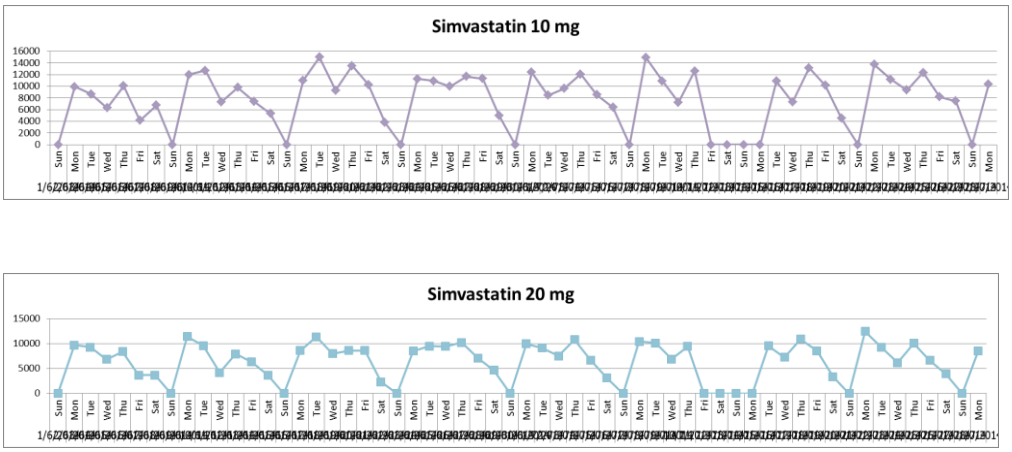
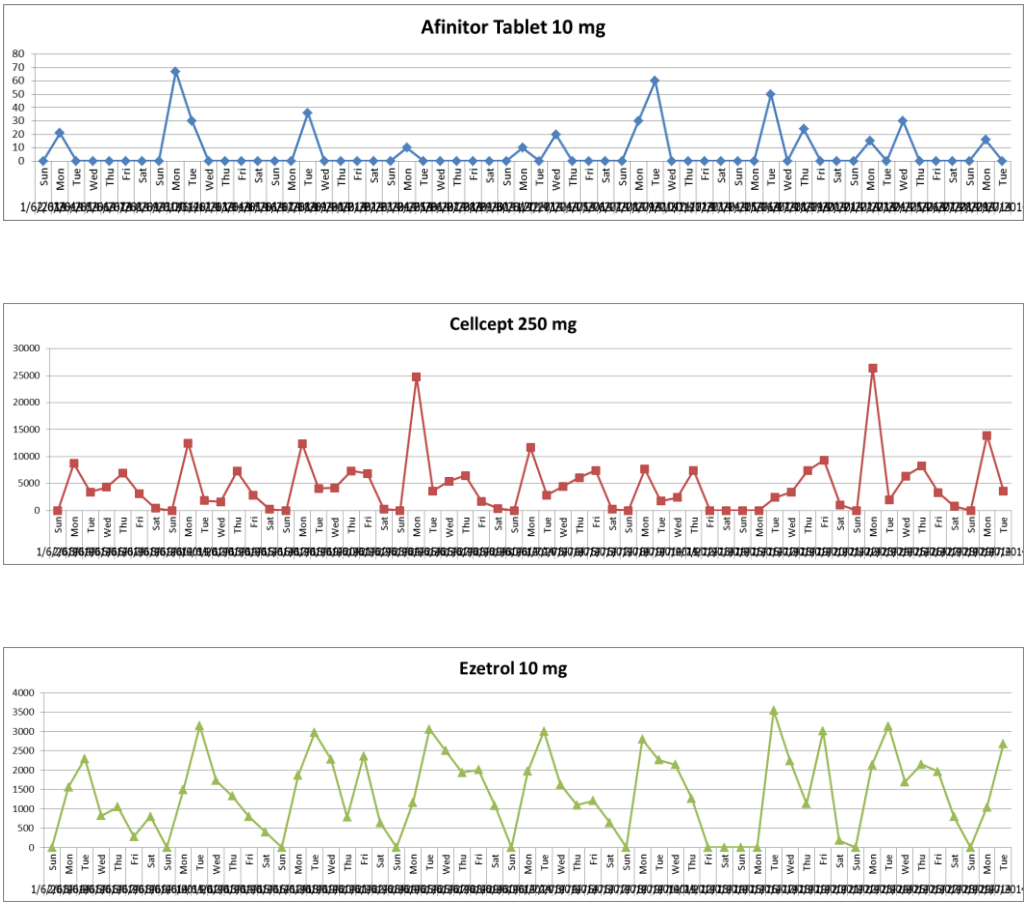
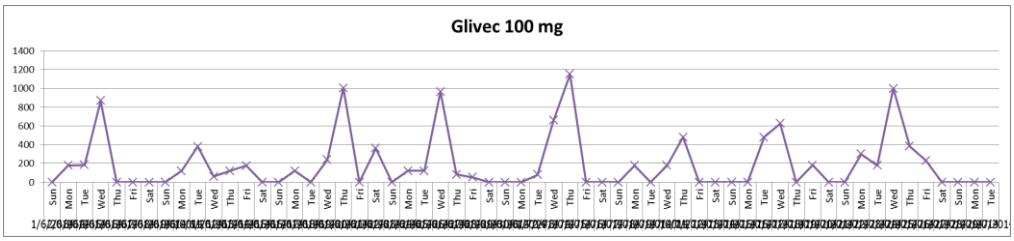


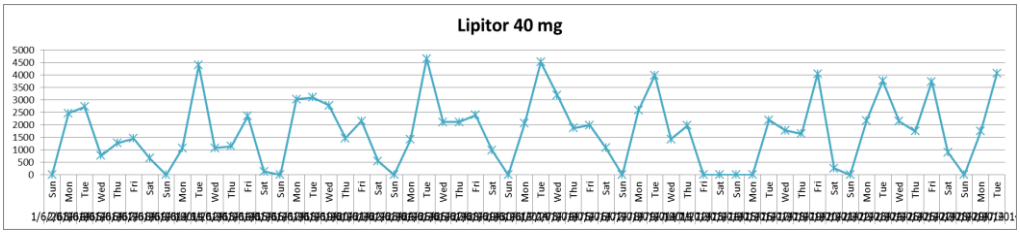
Figure 4.3 Pattern of utilization of medicine in Regular pattern

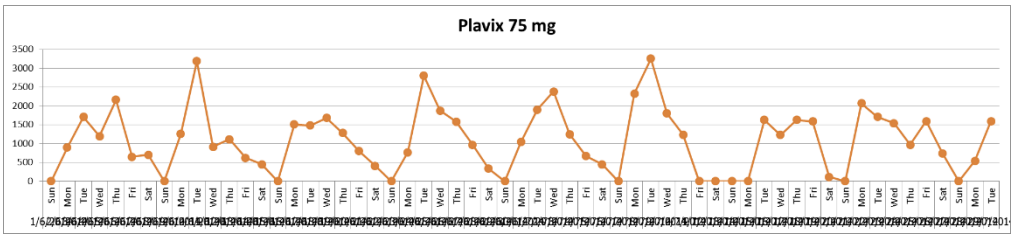
b) Irregular pattern

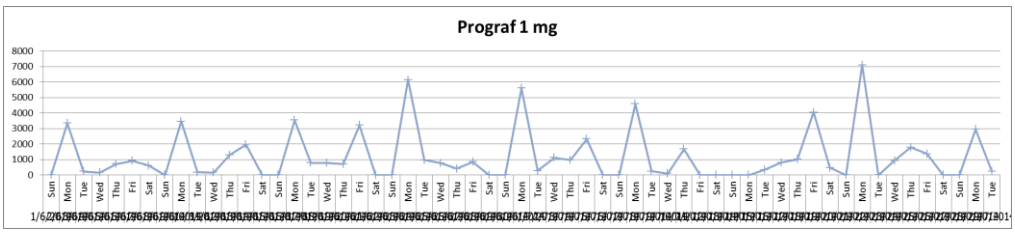
The characteristic of this pattern is the utilization during the week was not the same.

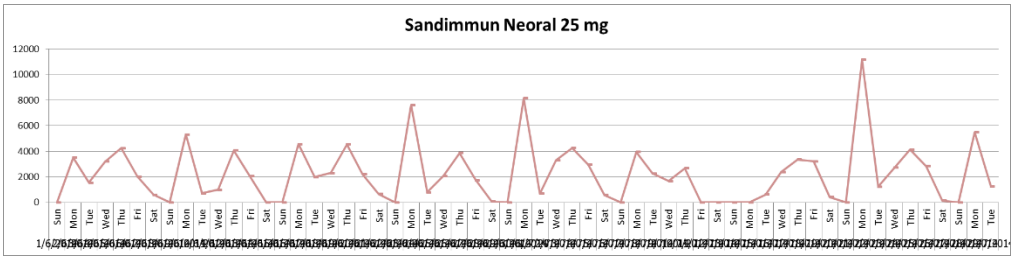


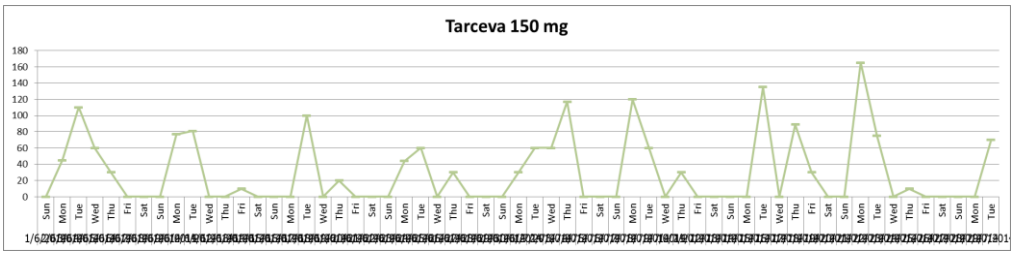

Glivec 100 mg

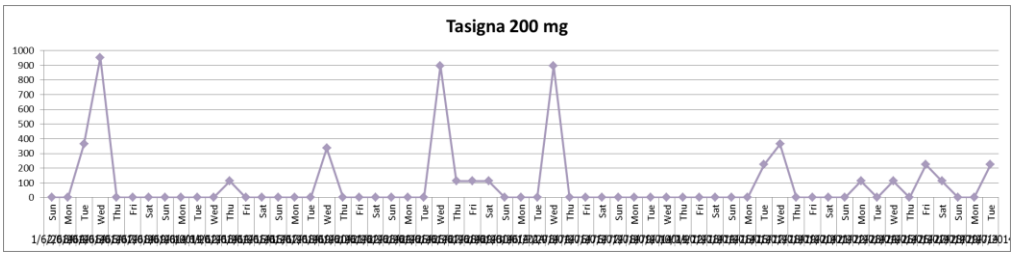

Lipitor 40 mg

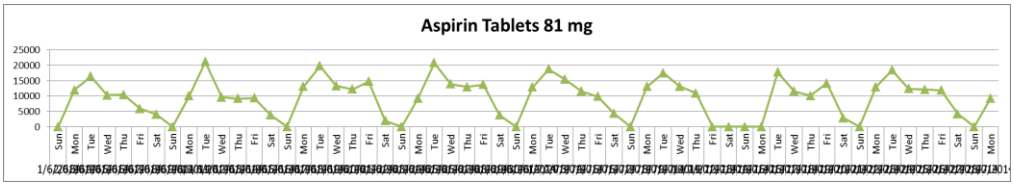

Plavix 75 mg

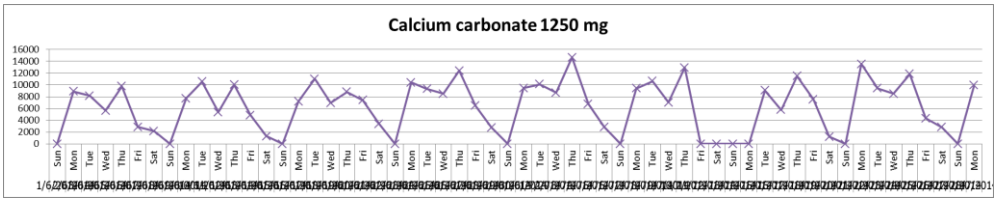

Prograf 1 mg

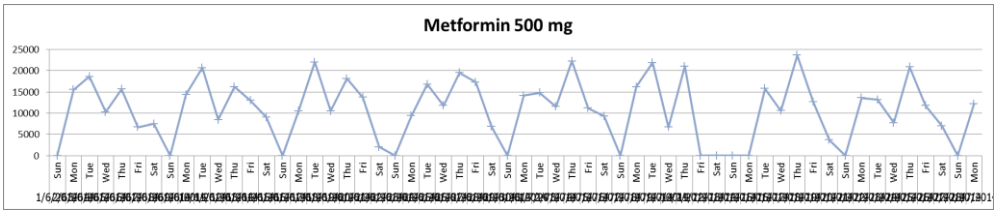

Sandimmun Neoral 25 mg

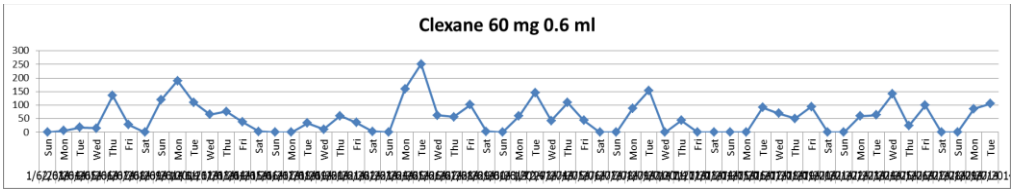

Tarceva 150 mg


Tasigna 200 mg


Aspirin Tablets 81 mg


Calcium carbonate 1250 mg


Metformin 500 mg


Clexane 60 mg 0.6 ml

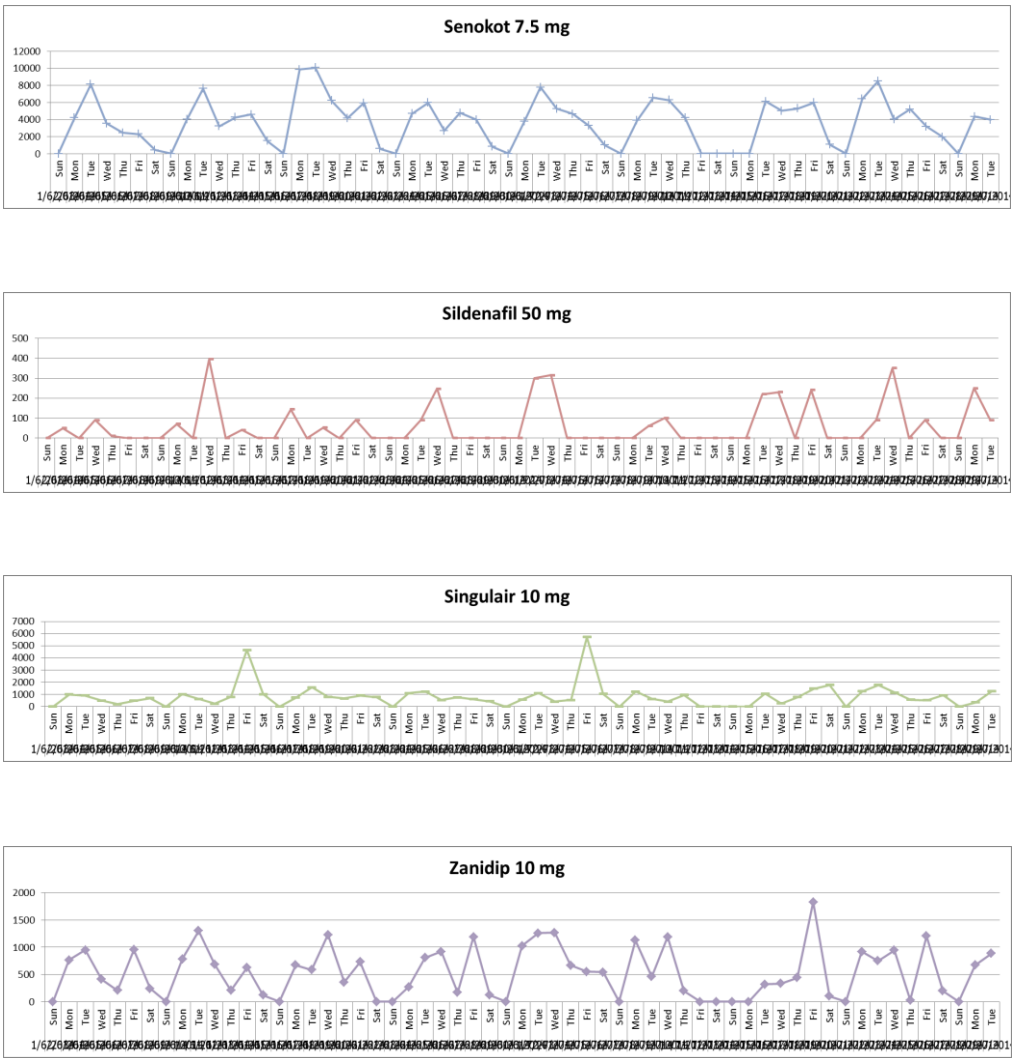
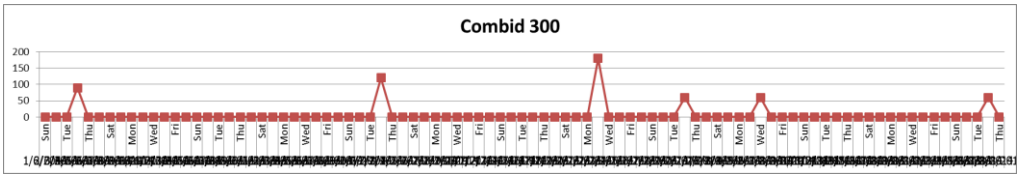


Figure 4.4 Pattern of utilization of medicine in Irregular pattern

c) By patient case pattern

The characteristic of this pattern is related to the patient visit.



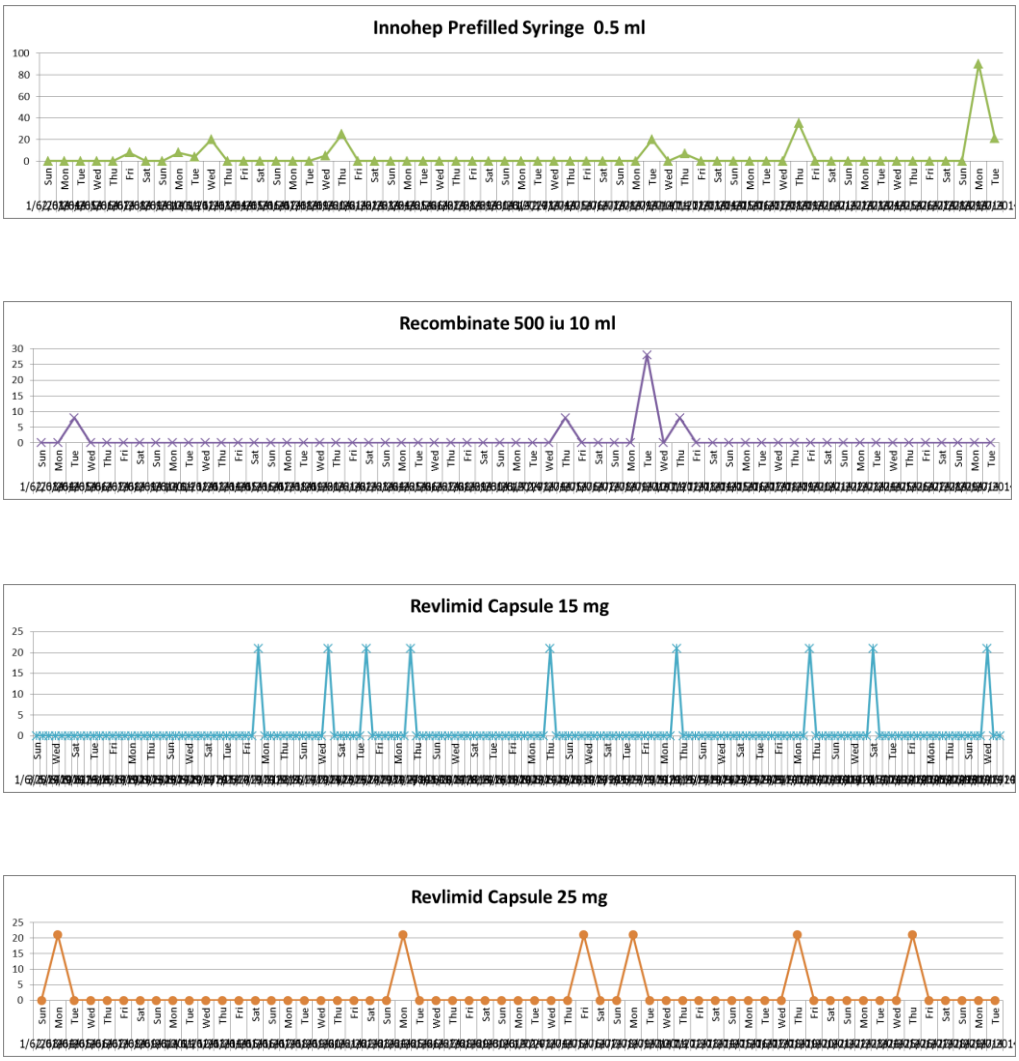


Figure 4.5 Pattern of utilization of medicine in by patient case pattern

4.2.2 Generated inventory scenarios.

4.2.2.1 Work flow between the dispensing unit and the pharmacy warehouse after applying the VMI model shown as follow.

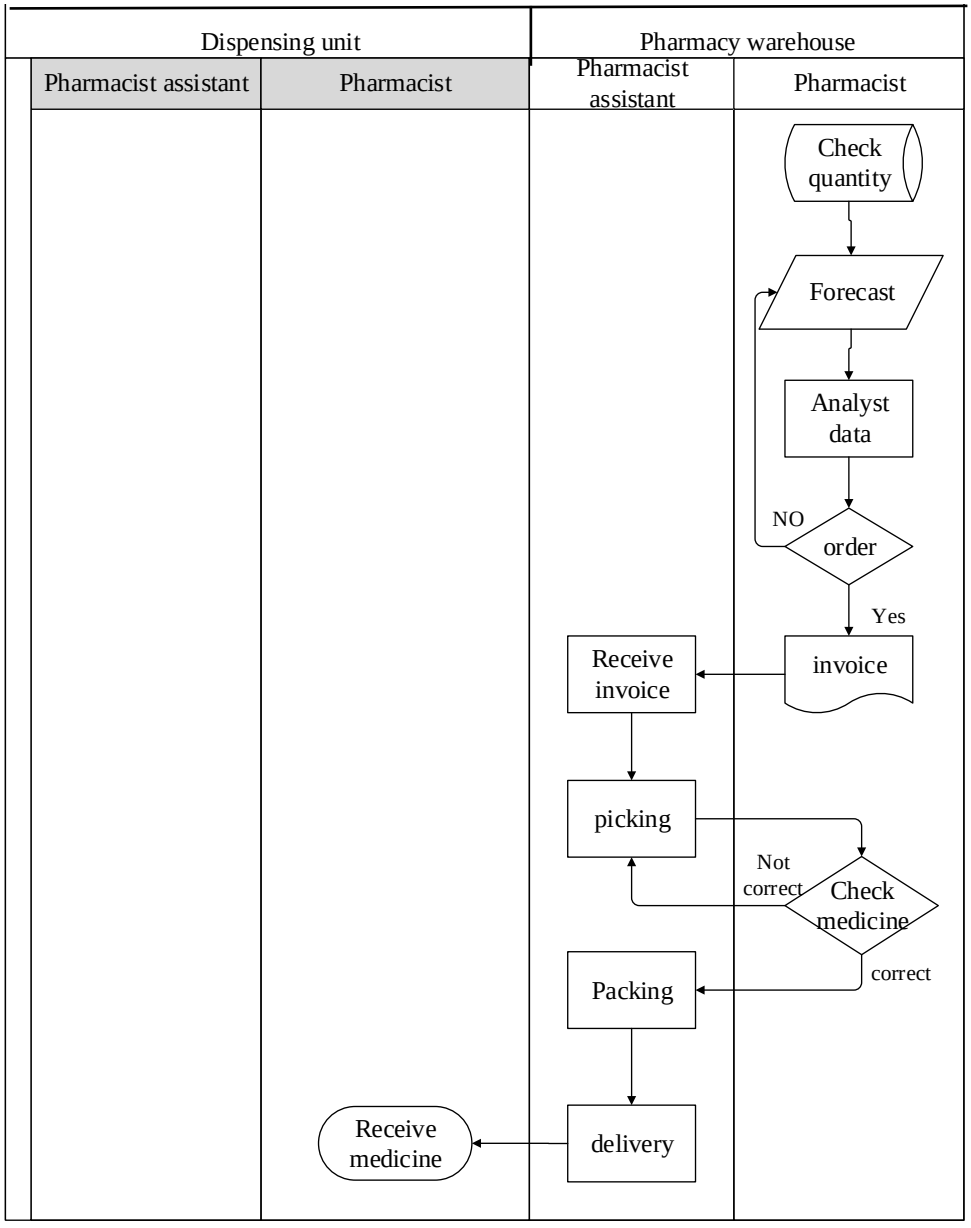


Figure 4.6 Work flow between the dispensing unit and the pharmacy warehouse after apply VMI

The decision to replenish the medicine was changed to be the pharmacy warehouse. The calculation of replenishment volume based on the dispensing rate.

4.2.2.2 Work flow between pharmacy warehouse and purchasing department after apply the VMI model shown as follow.

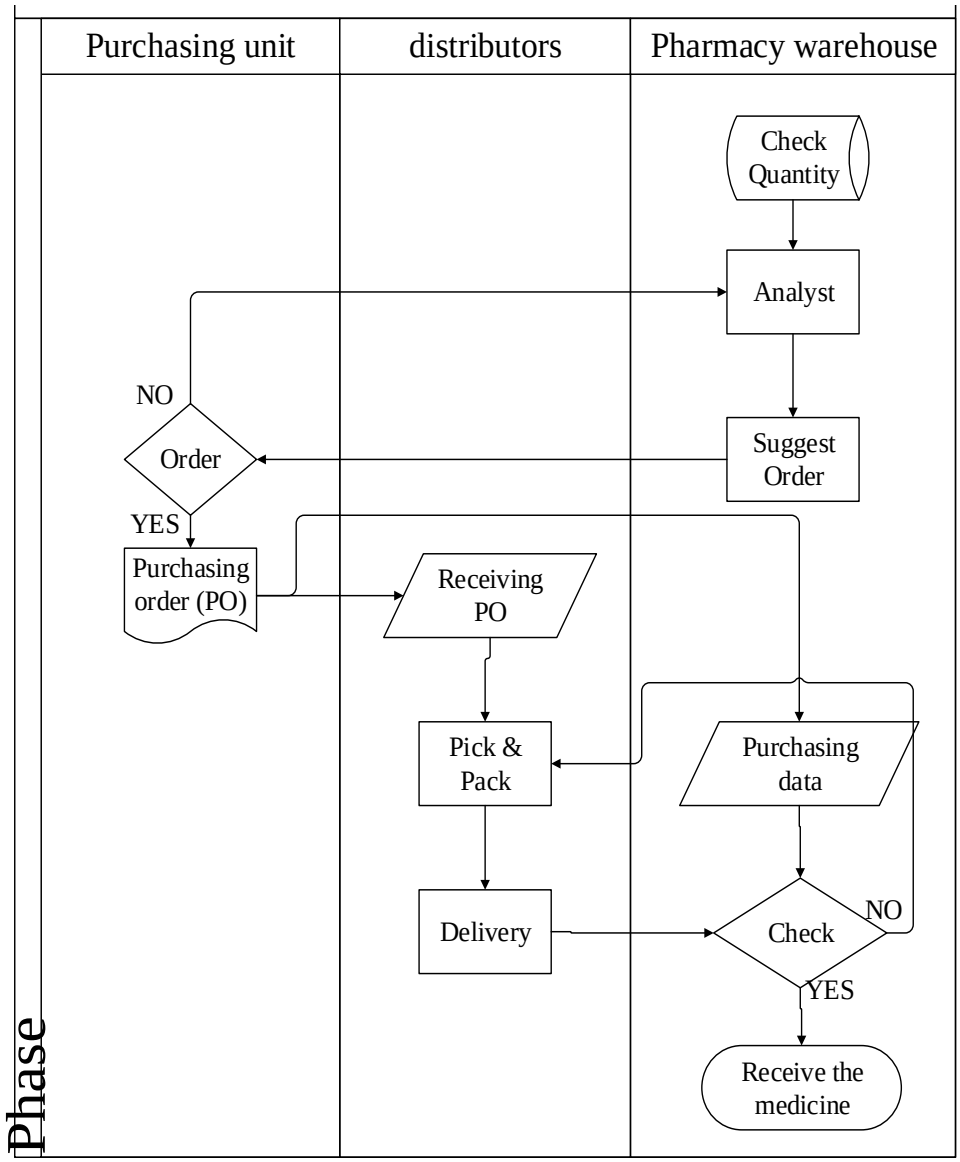


Figure 4.7 Work flow between the pharmacy warehouse and the purchasing department after apply VMI

The purchasing volume was created by the pharmacy warehouse. The data to calculate came from the dispensing rate to the patients and the balancing stock in the warehouse.

4.2.3. Created alternatives of replenishment.

The formula to replenish used the “average day formula” and “Sum of week formula” to create four alternatives. First alternative was “Average day formula” multiplied by 7 days. Second alternative was “Average day formula” multiply by 14 days. Third alternative was “Sum of week formula” multiplies by 1. Forth alternative was “Sum of week formula” multiplies by 1.2.

4.2.4. Model Assessment and KPI’s.

Each alternative was assessed by three KPI’s to select the best alternative.

1. Inventory value

The first alternative is the best because it can reduce the inventory value by 45.1 percent in regular pattern of drug utilization and 30.1 percent in irregular pattern of drug utilization. However third alternative would be consider because it can reduce the inventory value more than 20 percent.

Table 4.2 Inventory value of drug utilization

Alternatives		Pattern of drug utilization		
		Regular pattern N=7 (%change)	Irregular pattern N=18 (%change)	By Patient Case pattern N=5 (%change)
Existing performance		469,930	12,926,183	76,398
Average Day Formula	7 days (alternative 1)	**258,150 (- 45.1%)**	**9,032,388 (-30.1%)**	2,961,008
	14 days (alternative 2)	616,858	17,317,003	6,631,085
Sum of Week Formula	Sum of week*1 (alternative 3)	**324,333 (-31.0%)**	**9,600,005 (-25.7%)**	838,495
	Sum of week*1.2 (alternative 4)	418,504	12,020,026	1,118,437

2. Average of Days of stock

The third alternative is the best because it can provide the average of days of stock six days for regular pattern of drug utilization and eight days for irregular pattern of drug utilization. More over all of the medicines were not have average of day of stock more than 14 days.

Table 4.3 Average of Days of stock

Alternatives		Pattern of drug utilization	
		Regular pattern N=7 (Min-Max)	Irregular pattern N=18 (Min-Max)
Existing performance		10 (4-17) DOS over 14 days: 1 (14%)	10 (2-26) DOS over 14 days: 3 (17%)
Average Day Formula	7 days (alternative 1)	**5 (5-6)**	**7 (4-18)** DOS over 14 days: 1 (5.5%)
	14 days (alternative 2)	12 (11-13)	15 (11-37) DOS over 14 days: 5 (28%)
Sum of Week Formula	Sum of week*1 (alternative 3)	**6 (6-7)**	**8 (6-11)**
	Sum of week*1.2 (alternative 4)	8 (8-9)	10 (8-13)

3. Service Levels

The third alternative is the best because it can provide service levels 100 percent for regular pattern of drug utilization and 99 percent for irregular pattern of drug utilization. However all of the medicines have only one sample is service level less than 95 percent.

Table 4.4 Service Levels

Alternatives	Pattern of drug utilization		
	Regular pattern N=7 (Min-Max)		Irregular pattern N=18 (Min-Max)
Existing performance	100 (97-100)		99 (92-100) Below 95%: 3 (17%)
Average Day Formula	7 days (alternative 1)	**100 (97-100)**	**92** (63-100) Below 95%: 7 (39%)
	14 days (alternative 2)	100	98 (63-100) Below 95%: 2 (11%)
Sum of Week Formula	Sum of week*1 (alternative 3)	**100**	**99** (94-100) Below 95%: 1 (5.5%)
	Sum of week*1.2 (alternative 4)	100	100

4.2.5. Selection of alternatives

The selection of alternative was alternative 3, because it could reduce the inventory value by more than 20 percent, provided the average days of stock to be around 7 days and rendered 100 percent service rate. More over this alternative needed only once a week to replenish the medicines instead of twice a week for alternative 1, so it reduced the numbers of transportation the medicines from the warehouse to the OPD pharmacy room.

4.3. The impact of VMI model to the pharmacy warehouse and the purchasing department

Three drug samples, one (Folic acid) from high frequency picking group, second (Cellcept 250 mg) from class A medicine group and third (Senokot) from drug shortage group were purposively selected to analyze the impact of VMI model between the pharmacy warehouse and the purchasing department.

The data of drug utilization of seven pharmacy rooms, six OPD and one IPD, which are the customers of the warehouse, were retrieved from the hospital database.

The overall procedure for construction of the model composed of identified drug dispensing patterns in each pharmacy room, generated inventory scenario, created alternative choices of replenishment, assessed each alternative according to the hospital KPIs and selected the best alternative.

4.3.1 Models construction

4.3.1.1. Pattern of utilization in each room

First the pattern of drug utilization in each pharmacy room to find the consistency with the main OPD pharmacy room. The figure 4.8 to 4.10 shows the patterns. There are three medicines as follow;

1) Cellcept

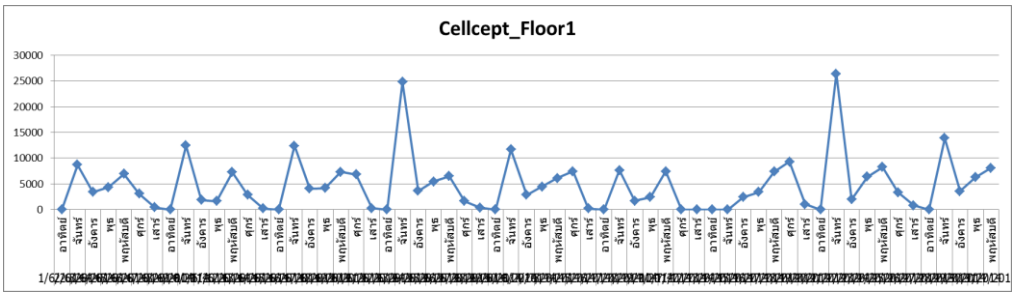
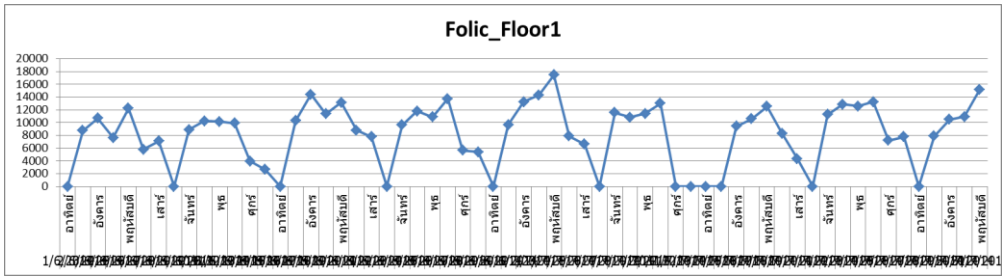
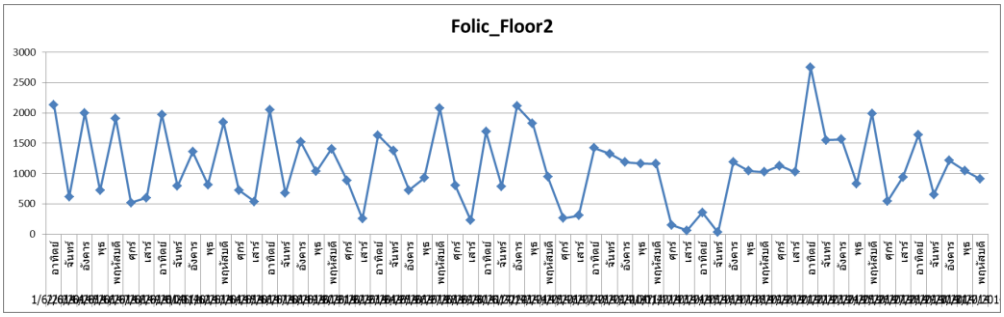
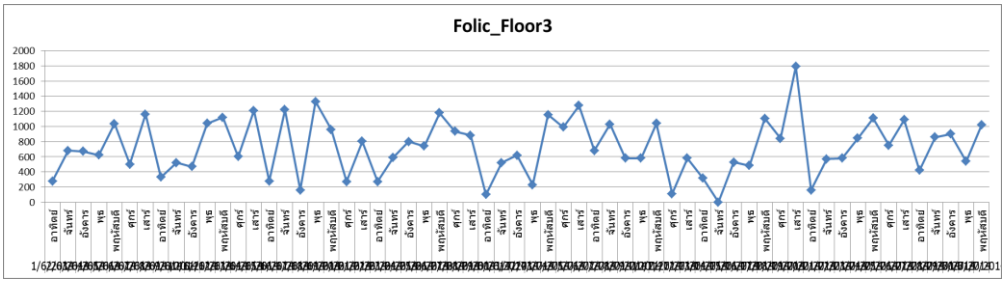


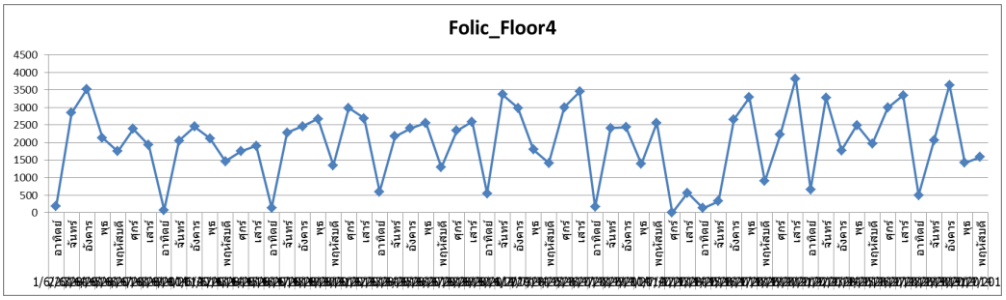
Figure 4.8 Pattern of utilization of Cellcept in each room.

2) Folic acid









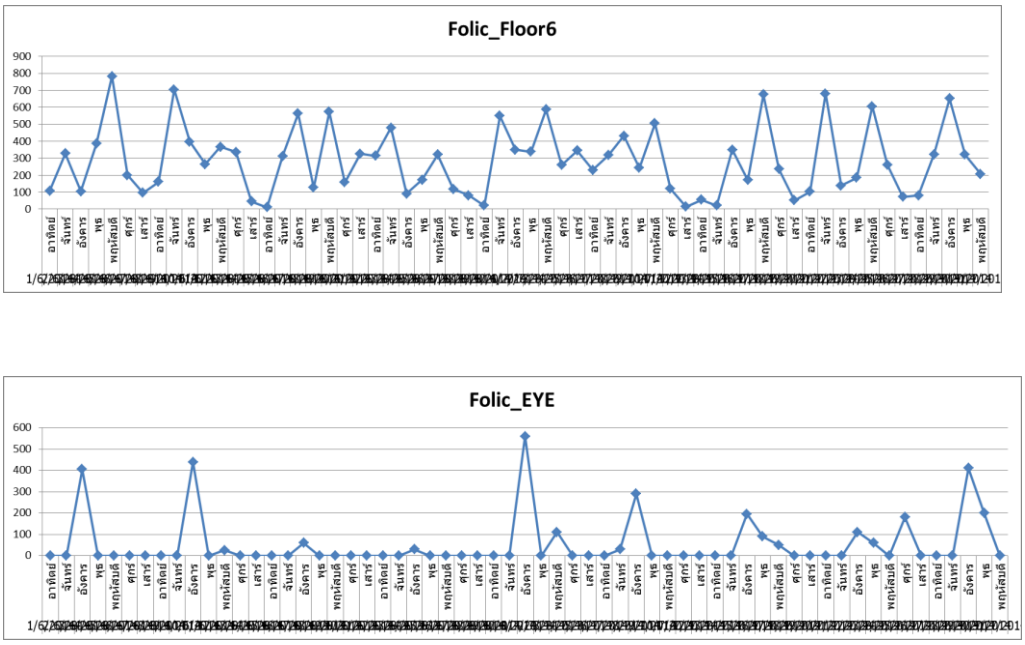
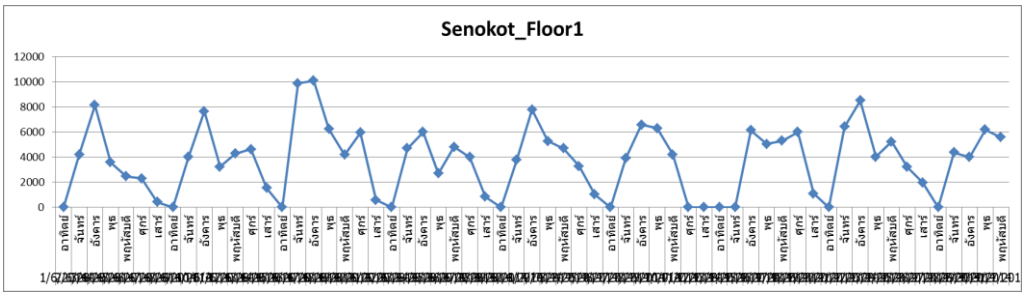
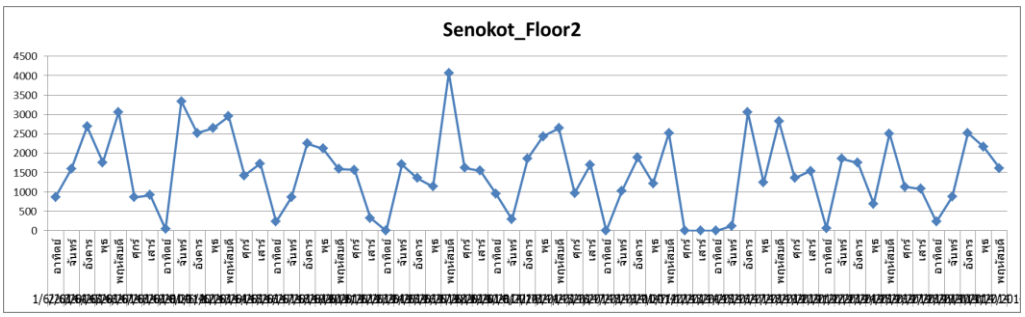


Figure 4.9 Pattern of utilization of Folic in each room.

3) Senokot





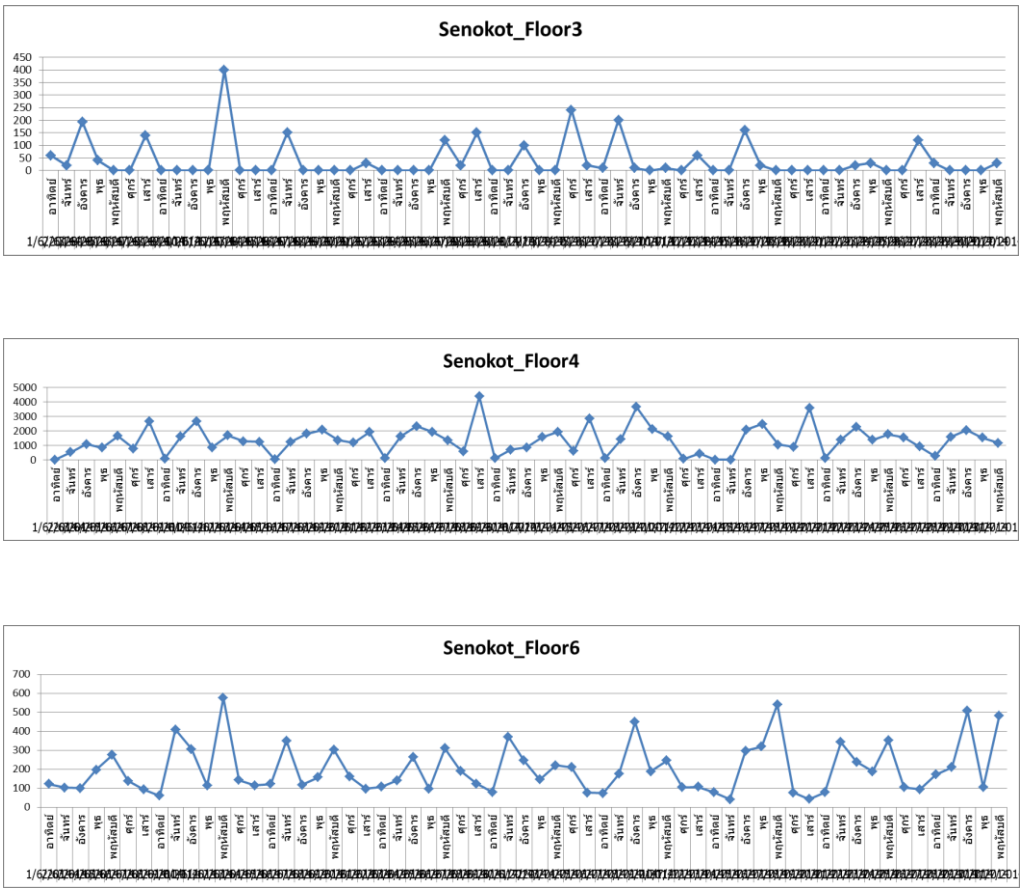


Figure 4.10 pattern of drug utilization of Senokot in each room

To summarize the pattern, it was found that;

1. The patterns of drug utilization of Folic in each room are different.
2. The patterns of drug utilization of Cellcept in each room are different.
3. The patterns of drug utilization of Senokot in each room are different.

4.3.1.2. Work flow between dispensing unit and pharmacy warehouse after apply VMI model shown as follow

At present all pharmacy dispensing rooms generated the replenishment volumes by themselves. The proposed internal VMI model is the system that the warehouse will desire the volume of replenishment for all pharmacy dispensing rooms. So they will not send the request orders to the pharmacy warehouse thus reduce the workload of all pharmacy dispensing rooms. The figure 4.11 shows the new system.

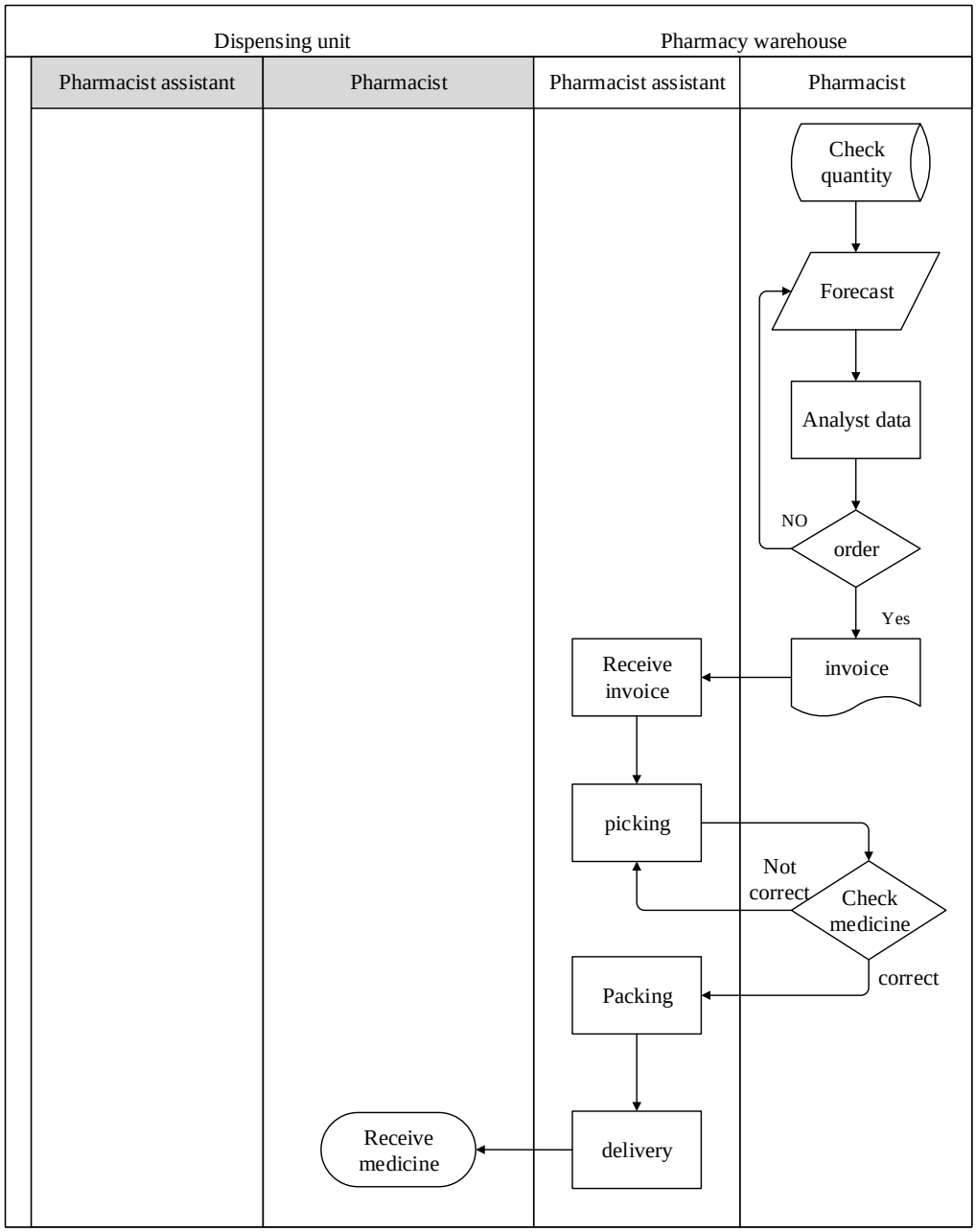


Figure 4.11 Work flow between dispensing unit and pharmacy warehouse after apply VMI model.

4.3.1.3. Application of internal VMI model to replenish the medicine from the warehouse to pharmacy dispensing room.

The selected VMI model from the previous sector was applied to all seven pharmacy rooms. There are two models; alternative 3 the replenishment volume was calculated from the highest amount of the summation of drug utilization in one week among eight consecutive weeks. The alternative 4 is alternative 3 multiplied by 1.2. The replenishment volumes from the warehouse to six pharmacy rooms were calculated. The result will reveal the efficacy of the proposed VMI models that can apply to each pharmacy dispensing room. The result shows that the alternative 3 can be applied to every room and every medicine except Cellcept to room 7012 and 7013. The reason is the different pattern of drug utilization. It was found that the pattern in the room 7012 and 7013 are the “by case of patient” while in other rooms are regular and irregular pattern. The alternative 4 can be applied to every room and every medicine except Cellcept for room 7013. The reason is the same as alternative 3. The warehouse will suggest room 7012 and 7013 to manage the inventory of Cellcept by manually.

This confirms that alternative 3 and alternative 4 can be applied to calculate the replenishment volume for every room and all medicines possessing both regular and irregular pattern.

Table 4.5 Drug performance of Celcept, Folic acid, and Senokot after implementation of alternative 3 and 4 among all dispensing room.

		Cellcept			Folic			Senoket		
Room		DOS	Av Value	Service level	DOS	Av Value	Service level	DOS	Av Value	Service level
7011	Existing	9	2,021,401	100	7	54,863	100	5	19,342	100
	sum of wk*1	8	1,955,991	100	5	42,626	100	6	24,019	100
	sum of wk*1.2	11	2,516,401	100	7	56,158	100	8	31,306	100
7012	Existing	14	202,587	100	11	11,849	100	21	31,345	100
	sum of wk*1	11	166,211	97	8	8,070	100	8	11,969	100
	sum of wk*1.2	14	193,120	100	11	11,226	100	10	14,731	100
7013	Existing	31	28,458	100	19	14,983	100	20	911	100
	sum of wk*1	25	24,898	95	6	4,615	100	18	825	100
	sum of wk*1.2	25	24,898	95	7	5,574	100	21	926	100
7014	Existing	14	269,848	100	10	20,681	100	9	12,619	100
	sum of wk*1	9	181,078	100	5	10,697	100	5	7,236	100
	sum of wk*1.2	12	225,709	100	7	14,115	100	7	9,825	100
7016	Existing	24	16,595	100	16	4,467	100	12	2,708	100
	sum of wk*1	18	12,046	100	10	2,729	100	7	1,517	100
	sum of wk*1.2	26	17,702	100	13	3,614	100	8	1,889	100
2025	Existing	-	-	-	98	3,380	100	57	983	100
	sum of wk*1	-	-	-	98	3,380	100	25	432	100
	sum of wk*1.2	-	-	-	98	3,380	100	32	560	100

The warehouse will select the VMI replenishment alternative 3 (Sum of week *1) to the maximum level of seven-day utilization. Then the warehouse will use this model to calculate the replenishment volume from pharmacy warehouse to all pharmacy dispensing rooms.

Next step, the purchasing volume of each medicine will be calculated. The replenishment volume of each room will be sum up to calculate the purchasing volume for the purchasing unit. At present the average lead time to replenish the medicine into the warehouse is 10 days. The researcher set the new lead time to be 7 and 14 days to see its effects on KPIs of pharmacy warehouse. Then simulate scenario to assess by varying lead time and the formula of replenishment from previous sector. After calculation of each scenario the KPIs of pharmacy warehouse will collected to assess the performance of pharmacy warehouse.

4.3.2 Model Assessment and KPIs

The selected model-1 was assessed its efficacy by these indicators:1) Inventory value 2) Average of Days of stock and 3) Service Levels

In the case of Cellcept, by the current purchase procedure it was found that the service level was 100 percent, day of stock was 18.33 days and the inventory value was 5,020,984 baht. By new VMI scenarios, a comparison between the purchasing lead times of 7 days and 14 days, the service level are the same as current system but day of stock reduced from 18.33 days to 10.28 days and 10.98 days, the inventory value decreased from 5,020,984 Baht to 3,190,738 Baht and 3,406,967 Baht or reduced 36.45 percent and 32.15 percent respectively.

In the case of Folic Acid by current purchase it was found that the service level was 100 percent, day of stock was 23.12 days and the inventory value was 288,164 baht. By new scenarios, a comparison between purchasing lead times of 7 days and 14 days, the service level for lead time 7 and 14 days are the same as the current system, day of stock reduces from 23.12 days to 10.3 days and 17.7 days, the inventory value decreases from 288,164 Baht to 154,320 Baht and 265,318 Baht or 46.45 percent and 7.93 percent respectively.

In the case of Senokot by current purchase it was found that the service level was 100 percent, day of stock was 19.37 days and the inventory value was

134,538 Baht. By new scenarios, a comparison between purchasing lead times of 7 days and 14 days, the service level is the same as the current system; day of stock reduces from 19.37 days to 10.78 days and 16.29 days, the inventory value decreases from 134,538 Baht to 86,942 Baht and 131,427 Baht or 35.38 percent and 2.31 percent respectively.

Table 4.6 Results of model assessment and KPI's.

		Cellcept 250 mg			Folic Acid 5 mg			Senokot 7.5 mg		
	KPI's	Current Purchase	Pur-LT7d	Pur-LT14d	Current Purchase	Pur-LT7d	Pur-LT14d	Current Purchase	Pur-LT7d	Pur-LT14d
New purchasing	Service level	100	100	100*	100	100	100	100	100	100
	DOS	18.33	10.28	10.98	23.12	10.3	17.7	19.37	10.78	16.29
	AV Value	5,020,984	3,190,738	3,406,967	288,164	154,320	265,318	134,538	86,942	131,427
	(% change)		-36.45	-32.15		-46.45	-7.93		-35.38	-2.31

4.3.3 Selection of purchasing model

The selected model is the one with the purchasing lead time 7 days because this model can provide the service level at 100 percent. It also reduced more days of stock and average inventory value of stock, even though at the first week of transition the service level dropped because at that time is a transaction period for implementation.

4.4. The best alternative of VMI models along the supply chain

This internal VMI model will assign the pharmacy inventory unit as a system manager to run both upstream and downstream drug supply chain. The upstream starts from the pharmacy warehouse suggesting the purchasing volume to pharmacy purchasing unit. The downstream starts from the pharmacy warehouse replenishing medicines to the pharmacy dispensing rooms.

Along the downstream VMI model, it can save the amount of stock value at pharmacy dispensing floor 1 SDMC building from 25.7 to 31.0 percent, which the sample is 25 percent of total value of stock in this room. If it is applied to all medicine (100%), it should save from 13,293,696 to 15,517,933 Baht. Moreover if this system is apply to every pharmacy room, it should save much more. Right now the value of total stock is 120,699,071 (all pharmacy dispensing room) Baht then this system can save the budget approximately 58,572,676 to 69,577,786 baht. But this system cannot be applied to the medicine is “by patient case pattern”, which from 30 samples this pattern accounted for 16.67 percent. Thus at least 80 percent of total medicine should gain benefit after the implement of this system. It should be reduced the value of stock approximately 31,019,661 to 36,209,721 baht.

The upstream VMI model can reduce the stock of the pharmacy inventory unit by 35.38 to 46.45 percent. At present total stock value is 200,073,802 baht if implement this system it can save 70,780,840 to 92,928,603 baht.

CHAPTER V
DISSCUSSION

This research selected 30 drug items from 3 groups of drug that represent major inventory problems of Somdech Phra Debaratana Medical Center, Ramathibodi Hospital. The main reason was to see if the internal VMI model can solve the existing problems or not.

1) 'The Class A group' was concerned by the hospital administration because they represented high value of drug utilization. So if the VMI model works, it would benefit in term of reduce hospital costs.

2) 'The high frequency dispensed drugs group' was concerned by the staff of pharmacy warehouse and pharmacy dispensing rooms because they represented high number of transactions. So if the VMI model works, it would benefit in term of reducing the work load.

3) 'The drug frequently faced shortage group' was concerned by the administration of the hospital and pharmacy dispensing room because they represented the quality of the ordering and delivery system. So if the VMI model works, it would benefit in term of increase service level to the patients, thus increase satisfaction.

And it was found that the new internal VMI model can improve the inventory performance both at the warehouse and at the dispensing units. The reduction of inventory volume and the days of stock, while maintain the service rate at 100 percent. Also reduced the work load at pharmacy dispensing rooms and changed the duty to pharmacy warehouse. So implementation this model to all dispensing rooms would return in higher efficiency of the whole drug supply system. The hospital administrator should make decision to release a policy and support these changes.

The researcher tried to identify the patterns of drug utilization in order to find the best alternative formula to calculate the replenishment volume that fit each pattern. But this trial resulted that the best alternative formula can be applied to every pattern of drug utilization except the 'By patients case pattern'. Which it needs close

monitoring and manually inventory management case by case. The pharmacists should follow the appointment schedule of the patients and prepare the medicines before their visits.

The pattern of drug utilization should be considered by more statistic application to find out the difference between patterns and identify the pattern.

In reality, there are more than one thousands of medicines to run the patterns. So there is no need to conduct this step, just identify the medicines that used case by case. The internal VMI can apply. There might be some medicines are overstock or out of stock, those medicines should be run the pattern of drug utilization then consider about the management alternative for replenish the medicines. However the vital drugs should be closely monitoring because those medicines are live saving it cannot allow being shortage.

There should be a good cooperation between the pharmacy department and the IT department, because the pharmacy warehouse needs to use the hospital data base to calculate the replenishment volume for the dispensing units and suggests the purchasing volume for the purchasing unit. And also needs some data to assess the performance of the internal VMI system.

Methods to create the alternatives for replenishing the medicines for the dispensing units came from the researcher's 'trial and errors' to find out the way to solve the problems. There are three main though to create the alternative by looking the drug patterns to lead the way to solve the problems. First, calculated by base on average drug utilization per day and found that this method can lead to drug shortage when it facing the peak of unusual drug utilization during a week. Second, tried to solve that problem by used the peak of drug utilization during a week to calculate the replenishment volume but it facing the problems as the previous method. Finally, the researcher used the summation of drug utilization in the whole week to calculate to solve the problems of peak during the week and found that it was sound.

Along with the selected best alternative #3, not only the inventory performance indicators improved but also the workload of staff in the warehouse. This is because the number of transportation from the warehouse to the dispensing units was set at once a week. The warehouse can arrange the replenishment day to

send the medicines in order to reduce the traffic inside the warehouse and maximize the convenience to the dispensing rooms.

This internal VMI is the active system that allows the warehouse to replace the medicines without waiting for the orders from the pharmacy dispensing rooms. The pharmacy warehouse can control its work activities. When the dispensing rooms release all the responsibility in inventory management including making a request for medicine, they should have more time to concentrate on clinical activities such as render intervention to the patients.

The implementation of internal VMI would reduce work load of dispensing room, but however the burden in forecasting the replenishment volume goes to the pharmacy warehouse. So there should be a study on the workload for a smooth operation in the warehouse.

During the transition period from the present system to the VMI system, there were some drug shortages caused by the insufficiency of the first on hand volume. But as the VMI process continues, the volume of daily on hand resilience to a stable level. The pharmacist should pay attention to the vital (V) drugs during this transition, because the service rate of vital drugs must be 100 percent.

While routine operating the VMI, if there are drug shortages or over stock, the pattern of utilization should be re-consider.

The service level of Cellcept at the purchasing lead time 14 days are not 100 percent because at the beginning of the simulation the utilization rate was over than normal, but on the following weeks there were no drug shortage. This situation of drug shortage also affected to the day of stock and the average inventory value to be less than the scenario of lead time 7 days because of more medicines shortage than the lead time 7 days scenario.

The volume to purchase the medicines was reduced by the lead time of 7 days and may lead to more expensive purchasing price. The hospital should contact the distributors to fix the purchasing price of medicines when the volume is decrease. In case of Ramathibodi hospital, the prices were fixed for 1 year.

The hospital administrator should satisfy with this implementation of the internal VMI system because it can reduce the inventory value of the warehouse and the dispensing units which save the hospital budget reduce days of stock which should

increase space availability in the warehouse, and still maintain the service rate to secure the patient safety and satisfaction.

CHAPTER VI
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This research ‘Application of the VMI system to replenish medicines at Ramathibodi Hospital.’ aims to construct a vender management inventory (VMI) system applicable to the hospital supply chain and evaluate the efficiency of the VMI system by 3 suitable logistic indicators and to propose a process for supply of medicines in the hospital

The current drug inventory system is a passive system and leads to inefficient service. This study tried to find a new system to solve problems in the hospital supply chain. The active internal VMI system was developed as a mean to achieve financial benefit and better service. The results of this research can be used to improve the efficiency of routine internal inventory services.

Vendor Management Inventory (VMI) can improve supply chain performance by decreasing inventory-related costs and increasing customer service. Unlike a traditional supply chain in which each member manages its own inventories and makes individual stocking decisions, VMI is a collaborative initiative where a downstream customer (internal hospital supply chain in our study) shifts the ownership of inventories to immediate upstream supplier (pharmacy warehouse) and allows the pharmacy warehouse to access their demand information in return. The upstream pharmacy warehouse has ownership of the inventories. The inventories are shipped to the warehouse

The data was collected from Ramathibodi hospital. The Vendor management inventory (VMI) system was applied to replenish medicines at the dispensing unit by using statistics from dispensing rate of medicines dispensed to the patients. Drug dispensing and transferring electronic database from August 2014 to September 2014 was retrieved to construct the model.

This research selected 30 drug items from 3 groups of drug that represent major inventory problems of Somdech Phra Debaratana Medical Center, Ramathibodi

Hospital. The main reason was to see if the internal VMI model can solve the existing problems or not.

1) 'The top ten of Class A group' (ABC analysis) was concerned by the hospital administration because they represented high value of drug utilization. So if the VMI model works, it would benefit in term of reduce hospital costs.

2) 'The high frequency dispensed drugs group' was concerned by the staff of pharmacy warehouse and pharmacy dispensing rooms because they represented high number of transactions. So if the VMI model works, it would benefit in term of reducing the work load.

3) 'The drug frequently faced shortage group' was concerned by the administration of the hospital and pharmacy dispensing room because they represented the quality of the ordering and delivery system. So if the VMI model works, it would benefit in term of increase service level to the patients, thus increase satisfaction.

The key performance indicators to assess the proposed internal VMI model were inventory volume, days of stock, and service rate.

Two active internal VMI models were developed and assessed. The first one was between the warehouse and the dispensing units, or called 'downstream VMI'. The warehouse was the vendor to manage the inventory for the dispensing unit. The simulation model ran on 30 medicines and between the warehouse and only one main dispensing unit. The second one was an 'upstream VMI', between the warehouse and the purchasing unit. The warehouse was the vendor to suggest the purchasing volume to the purchasing unit. Proper purchasing volume will return in higher warehouse efficient performance.

Four alternatives by vary the methods to calculate the replenishment volume and days of replenishment, for the 'downstream VMI' were generated and assessed. At this point the performance of VMI at the dispensing unit was assessed. The best alternative was selected and applied to all dispensing units to simulate the effect of application of 'downstream VMI' to the warehouse work performance. Two scenarios of the warehouse were proposed. At this point the warehouse work

performance at different scenario was assessed. The best scenario will be selected as a sample for an 'upstream VMI' simulation.

The conclusions of the results are as follow:

1. This active internal VMI is an efficient model for hospital inventory system management. It reduces the inventory volume and days of stock, both at the dispensing units and at the warehouse, while maintaining the high service level.

2. The first priority drug group to apply this model, according to ABC analysis, the Class A should be considered because they are highly impact to the inventory value.

3. The VMI model can be applied to any type of hospital but the work flow should be arranged as figure 4.1 and 4.2. The warehouse will act as the vendor for dispensing units by forecasting the replenishment volume and replenish up to the maximum level without the request. Moreover the warehouse will act as the customer to the purchasing unit by suggests the purchasing volume to purchasing unit.

4. In the application of VMI model, the pattern of drug utilization is one factor to be concerned. The regular and irregular patterns can applied by calculated the maximum level and replenishment volume by drug utilization in whole week. By patient case pattern is a pattern that cannot predictable because it up to visiting of the patient. The appointment schedule of inpatients and outpatients should be send to the warehouse to prepare the medicines for the patients. The patterns of drug utilization should be run before implement the VMI because drug patterns of each setting might be the same as this research up to the utilization of hospital.

5. The purchasing volume will be suggested by the pharmacy warehouse to the purchasing unit. This system shows the benefits to the warehouse by reduction of the day of stock about 10 days and reduction of the average inventory value about 35.38 to 46.45 percent for lead time 7 days.

Recommendations

1. To researchers

For further research approach, there should be a simulation to demonstrate the workload and performance of the warehouse to run this active VMI model to more (or every) drug samples and to every dispensing unit. Also more simulation models for 'upstream VMI'.

1) A queuing system for selection of the best replenishment day from the warehouse to all dispensing units should be studied.

2) A higher precision on forecasting the replenishment volume may come from longer time slot of drug utilization data.

3) Another perspective for performance assessment should be considered, such as manpower requirement, workload distribution, possibility of IT involvement for sustainable utilization, and warehouse space utilization.

4) The slow moving medicines group should be studied to calculate the replenishment volume for the dispensing rooms because alternative 3 was replenish the medicines every week. Those medicines might be used once a month. So the formula to calculate should be arrange such as replenish 1 times per month.

2. To hospital administrators

A full support to implement this active internal VMI system should be considered. The involvement of IT, rearrangement of workflow and duties should be the order from the hospital management team.

All formula for calculation of the maximum stock level, replenishment volume, etc. should be embedded to the hospital IT system, data retrieving and generation of reports could be done by the warehouse.

Development of policy on inventory volume for the warehouse and dispensing units should base on drug utility (VEN) such as vital, essential, and non-essential drugs.

This active internal VMI is applicable to every hospital.

3. To the pharmacy warehouse

Consideration of manpower because of changing the work process.

More closer cooperation between the warehouse and the dispensing units to monitor drug utilization pattern especially the 'By patient case' pattern.

An agreement on replenishment volume of medicines between the warehouse and the dispensing units should be considered.

An agreement on workflow and auditing process between the warehouse and the purchasing unit should be considered.

4. To the dispensing unit

Reduction of workload should lead to more time for clinical activities.

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APPENDICES

APPENDIX A

List of sample

Top 10 of High frequency picking

Drug	Row Labels	PICKING per Year	%	cum	No.
Folic Acid 5 mg	FOLA-T-	42389	3.20	3.20	1
Omeprazole 20 mg	OMPZ-C-	38755	2.93	6.14	2
Aspirin Tablets 81 mg	ASA.1T-	38306	2.90	9.03	3
Simvastatin 10 mg	SIMV-T-	35808	2.71	11.74	4
Simvastatin 20 mg	SIMV1T-	28180	2.13	13.87	5
Amlopine 5 mg	AMLP1T-	24963	1.89	15.76	6
Calcium carbonate 1250 mg	CALT2T-	22565	1.71	17.46	7
Metformin 500 mg	MEFM-T-	21806	1.65	19.11	8
Amlopine 10 mg	AMLP2T-	21205	1.60	20.71	9
Losartan 50 mg	LOST-T-	20829	1.57	22.29	10

Top 10 of Class A (by ABC Anaysis)

Drug	Row Labels	Amount in LC	%	cum	No.
Glivec Access Program (GPAP) 100 mg	**GLAP-T-**	**- 161,936,439**	9.25	9.25	1
Cellcept 250 mg	CELC-C-	- 89,001,558	5.08	14.33	2
Glivec 100 mg	GLIV-T-	- 73,299,612	4.19	18.51	3
Tasigna Access Program 200 mg	**TAAP-C-**	**- 70,148,264**	4.01	22.52	4
Tasigna 200 mg	TASN-C-	- 49,905,977	2.85	25.37	5
Prograf 1 mg	PRGF1C-	- 49,375,257	2.82	28.19	6
Sandimmun Neoral 25 mg	SADN1C-	- 29,463,289	1.68	29.87	7
Lipitor 40 mg	LIPR3T-	- 27,801,272	1.59	31.46	8
Plavix 75 mg	PLAV-T-	- 27,357,213	1.56	33.02	9
Tarceva 150 mg	TACV1T-	- 24,178,084	1.38	34.40	10
Ezetrol 10 mg	EZET-T-	- 19,419,973	1.11	35.51	11
Afinitor Tablet 10 mg	AFIN1T-	- 18,829,860	1.08	36.59	12

Top 10 of drug shortage

Material Description	Material	Number of shortage	NO
Revlimid Capsule 25 mg	REVL3C-	9	1
Sildenafil 50 mg	SILD-T-	8	2
Zanidip 10 mg	ZAND-T-	6	3
Clexane 60 mg 0.6 ml	CLEX2I-	5	4
Combid 300	COMB-T-	5	5
Innohep Prefilled Syringe 0.5 ml	INNS-I-	5	6
Recombinate 500 iu 10 ml	RECO1I-	5	7
Revlimid Capsule 15 mg	REVL2C-	5	8
Senokot 7.5 mg	SENK-T-	5	9
Singulair 10 mg	SIGL2T-	5	10

APPENDIX B

The calculation table of medicine for downstream of each alternatives

Alternative 1

		Cellcept	start (08.2014)	45,267		Alternative 1	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
01.08.2014	Fri	- 1,859	6000	49,408		7,800	51,208
02.08.2014	Sat	- 490	0	48,918		0	50,718
03.08.2014	Sun	-	0	48,918		0	50,718
04.08.2014	Mon	- 15,855	6000	39,063		0	34,863
05.08.2014	Tue	- 2,180	0	36,883		0	32,683
06.08.2014	Wed	- 6,611	12000	42,272		20,400	46,472
07.08.2014	Thu	- 11,742	0	30,530		0	34,730
08.08.2014	Fri	- 8,110	24000	46,420		18,300	44,920
09.08.2014	Sat	- 606	0	45,814		0	44,314
10.08.2014	Sun	-	0	45,814		0	44,314
11.08.2014	Mon	-	0	45,814		0	44,314
12.08.2014	Tue	-	0	45,814		0	44,314
13.08.2014	Wed	- 4,270	15000	56,544		8,700	48,744
14.08.2014	Thu	- 5,040	0	51,504		0	43,704
15.08.2014	Fri	- 2,895	15000	63,609		9,300	50,109
16.08.2014	Sat	- 60	0	63,549		0	50,049

		Cellcept	start (08.2014)	45,267		Alternative 1	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
17.08.2014	Sun	-	0	63,549		0	50,049
18.08.2014	Mon	- 26,295	15000	52,254		0	23,754
19.08.2014	Tue	- 3,190	0	49,064		0	20,564
20.08.2014	Wed	- 5,580	9000	52,484		32,500	47,484
21.08.2014	Thu	- 4,930	0	47,554		0	42,554
22.08.2014	Fri	- 6,140	12000	53,414		10,500	46,914
23.08.2014	Sat	-	0	53,414		0	46,914
24.08.2014	Sun	-	0	53,414		0	46,914
25.08.2014	Mon	- 15,588	27700	65,526		0	31,326
26.08.2014	Tue	- 4,340	0	61,186		0	26,986
27.08.2014	Wed	- 2,625	15000	73,561		26,100	50,461
28.08.2014	Thu	- 6,225	0	67,336		0	44,236
29.08.2014	Fri	- 6,284	0	61,052		8,800	46,752
30.08.2014	Sat	- 420	0	60,632		0	46,332
31.08.2014	Sun	-	0	60,632		0	46,332
01.09.2014	Mon	-	0	60,632		0	46,332
02.09.2014	Tue	- 1,750	0	58,882		0	44,582
03.09.2014	Wed	- 3,240	9000	64,642		8,100	49,442
04.09.2014	Thu	- 5,880	0	58,762		0	43,562
05.09.2014	Fri	- 6,120	0	52,642		9,100	46,542
06.09.2014	Sat	- 930	0	51,712		0	45,612
07.09.2014	Sun	-	0	51,712		0	45,612
08.09.2014	Mon	- 9,448	15000	57,264		0	36,164
09.09.2014	Tue	- 2,620	0	54,644		0	33,544

		Cellcept	start (08.2014)	45,267		Alternative 1	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
10.09.2014	Wed	- 6,665	0	47,979		19,100	45,979
11.09.2014	Thu	- 7,054	0	40,925		0	38,925
12.09.2014	Fri	- 1,430	15000	54,495		13,700	51,195
13.09.2014	Sat	-	0	54,495		0	51,195
14.09.2014	Sun	-	-700	53,795		0	51,195
15.09.2014	Mon	- 10,132	15000	58,663		0	41,063
16.09.2014	Tue	- 2,390	0	56,273		0	38,673
17.09.2014	Wed	- 3,237	0	53,036		14,000	49,436
18.09.2014	Thu	- 11,012	0	42,024		0	38,424
19.09.2014	Fri	- 3,464	15000	53,560		14,200	49,160
20.09.2014	Sat	- 1,370	0	52,190		0	47,790
21.09.2014	Sun	-	0	52,190		0	47,790
22.09.2014	Mon	- 16,554	15000	50,636		0	31,236
23.09.2014	Tue	- 2,790	0	47,846		0	28,446
24.09.2014	Wed	- 1,780	30000	76,066		24,200	50,866
25.09.2014	Thu	- 7,835	0	68,231		0	43,031
26.09.2014	Fri	- 6,140	0	62,091		9,600	46,491
27.09.2014	Sat	- 1,044	0	61,047		0	45,447
28.09.2014	Sun	-	0	61,047		0	45,447
29.09.2014	Mon	- 17,086	0	43,961		0	28,361
30.09.2014	Tue	- 3,416	0	40,545		0	24,945

Alternative 2

		Cellcept	start (08.2014)	45,267		Alternative 2	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
01.08.2014	Fri	- 1,859	6000	49,408		38,800	82,208
02.08.2014	Sat	- 490	0	48,918		0	81,718
03.08.2014	Sun	-	0	48,918		0	81,718
04.08.2014	Mon	- 15,855	6000	39,063		0	65,863
05.08.2014	Tue	- 2,180	0	36,883		0	63,683
06.08.2014	Wed	- 6,611	12000	42,272		0	57,072
07.08.2014	Thu	- 11,742	0	30,530		0	45,330
08.08.2014	Fri	- 8,110	24000	46,420		38,700	75,920
09.08.2014	Sat	- 606	0	45,814		0	75,314
10.08.2014	Sun	-	0	45,814		0	75,314
11.08.2014	Mon	-	0	45,814		0	75,314
12.08.2014	Tue	-	0	45,814		0	75,314
13.08.2014	Wed	- 4,270	15000	56,544		0	71,044
14.08.2014	Thu	- 5,040	0	51,504		0	66,004
15.08.2014	Fri	- 2,895	15000	63,609		18,000	81,109
16.08.2014	Sat	- 60	0	63,549		0	81,049
17.08.2014	Sun	-	0	63,549		0	81,049
18.08.2014	Mon	- 26,295	15000	52,254		0	54,754
19.08.2014	Tue	- 3,190	0	49,064		0	51,564
20.08.2014	Wed	- 5,580	9000	52,484		0	45,984
21.08.2014	Thu	- 4,930	0	47,554		0	41,054
22.08.2014	Fri	- 6,140	12000	53,414		43,000	77,914

		Cellcept	start (08.2014)	45,267		Alternative 2	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
23.08.2014	Sat	-	0	53,414		0	77,914
24.08.2014	Sun	-	0	53,414		0	77,914
25.08.2014	Mon	- 15,588	27700	65,526		0	62,326
26.08.2014	Tue	- 4,340	0	61,186		0	57,986
27.08.2014	Wed	- 2,625	15000	73,561		0	55,361
28.08.2014	Thu	- 6,225	0	67,336		0	49,136
29.08.2014	Fri	- 6,284	0	61,052		34,900	77,752
30.08.2014	Sat	- 420	0	60,632		0	77,332
31.08.2014	Sun	-	0	60,632		0	77,332
01.09.2014	Mon	-	0	60,632		0	77,332
02.09.2014	Tue	- 1,750	0	58,882		0	75,582
03.09.2014	Wed	- 3,240	9000	64,642		0	72,342
04.09.2014	Thu	- 5,880	0	58,762		0	66,462
05.09.2014	Fri	- 6,120	0	52,642		17,600	77,942
06.09.2014	Sat	- 930	0	51,712		0	77,012
07.09.2014	Sun	-	0	51,712		0	77,012
08.09.2014	Mon	- 9,448	15000	57,264		0	67,564
09.09.2014	Tue	- 2,620	0	54,644		0	64,944
10.09.2014	Wed	- 6,665	0	47,979		0	58,279
11.09.2014	Thu	- 7,054	0	40,925		0	51,225
12.09.2014	Fri	- 1,430	15000	54,495		32,800	82,595
13.09.2014	Sat	-	0	54,495		0	82,595
14.09.2014	Sun	-	-700	53,795		0	82,595
15.09.2014	Mon	- 10,132	15000	58,663		0	72,463

		Cellcept	start (08.2014)	45,267		Alternative 2	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
16.09.2014	Tue	- 2,390	0	56,273		0	70,073
17.09.2014	Wed	- 3,237	0	53,036		0	66,836
18.09.2014	Thu	- 11,012	0	42,024		0	55,824
19.09.2014	Fri	- 3,464	15000	53,560		28,200	80,560
20.09.2014	Sat	- 1,370	0	52,190		0	79,190
21.09.2014	Sun	-	0	52,190		0	79,190
22.09.2014	Mon	- 16,554	15000	50,636		0	62,636
23.09.2014	Tue	- 2,790	0	47,846		0	59,846
24.09.2014	Wed	- 1,780	30000	76,066		0	58,066
25.09.2014	Thu	- 7,835	0	68,231		0	50,231
26.09.2014	Fri	- 6,140	0	62,091		33,800	77,891
27.09.2014	Sat	- 1,044	0	61,047		0	76,847
28.09.2014	Sun	-	0	61,047		0	76,847
29.09.2014	Mon	- 17,086	0	43,961		0	59,761
30.09.2014	Tue	- 3,416	0	40,545		0	56,345

Alternative 3

		Cellcept	start (08.2014)	45,267		Alternative 3	
pivot_date	**day**	**issue**	**Exiting**	**balance_1**		**receive_2**	**balance_2**
01.08.2014	Fri	- 1,859	6000	49,408		4,500	47,908
02.08.2014	Sat	- 490	0	48,918		0	47,418
03.08.2014	Sun	-	0	48,918		0	47,418
04.08.2014	Mon	- 15,855	6000	39,063		0	31,563
05.08.2014	Tue	- 2,180	0	36,883		0	29,383
06.08.2014	Wed	- 6,611	12000	42,272		0	22,772
07.08.2014	Thu	- 11,742	0	30,530		0	11,030
08.08.2014	Fri	- 8,110	24000	46,420		38,700	41,620
09.08.2014	Sat	- 606	0	45,814		0	41,014
10.08.2014	Sun	-	0	45,814		0	41,014
11.08.2014	Mon	-	0	45,814		0	41,014
12.08.2014	Tue	-	0	45,814		0	41,014
13.08.2014	Wed	- 4,270	15000	56,544		0	36,744
14.08.2014	Thu	- 5,040	0	51,504		0	31,704
15.08.2014	Fri	- 2,895	15000	63,609		18,000	46,809
16.08.2014	Sat	- 60	0	63,549		0	46,749
17.08.2014	Sun	-	0	63,549		0	46,749
18.08.2014	Mon	- 26,295	15000	52,254		0	20,454
19.08.2014	Tue	- 3,190	0	49,064		0	17,264
20.08.2014	Wed	- 5,580	9000	52,484		0	11,684
21.08.2014	Thu	- 4,930	0	47,554		0	6,754
22.08.2014	Fri	- 6,140	12000	53,414		43,000	43,614

		Cellcept	start (08.2014)	45,267		Alternative 3	
pivot_date	**day**	**issue**	**Exiting**	**balance_1**		**receive_2**	**balance_2**
23.08.2014	Sat	-	0	53,414		0	43,614
24.08.2014	Sun	-	0	53,414		0	43,614
25.08.2014	Mon	- 15,588	27700	65,526		0	28,026
26.08.2014	Tue	- 4,340	0	61,186		0	23,686
27.08.2014	Wed	- 2,625	15000	73,561		0	21,061
28.08.2014	Thu	- 6,225	0	67,336		0	14,836
29.08.2014	Fri	- 6,284	0	61,052		34,900	43,452
30.08.2014	Sat	- 420	0	60,632		0	43,032
31.08.2014	Sun	-	0	60,632		0	43,032
01.09.2014	Mon	-	0	60,632		0	43,032
02.09.2014	Tue	- 1,750	0	58,882		0	41,282
03.09.2014	Wed	- 3,240	9000	64,642		0	38,042
04.09.2014	Thu	- 5,880	0	58,762		0	32,162
05.09.2014	Fri	- 6,120	0	52,642		19,500	45,542
06.09.2014	Sat	- 930	0	51,712		0	44,612
07.09.2014	Sun	-	0	51,712		0	44,612
08.09.2014	Mon	- 9,448	15000	57,264		0	35,164
09.09.2014	Tue	- 2,620	0	54,644		0	32,544
10.09.2014	Wed	- 6,665	0	47,979		0	25,879
11.09.2014	Thu	- 7,054	0	40,925		0	18,825
12.09.2014	Fri	- 1,430	15000	54,495		32,800	50,195
13.09.2014	Sat	-	0	54,495		0	50,195
14.09.2014	Sun	-	-700	53,795		0	50,195
15.09.2014	Mon	- 10,132	15000	58,663		0	40,063

		Cellcept	start (08.2014)	45,267		Alternative 3	
pivot_date	**day**	**issue**	**Exiting**	**balance_1**		**receive_2**	**balance_2**
16.09.2014	Tue	- 2,390	0	56,273		0	37,673
17.09.2014	Wed	- 3,237	0	53,036		0	34,436
18.09.2014	Thu	- 11,012	0	42,024		0	23,424
19.09.2014	Fri	- 3,464	15000	53,560		28,200	48,160
20.09.2014	Sat	- 1,370	0	52,190		0	46,790
21.09.2014	Sun	-	0	52,190		0	46,790
22.09.2014	Mon	- 16,554	15000	50,636		0	30,236
23.09.2014	Tue	- 2,790	0	47,846		0	27,446
24.09.2014	Wed	- 1,780	30000	76,066		0	25,666
25.09.2014	Thu	- 7,835	0	68,231		0	17,831
26.09.2014	Fri	- 6,140	0	62,091		33,800	45,491
27.09.2014	Sat	- 1,044	0	61,047		0	44,447
28.09.2014	Sun	-	0	61,047		0	44,447
29.09.2014	Mon	- 17,086	0	43,961		0	27,361
30.09.2014	Tue	- 3,416	0	40,545		0	23,945

Alternative 4

			start (08.2014)	45,267		Alternative 4	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
01.08.2014	Fri	- 1,859	6000	49,408		14,400	57,808
02.08.2014	Sat	- 490	0	48,918		0	57,318
03.08.2014	Sun	-	0	48,918		0	57,318
04.08.2014	Mon	- 15,855	6000	39,063		0	41,463
05.08.2014	Tue	- 2,180	0	36,883		0	39,283
06.08.2014	Wed	- 6,611	12000	42,272		0	32,672
07.08.2014	Thu	- 11,742	0	30,530		0	20,930
08.08.2014	Fri	- 8,110	24000	46,420		38,700	51,520
09.08.2014	Sat	- 606	0	45,814		0	50,914
10.08.2014	Sun	-	0	45,814		0	50,914
11.08.2014	Mon	-	0	45,814		0	50,914
12.08.2014	Tue	-	0	45,814		0	50,914
13.08.2014	Wed	- 4,270	15000	56,544		0	46,644
14.08.2014	Thu	- 5,040	0	51,504		0	41,604
15.08.2014	Fri	- 2,895	15000	63,609		18,100	56,809
16.08.2014	Sat	- 60	0	63,549		0	56,749
17.08.2014	Sun	-	0	63,549		0	56,749
18.08.2014	Mon	- 26,295	15000	52,254		0	30,454
19.08.2014	Tue	- 3,190	0	49,064		0	27,264
20.08.2014	Wed	- 5,580	9000	52,484		0	21,684
21.08.2014	Thu	- 4,930	0	47,554		0	16,754
22.08.2014	Fri	- 6,140	12000	53,414		42,900	53,514

			start (08.2014)	45,267		Alternative 4	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
23.08.2014	Sat	-	0	53,414		0	53,514
24.08.2014	Sun	-	0	53,414		0	53,514
25.08.2014	Mon	- 15,588	27700	65,526		0	37,926
26.08.2014	Tue	- 4,340	0	61,186		0	33,586
27.08.2014	Wed	- 2,625	15000	73,561		0	30,961
28.08.2014	Thu	- 6,225	0	67,336		0	24,736
29.08.2014	Fri	- 6,284	0	61,052		34,900	53,352
30.08.2014	Sat	- 420	0	60,632		0	52,932
31.08.2014	Sun	-	0	60,632		0	52,932
01.09.2014	Mon	-	0	60,632		0	52,932
02.09.2014	Tue	- 1,750	0	58,882		0	51,182
03.09.2014	Wed	- 3,240	9000	64,642		0	47,942
04.09.2014	Thu	- 5,880	0	58,762		0	42,062
05.09.2014	Fri	- 6,120	0	52,642		19,900	55,842
06.09.2014	Sat	- 930	0	51,712		0	54,912
07.09.2014	Sun	-	0	51,712		0	54,912
08.09.2014	Mon	- 9,448	15000	57,264		0	45,464
09.09.2014	Tue	- 2,620	0	54,644		0	42,844
10.09.2014	Wed	- 6,665	0	47,979		0	36,179
11.09.2014	Thu	- 7,054	0	40,925		0	29,125
12.09.2014	Fri	- 1,430	15000	54,495		32,900	60,595
13.09.2014	Sat	-	0	54,495		0	60,595
14.09.2014	Sun	-	-700	53,795		0	60,595

			start (08.2014)	45,267		Alternative 4	
pivot_date	**day**	**issue**	**Existing**	**balance_1**		**receive_2**	**balance_2**
15.09.2014	Mon	- 10,132	15000	58,663		0	50,463
16.09.2014	Tue	- 2,390	0	56,273		0	48,073
17.09.2014	Wed	- 3,237	0	53,036		0	44,836
18.09.2014	Thu	- 11,012	0	42,024		0	33,824
19.09.2014	Fri	- 3,464	15000	53,560		28,200	58,560
20.09.2014	Sat	- 1,370	0	52,190		0	57,190
21.09.2014	Sun	-	0	52,190		0	57,190
22.09.2014	Mon	- 16,554	15000	50,636		0	40,636
23.09.2014	Tue	- 2,790	0	47,846		0	37,846
24.09.2014	Wed	- 1,780	30000	76,066		0	36,066
25.09.2014	Thu	- 7,835	0	68,231		0	28,231
26.09.2014	Fri	- 6,140	0	62,091		33,700	55,791
27.09.2014	Sat	- 1,044	0	61,047		0	54,747
28.09.2014	Sun	-	0	61,047		0	54,747
29.09.2014	Mon	- 17,086	0	43,961		0	37,661
30.09.2014	Tue	- 3,416	0	40,545		0	34,245

APPENDIX C

The calculation of all dispensing rooms to the warehouse

Cellcept

Date	Room 7011	Room 7012	Room 7013	Room 7014	Room 7015	Room 7016	Room 2025	(Cellcept) Total
01.08.2014	23000	300	0	0	0	0	0	23300
02.08.2014	0	0	0	0	0	0	0	0
03.08.2014	0	0	0	0	0	0	0	0
04.08.2014	0	0	0	0	0	0	0	0
05.08.2014	0	0	0	0	0	0	0	0
06.08.2014	0	0	0	0	0	0	0	0
07.08.2014	0	0	0	0	0	0	0	0
08.08.2014	38700	1300	0	3800	0	150	0	43950
09.08.2014	0	0	0	0	0	0	0	0
10.08.2014	0	0	0	0	0	0	0	0
11.08.2014	0	0	0	0	0	0	0	0
12.08.2014	0	0	0	0	0	0	0	0
13.08.2014	0	0	0	0	0	0	0	0
14.08.2014	0	0	0	0	0	0	0	0
15.08.2014	18000	300	0	1700	0	0	0	20000
16.08.2014	0	0	0	0	0	0	0	0
17.08.2014	0	0	0	0	0	0	0	0
18.08.2014	0	0	0	0	0	0	0	0
19.08.2014	0	0	0	0	0	0	0	0
20.08.2014	0	0	0	0	0	0	0	0
21.08.2014	0	0	0	0	0	0	0	0
22.08.2014	43000	4050	0	3800	0	150	0	51000
23.08.2014	0	0	0	0	0	0	0	0
24.08.2014	0	0	0	0	0	0	0	0
25.08.2014	0	0	0	0	0	0	0	0
26.08.2014	0	0	0	0	0	0	0	0
27.08.2014	0	0	0	0	0	0	0	0
28.08.2014	0	0	0	0	0	0	0	0
29.08.2014	34900	0	0	1500	0	100	0	36500

Date	Room 7011	Room 7012	Room 7013	Room 7014	Room 7015	Room 7016	Room 2025	(Cellcept) Total
30.08.2014	0	0	0	0	0	0	0	0
31.08.2014	0	0	0	0	0	0	0	0
01.09.2014	0	0	0	0	0	0	0	0
02.09.2014	0	0	0	0	0	0	0	0
03.09.2014	0	0	0	0	0	0	0	0
04.09.2014	0	0	0	0	0	0	0	0
05.09.2014	28600	4500	0	2300	0	150	0	35550
06.09.2014	0	0	0	0	0	0	0	0
07.09.2014	0	0	0	0	0	0	0	0
08.09.2014	0	0	0	0	0	0	0	0
09.09.2014	0	0	0	0	0	0	0	0
10.09.2014	0	0	0	0	0	0	0	0
11.09.2014	0	0	0	0	0	0	0	0
12.09.2014	32800	1200	0	3800	0	150	0	37950
13.09.2014	0	0	0	0	0	0	0	0
14.09.2014	0	0	0	0	0	0	0	0
15.09.2014	0	0	0	0	0	0	0	0
16.09.2014	0	0	0	0	0	0	0	0
17.09.2014	0	0	0	0	0	0	0	0
18.09.2014	0	0	0	0	0	0	0	0
19.09.2014	28200	2400	0	3200	0	0	0	33800
20.09.2014	0	0	0	0	0	0	0	0
21.09.2014	0	0	0	0	0	0	0	0
22.09.2014	0	0	0	0	0	0	0	0
23.09.2014	0	0	0	0	0	0	0	0
24.09.2014	0	0	0	0	0	0	0	0
25.09.2014	0	0	0	0	0	0	0	0
26.09.2014	33800	4200	0	2300	0	300	0	40600
27.09.2014	0	0	0	0	0	0	0	0
28.09.2014	0	0	0	0	0	0	0	0
29.09.2014	0	0	0	0	0	0	0	0
30.09.2014	0	0	0	0	0	0	0	0

APPENDIX D

The calculation of upstream of Cellcept

Existing system

pivot_date	day	ISSUE_warehouse	Receive	Balance	DOS	Value
01.08.2014	Fri	23,300	100,800	134,500	25	6,725,000
02.08.2014	Sat	-	-	134,500	25	6,725,000
03.08.2014	Sun	-	-	134,500	25	6,725,000
04.08.2014	Mon	-	-	134,500	25	6,725,000
05.08.2014	Tue	-	-	134,500	25	6,725,000
06.08.2014	Wed	-	-	134,500	25	6,725,000
07.08.2014	Thu	-	-	134,500	25	6,725,000
08.08.2014	Fri	43,950	-	90,550	17	4,527,500
09.08.2014	Sat	-	-	90,550	17	4,527,500
10.08.2014	Sun	-	-	90,550	17	4,527,500
11.08.2014	Mon	-	-	90,550	17	4,527,500
12.08.2014	Tue	-	-	90,550	17	4,527,500
13.08.2014	Wed	-	-	90,550	17	4,527,500
14.08.2014	Thu	-	-	90,550	17	4,527,500
15.08.2014	Fri	20,000	-	70,550	13	3,527,500
16.08.2014	Sat	-	-	70,550	13	3,527,500
17.08.2014	Sun	-	-	70,550	13	3,527,500

pivot_date	day	ISSUE_warehouse	Receive	Balance	DOS	Value
18.08.2014	Mon	-	-	70,550	13	3,527,500
19.08.2014	Tue	-	-	70,550	13	3,527,500
20.08.2014	Wed	-	-	70,550	13	3,527,500
21.08.2014	Thu	-	-	70,550	13	3,527,500
22.08.2014	Fri	51,000	-	19,550	4	977,500
23.08.2014	Sat	-	-	19,550	4	977,500
24.08.2014	Sun	-	-	19,550	4	977,500
25.08.2014	Mon	-	100,800	120,350	22	6,017,500
26.08.2014	Tue	-	-	120,350	22	6,017,500
27.08.2014	Wed	-	-	120,350	22	6,017,500
28.08.2014	Thu	-	-	120,350	22	6,017,500
29.08.2014	Fri	36,500	-	83,850	15	4,192,500
30.08.2014	Sat	-	-	83,850	15	4,192,500
31.08.2014	Sun	-	-	83,850	15	4,192,500
01.09.2014	Mon	-	-	83,850	15	4,192,500
02.09.2014	Tue	-	-	83,850	15	4,192,500
03.09.2014	Wed	-	-	83,850	15	4,192,500
04.09.2014	Thu	-	-	83,850	15	4,192,500
05.09.2014	Fri	35,550	-	48,300	9	2,415,000
06.09.2014	Sat	-	-	48,300	9	2,415,000
07.09.2014	Sun	-	-	48,300	9	2,415,000
08.09.2014	Mon	-	-	48,300	9	2,415,000
09.09.2014	Tue	-	100,800	149,100	27	7,455,000
10.09.2014	Wed	-	-	149,100	27	7,455,000
11.09.2014	Thu	-	-	149,100	27	7,455,000

pivot_date	day	ISSUE_warehouse	Receive	Balance	DOS	Value
12.09.2014	Fri	37,950	-	111,150	20	5,557,500
13.09.2014	Sat	-	-	111,150	20	5,557,500
14.09.2014	Sun	-	-	111,150	20	5,557,500
15.09.2014	Mon	-	-	111,150	20	5,557,500
16.09.2014	Tue	-	-	111,150	20	5,557,500
17.09.2014	Wed	-	-	111,150	20	5,557,500
18.09.2014	Thu	-	-	111,150	20	5,557,500
19.09.2014	Fri	33,800	100,800	178,150	33	8,907,500
20.09.2014	Sat	-	-	178,150	33	8,907,500
21.09.2014	Sun	-	-	178,150	33	8,907,500
22.09.2014	Mon	-	-	178,150	33	8,907,500
23.09.2014	Tue	-	-	178,150	33	8,907,500
24.09.2014	Wed	-	-	178,150	33	8,907,500
25.09.2014	Thu	-	-	178,150	33	8,907,500
26.09.2014	Fri	40,600	-	137,550	25	6,877,500
27.09.2014	Sat	-	-	137,550	25	6,877,500
28.09.2014	Sun	-	-	137,550	25	6,877,500
29.09.2014	Mon	-	-	137,550	25	6,877,500
30.09.2014	Tue	-	-	137,550	25	6,877,500

Lead time 7 days

pivot_date	day	ISSUE	Purchase	Receive	Balance	DOS	Value
01.08.2014	Fri	23,300	45,000		33,700	5	1,685,000
02.08.2014	Sat	-		-	33,700	5	1,685,000
03.08.2014	Sun	-		-	33,700	5	1,685,000
04.08.2014	Mon	-		-	33,700	5	1,685,000
05.08.2014	Tue	-		-	33,700	5	1,685,000
06.08.2014	Wed	-		-	33,700	5	1,685,000
07.08.2014	Thu	-		45,000	78,700	13	3,935,000
08.08.2014	Fri	44,000	67,300		34,700	6	1,735,000
09.08.2014	Sat	-		-	34,700	6	1,735,000
10.08.2014	Sun	-		-	34,700	6	1,735,000
11.08.2014	Mon	-		-	34,700	6	1,735,000
12.08.2014	Tue	-		-	34,700	6	1,735,000
13.08.2014	Wed	-			34,700	6	1,735,000
14.08.2014	Thu	-		67,300	102,000	16	5,100,000
15.08.2014	Fri	20,000	20,000		82,000	13	4,100,000
16.08.2014	Sat	-		-	82,000	13	4,100,000
17.08.2014	Sun	-		-	82,000	13	4,100,000
18.08.2014	Mon	-		-	82,000	13	4,100,000
19.08.2014	Tue	-		-	82,000	13	4,100,000
20.08.2014	Wed	-		-	82,000	13	4,100,000
21.08.2014	Thu	-		20,000	102,000	16	5,100,000

pivot_date	day	ISSUE	Purchase	Receive	Balance	DOS	Value
22.08.2014	Fri	51,000	51,000		51,000	8	2,550,000
23.08.2014	Sat	-		-	51,000	8	2,550,000
24.08.2014	Sun	-		-	51,000	8	2,550,000
25.08.2014	Mon	-		-	51,000	8	2,550,000
26.08.2014	Tue	-		-	51,000	8	2,550,000
27.08.2014	Wed	-		-	51,000	8	2,550,000
28.08.2014	Thu	-		51,000	102,000	16	5,100,000
29.08.2014	Fri	36,500	36,500		65,500	11	3,275,000
30.08.2014	Sat	-		-	65,500	11	3,275,000
31.08.2014	Sun	-		-	65,500	11	3,275,000
01.09.2014	Mon	-		-	65,500	11	3,275,000
02.09.2014	Tue	-		-	65,500	11	3,275,000
03.09.2014	Wed	-		-	65,500	11	3,275,000
04.09.2014	Thu	-		36,500	102,000	16	5,100,000
05.09.2014	Fri	35,600	35,600		66,400	11	3,320,000
06.09.2014	Sat	-		-	66,400	11	3,320,000
07.09.2014	Sun	-		-	66,400	11	3,320,000
08.09.2014	Mon	-		-	66,400	11	3,320,000
09.09.2014	Tue	-		-	66,400	11	3,320,000
10.09.2014	Wed	-		-	66,400	11	3,320,000
11.09.2014	Thu	-		35,600	102,000	16	5,100,000
12.09.2014	Fri	38,000	38,000		64,000	10	3,200,000

pivot_date	day	ISSUE	Purchase	Receive	Balance	DOS	Value
13.09.2014	Sat	-		-	64,000	10	3,200,000
14.09.2014	Sun	-		-	64,000	10	3,200,000
15.09.2014	Mon	-		-	64,000	10	3,200,000
16.09.2014	Tue	-		-	64,000	10	3,200,000
17.09.2014	Wed	-		-	64,000	10	3,200,000
18.09.2014	Thu	-		38,000	102,000	16	5,100,000
19.09.2014	Fri	33,800	33,800		68,200	11	3,410,000
20.09.2014	Sat	-		-	68,200	11	3,410,000
21.09.2014	Sun	-		-	68,200	11	3,410,000
22.09.2014	Mon	-		-	68,200	11	3,410,000
23.09.2014	Tue	-		-	68,200	11	3,410,000
24.09.2014	Wed	-		-	68,200	11	3,410,000
25.09.2014	Thu	-		33,800	102,000	16	5,100,000
26.09.2014	Fri	40,600		-	61,400	10	3,070,000
27.09.2014	Sat	-		-	61,400	10	3,070,000
28.09.2014	Sun	-		-	61,400	10	3,070,000
29.09.2014	Mon	-		-	61,400	10	3,070,000
30.09.2014	Tue	-		-	61,400	10	3,070,000

Lead time 14 days

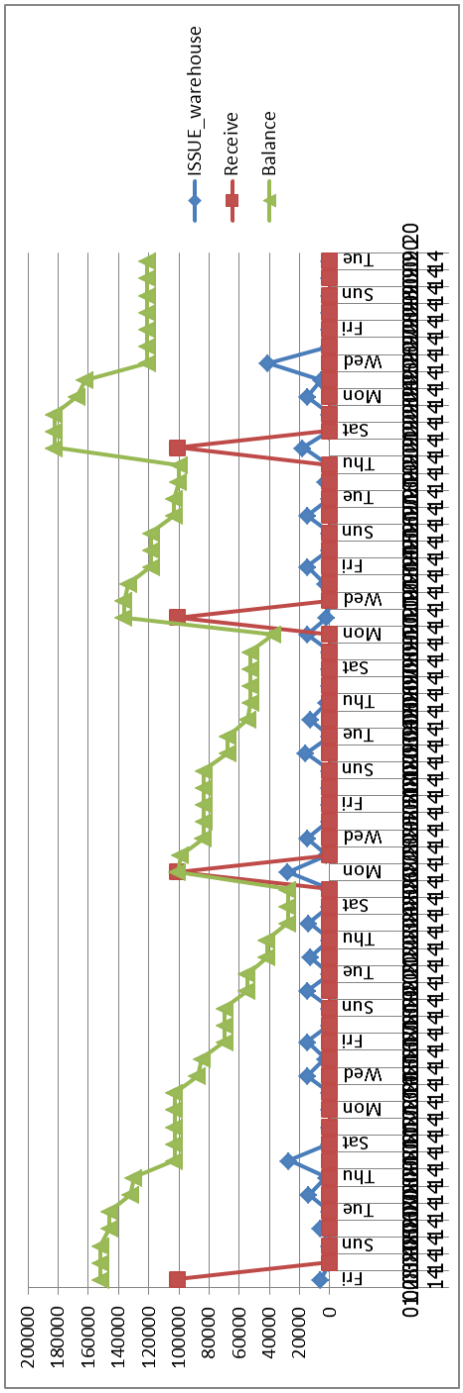
pivot_date	day	ISSUE	Purchase	Receive	Balance	DOS	Value
01.08.2014	Fri	27,000	96,000		30,000	5	1,500,000
02.08.2014	Sat	-		-	30,000	5	1,500,000
03.08.2014	Sun	-		-	30,000	5	1,500,000
04.08.2014	Mon	-		-	30,000	5	1,500,000
05.08.2014	Tue	-		-	30,000	5	1,500,000
06.08.2014	Wed	-		-	30,000	5	1,500,000
07.08.2014	Thu	-			30,000	5	1,500,000
08.08.2014	Fri	44,300	167,300		- 14,300	- 2	- 715,000
09.08.2014	Sat	-		-	- 14,300	- 2	- 715,000
10.08.2014	Sun	-		-	- 14,300	- 2	- 715,000
11.08.2014	Mon	-		-	- 14,300	- 2	- 715,000
12.08.2014	Tue	-		-	- 14,300	- 2	- 715,000
13.08.2014	Wed	-			- 14,300	- 2	- 715,000
14.08.2014	Thu	-		96,000	81,700	13	4,085,000
15.08.2014	Fri	27,000	98,300		54,700	9	2,735,000
16.08.2014	Sat	-		-	54,700	9	2,735,000
17.08.2014	Sun	-		-	54,700	9	2,735,000
18.08.2014	Mon	-		-	54,700	9	2,735,000
19.08.2014	Tue	-		-	54,700	9	2,735,000
20.08.2014	Wed	-		-	54,700	9	2,735,000
21.08.2014	Thu	-		167,300	222,000	36	11,100,000

pivot_date	day	ISSUE	Purchase	Receive	Balance	DOS	Value
22.08.2014	Fri	56,000	- 13,000		166,000	27	8,300,000
23.08.2014	Sat	-		-	166,000	27	8,300,000
24.08.2014	Sun	-		-	166,000	27	8,300,000
25.08.2014	Mon	-		-	166,000	27	8,300,000
26.08.2014	Tue	-		-	166,000	27	8,300,000
27.08.2014	Wed	-		-	166,000	27	8,300,000
28.08.2014	Thu	-			166,000	27	8,300,000
29.08.2014	Fri	60,600	47,600		105,400	17	5,270,000
30.08.2014	Sat	-		-	105,400	17	5,270,000
31.08.2014	Sun	-		-	105,400	17	5,270,000
01.09.2014	Mon	-		-	105,400	17	5,270,000
02.09.2014	Tue	-		-	105,400	17	5,270,000
03.09.2014	Wed	-		-	105,400	17	5,270,000
04.09.2014	Thu	-			105,400	17	5,270,000
05.09.2014	Fri	38,600	86,200		66,800	11	3,340,000
06.09.2014	Sat	-		-	66,800	11	3,340,000
07.09.2014	Sun	-		-	66,800	11	3,340,000
08.09.2014	Mon	-		-	66,800	11	3,340,000
09.09.2014	Tue	-		-	66,800	11	3,340,000
10.09.2014	Wed	-		-	66,800	11	3,340,000
11.09.2014	Thu	-		47,600	114,400	18	5,720,000
12.09.2014	Fri	47,000	85,600		67,400	11	3,370,000

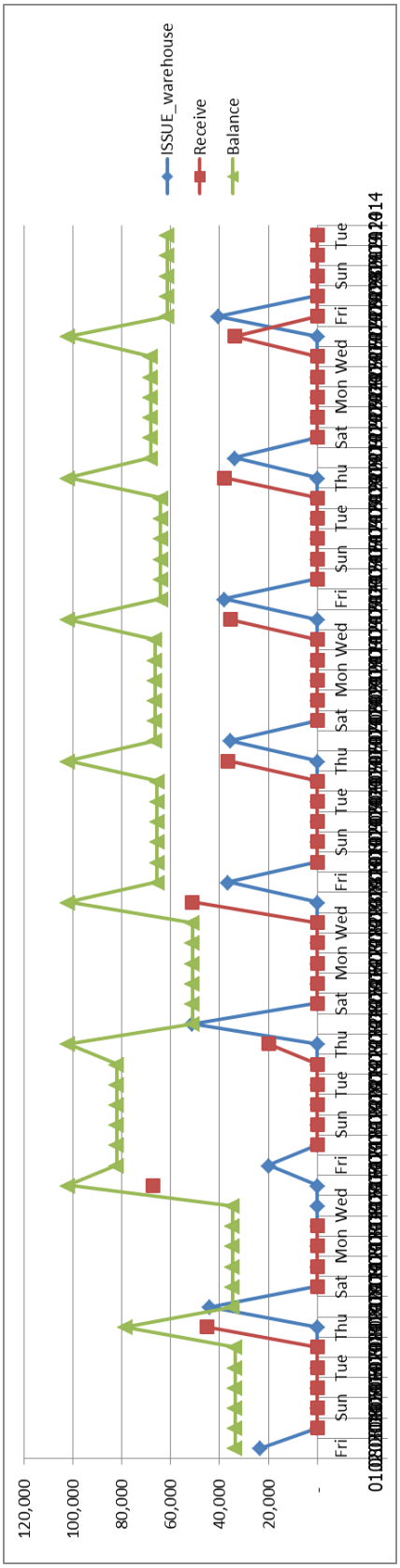
pivot_date	day	ISSUE	Purchase	Receive	Balance	DOS	Value
13.09.2014	Sat	-		-	67,400	11	3,370,000
14.09.2014	Sun	-		-	67,400	11	3,370,000
15.09.2014	Mon	-		-	67,400	11	3,370,000
16.09.2014	Tue	-		-	67,400	11	3,370,000
17.09.2014	Wed	-		-	67,400	11	3,370,000
18.09.2014	Thu	-			67,400	11	3,370,000
19.09.2014	Fri	44,900	130,500		22,500	4	1,125,000
20.09.2014	Sat	-		-	22,500	4	1,125,000
21.09.2014	Sun	-		-	22,500	4	1,125,000
22.09.2014	Mon	-		-	22,500	4	1,125,000
23.09.2014	Tue	-		-	22,500	4	1,125,000
24.09.2014	Wed	-		-	22,500	4	1,125,000
25.09.2014	Thu	-		85,600	108,100	17	5,405,000
26.09.2014	Fri	54,000		-	54,100	9	2,705,000
27.09.2014	Sat	-		-	54,100	9	2,705,000
28.09.2014	Sun	-		-	54,100	9	2,705,000
29.09.2014	Mon	-		-	54,100	9	2,705,000
30.09.2014	Tue	-		-	54,100	9	2,705,000

APPENDIX E

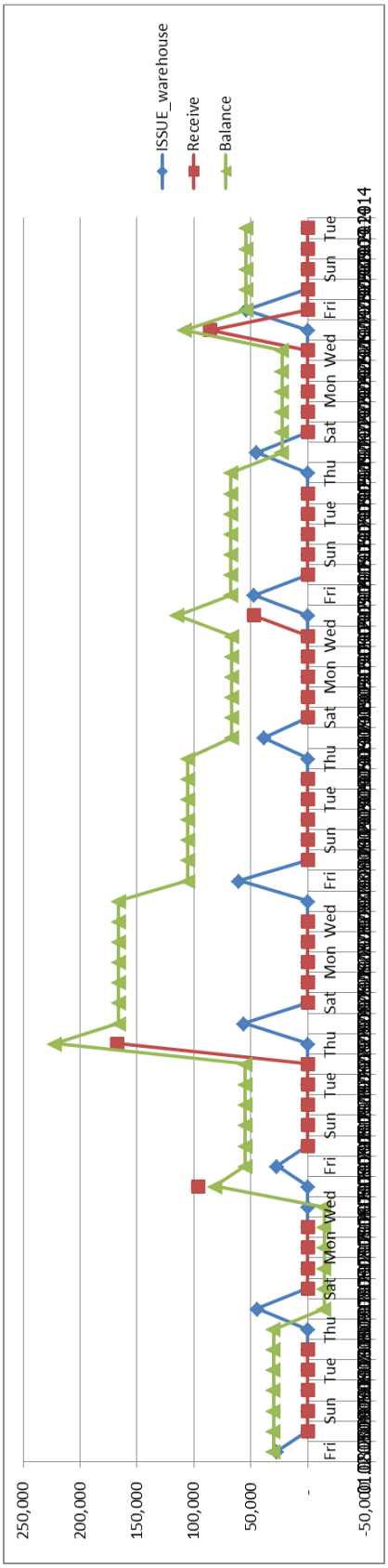
Drug utilization pattern in the warehouse (Existing system)



(After implement VMI, lead time 7 days)



(After implement VMI, lead time 14 days)



BIOGRAPHY

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