MODELLING LOGISTICS COST IN HOSPITAL: A CASE OF MEDICAL PRODUCTS

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Abstract

Healthcare providers currently operate in an environment of multifaceted supply chains. The increasing costs due to lack of attention to real costs has made implementing a costing system difficult. The fundamental issues for healthcare management today should take into consideration the manufacturing cost and non-manufacturing cost which is related to logistics activity. Based on these pressures, the purpose of this study is initially conducted to identify influencing factors implementation of Activity base costing (ABC) and Time driven activity base costing (TDABC) methods. These include activity, determine resource use, estimate time processing in each activity and then calculate the unit cost of services provided in a healthcare center. The corresponding basic mathematical formulas and design of the information flow system are also elaborated. The result of this study shows that most of the top concerns of effective in reducing logistics cost; improved quality and efficiency of the medical products care transport which they provide to Patients service.

Keywords
Costing system, Logistics activity, Activity-Based Costing (ABC), Time-Driven Activity-Based Costing (TDABC) and Information Flow System.

1. Introduction
Healthcare is the main issue for a country's welfare status at all levels and considered one of the most important sectors that cannot be lack in every country. Healthcare sector has a quick moving from traditional treatment to the modern treatment approach daily. With this changing situation, the growing population, high administrative costs, service provider consolidation, and more sophisticated treatment lead to healthcare costs increase. Both cost and quality of healthcare are major concerns for patient expectation (Fu & Wang, 2008). Not only the patient, but also the government, policy-maker, financers, and others responsible for healthcare expenditure have long worried the growing cost of healthcare (Abel-smith, 1992). According to these causes, it makes logistics business which the best management not only in other industry but it could be applied in the healthcare supply chain as well. The modern logistics used in healthcare area can decrease which lead times, costs and to increase customer service as well as the organization's revenues and profit (Wiger, 2018). In the study, global spending on health increased in the year 2014, starting from $9.21 trillion was spent on health worldwide. Past trends and relationships suggest that; $16.04 trillion will be spent on health by 2030 and also healthcare expenses will reach $24.24 trillion by 2040 (Dieleman et al., 2017). Moreover, the effect of living standards and an ageing population have to lead to the rapid growth in healthcare expenditure, so lead to demand increase and more complex problems. Base on the study of (Bartolacci, 2004), logistics activities are oriented to create value for consumers, suppliers and other healthcare involved in the physical management of goods. The capacity of these healthcare businesses to produce and deliver value depends on their ability to supply the consumers with the products and services in the location at the moment at which they want to get them, at competitive prices and at the lowest total cost. Therefore, the logistics cost is method gaining recognition as a tool to calculate the true costs not only in the healthcare industry but also in another industry because, logistics cost

is the key to managing logistics performance. Recently, the healthcare industry has started to invest in more adopted cost system management.

One of the most powerful tools is successfully applied in logistics cost field known as Activity Based Costing (ABC). ABC was introduced firstly in Harvard Business School by Professors Johnson and Kaplan (1987) and made popular by Cooper and Kaplan (1988). Their attention was focused on manufacturing and services industry. The ABC is a tool to calculate the true costs not only in the healthcare industry but another industry can be used. It gives healthcare managers understand the measure costs and performances of activities, resources and cost objects, assigns resources to activities and activities to cost objects based on our use, and recognizes causal relationships of cost drivers to activities (Dierks et al., 2000). In order to overcome the barrier of ABC system, time driven activity-based costing (TDABC) requires come up used time equations, unit cost and time estimates which directly distribute resources costs of the activities performed and processed transactions to cost objects (Robert S. Kaplan and Steven R. Anderson, 2003). So Activity Based Costing (ABC) and Time Driven Activity Based Costing (TDABC) are going to be implemented as a main tool in this research for developing logistics cost framework in Hospital at the early stage. In addition, the mathematical formulas and information flow system are also used as the supporting tools.

2. Literature Review

Medical product is a generic term for any product used to diagnose or manage patients and generated the medical product based on risk essentially embedded with patient. Managing the supply chain plays an important role in creating competitive advantages for healthcare sectors. Adequate information, goods, financial, and technology resource flows through supply chain and now face a very specific challenge. The main concern about healthcare supply chain management is related to its performance and the key measure of patient satisfaction.

2.1 Healthcare Logistics Activity

Logistics is the art and science of management, engineering and activities concerned with maintaining the resources which help to improve the plans, implement an operation and take place in any business. The basic role of the logistics is to maintain the balance between supply and demand but the role of hospital is to provide healthcare to patients. Pokharel (2005) stated that; logistics activities in a hospital involve planning, designing, implementing, operating and managing material or product flows in a supply chain to support functions such as procurement, distribution, stock management, packaging, receiving, purchasing and manufacturing. Consequently, it is very important to better examine the functions of this department to improve services and reduce costs. Similarly, (Dembińska-Cyran, 2005) argued that we could identify four major activities of hospital logistics: (i) Inventory management activities include procurement, receipt and inventory control of stock and supplies. (ii) Transport management activities include delivery of patients to and into hospitals, delivery of pharmaceutical and medical products, and etc. (iii) Production activities refer to clean washing, cafeteria, sterilization, etc. (iv) Distribution activities include delivery and sorting of items into order needs for individual departments. Hence, these activities have a contribution to the right item at the right place at the right time, every time, in the right quantity on the right costs.

2.2 Activity Based Costing (ABC) and Time Driven Activity Based Costing (TDABC)

Activity-Based Costing is a technique of the operations in an organization and designs, its activities are more understandable. It can create a map of an organization's operations and understand its processes. Once the activities have been mapping operative and then it can realize how much operations cost and especially what kind of activities and resources products, services and customers consume. According to Weetman (2006), launching and designing of ABC system require the following five steps. Firstly, identify performance of major activities by the organization. Secondly, identify the cost drivers which is the most closely significant cost of an activity. Cost driver can directly indicate how the activity consumes cost. Thirdly, create the cost pool for each activity and trace a cost to cost pool. Fourthly, calculate a cost driver rate. Lastly, assign the cost to the product by using the cost driver of each activity. Even though ABC has more advantages, it still faces the limitation, according to Kaplan 2004. According to Wegmann and Practices (2008), they claimed that traditional ABC is a complicated and expensive system that is difficult to implement, which leads to small to medium sized enterprises to give up it as their costing system. The new version of Activity-based Costing is Time Driven Activity Based Costing. TDABC was created by Professors Robert Kaplan and Steven Anderson (2007). Robert Kaplan was one of the developers of creating the traditional ABC as well, so he has had a powerful influence in creating both methods. There are only two estimates required to start building a TDABC model. First the cost per time unit of supplying capacity of resource and consumption unit times of resource capacity by products, services and customers (R. Kaplan & Anderson, 2004). The first different relationship between

ABC and TDABC systems is based on how the two systems overall the resource to a matrix of activity and it leads to how they total the stage one information. Activity-based costing uses resource cost drivers to aggregate first stage information by resource whereas time driven activity-based costing implicitly aggregates first stage information by an activity because this distinction between, ABC and TDABC systems are non-comparable in almost all setting (Hoozée & Hansen, 2018). The Activity-based Costing and Time Driven ABC is intended to overcome problems in implementing and using these systems in big firm through changing the method of collecting data on activity times and modification of activity cost computation procedure. In the table below, illustrated step of ABC and TDABC systems implementation method based on the time differences are summarized as follows (Everaert et al., 2008).

Table 1. Activity-based costing versus Time-driven activity-based costing

Panel A: ABC	
Step 1	Identify the different overhead activities
Step 2	Assign the overhead costs to the different activities using a resource driver
Step 3	Identify the activity driver for each activity
Step 4	Determine the activity driver rate by dividing the total activity costs by the practical volume of the activity driver
Step 5	Multiply the activity driver rate by the activity driver consumption to trace costs to orders, products or customers
Panel B: TDABC	
Step 1	Identify the various resource groups (departments)
Step 2	Estimate the total cost of each resource group
Step 3	Estimate the practical capacity of each resource group (e.g. available working hours, excluding vacation, meeting and training hours)
Step 4	Calculate the unit cost of each resource group by dividing the total cost of the resource group by the practical capacity
Step 5	Determine the time estimation for each event, based upon the time equation for the activity and the characteristics of the event
Step 6	Multiply the unit cost of each resource group by the time estimate for the event

2.3 Information flow

The way the information flows is usually much reliant on how the business processes are designed. The flow can be a portion of the process supporting other tasks or it can be the enable of the whole chain of procedures. Therefore, the improvement of information flow should be observed from the point of view of business process improvement. Changing the process in order to improve the flow or changing the flow to improve the process, both require the understanding of the business process as well as the understanding of the information flow. Regarding information systems, Waples and Norris (1992) recommended that information flow involves a set of interconnected information system. However, this structure uses information for communication so that an information flow is formed. Daveport and Short; (1990) define business process as a set of logistically related tasks intended to achieve a defined business outcome. A process is a structure, measured set of activities designed to achieve a specified output for a particular customer or market. This study defined information flows from the perspective of business process.

3. Methodology

3.1 Case study research and data collecting process

We studied the hospital situated in Bangkok, we collected data in warehouse department, including medicine warehouse, medical supply warehouse and sterile products warehouse. The Medicine warehouse, Medical supply warehouse and Sterile products warehouse are differently individual warehouses in the hospital. Its service concentrates on provide materials to patient care units of healthcare organizations by performed in two ways: the distributor delivers the material in the hospital, and responsible for storing and delivering the material to the patient care units; or delivers the material directly to the patient care units, and there is no storage. The activity data were collected through direct observation, multiple interviews with the head warehouse, head ward, and logistic process management experts. Cost data were obtained from warehouse department and hospital system. The service time was obtained from the observation while collecting data by tracking activity of each staff. We observed the time of each staff with each service by stopwatch which started from the activity ward workstation until warehouse and leaving the

service. For the time data, the research records only service time that the staff spent at all these stations from ward to warehouse, so the waiting time was not included from this research.

3.2 Activity Based Costing model development

The traditional costing system of hospital is so difficult and have more badly behaved in tracking the cost of resource usage with the demand of the product. Hence, ABC is one of the best costing systems which can control the cost and help improving balancing between supply and demand. So, in this study, the ABC model was developed and the steps in developing and implementing are presented below:

Step1: Hospital analysis and cost classification

In initial stage, the hospital was divided into supportive cost centers (SCCs). The SCCs prepared facilities and offered services to all hospital units such as management, administrative and service division, warehouse division, ward division and accounting. In this research, the case study is based on the warehouse and ward flows in the warehouse department.

Step 2: Identifying major activities

This stage of cost calculation involved defining activities that reflect significant cost in the given hospital department. In this point, necessary activities in providing services to patients should be identified, including activities related to service activities performed in warehouse and ward, such as performed by personnel of transport product, personnel of delivery receipt and etc.

Step 3: Assigning costs to activities

Once the major activities had been identified, it was possible to determine the total costs of activities. Costs were allocated to activities via several resource-cost drivers, such as the labor consumption of physicians based on activities or employee's workload, and quantity of equipment. Wage costs were allocated to the different activity groups on the basis of the employees for that activity.

Step 4: Definition of activity cost drivers

This phase required defining cost drivers for each activity. These cost drivers represent the activity performance level. Following this, it was necessary to determine the output measures of individual activities, i.e. the number of activity units consumed. Cost driver rates of individual activities were calculated by dividing the total activity costs by the practical volume of the activity driver. Some cost drivers were selected based on recommendations of hospital management experts.

Step 5: Calculation unit cost of an activity and services

After completing the above stages, it was possible, to calculate the unit costs of activities – activity rates. These could be calculated by simple division of the total activity cost by the activity output measure determined. Activity rates can be calculated by the single formula: Activity rate = total activity cost / activity output measure.

3.3 Time driven ABC model development

ABC is one of the best costing systems which can control the cost and help improving balancing between resource and demand. However, it still has a limitation. So, in this study, the new update ABC model is TDABC model, which was developed and the step in developing and implementing are presented below:

Step 1: Document medical products in healthcare supply chain operations

In this research, the case study is based on the resource flow from warehouse to ward. Step 1 is to understand and receive the medical's products operations of the healthcare organization. This is achieved through the development of process maps. This step needs direct input from the managers and personnel who are most familiar with the healthcare supply chain processes. The process map provides a clear illustration of supply chain processes which can be used during implement cost reduction techniques.

Step 2: Identify activity and resources of medical products

First, we identified the groups of resources that perform activities from warehouse to ward in hospital. The cost of resources supplied to an operating department consists of several elements. There are 5 basic resources such as: Register Nurse, Housekeepers, Pharmacists, Pharmacists' assistant, and Administrative staff. In this research study, the researcher scope to analyze cost in the assessment of provider perspective and classify cost by input which are divided into two groups: (i) fix cost including Inventory value and Inventory holding cost, (ii) activity cost including Transportation cost and Administrative cost. All of these costs are components of total logistics cost.

Step 3-5: Total cost, Practical capacity, and Unit cost for each resource group

The total cost of each resource can be calculated by equation 1: Total cost of each resource= $\sum_{i=1} q_i * r_i$ (1)
Let r resource used (resource cost) and q the quantity of resource used.
Practical capacity can be assumed as a specified percentage, 80 or 85 percent, of theoretical capacity (Robert S. Kaplan and Steven R. Anderson, 2003). That is, if an employee can normally work forty hours per week, the practical capacity could be assumed to be thirty-two hours per week, allowing 20 percent of personnel time for breaks, sick, late for work, training, meetings, and employee chitchat that is unrelated to direct work performed.
The theory capacity can be calculated by the equation 2:
Monthly Practical Capacityy_i = 0.8*weekly minutes_i*4 weeks (2)

To calculate unit cost, first the total monthly cost for each resource group i. Equation 3 calculates the unit cost of resource group i by dividing the total monthly cost of resource group i by the monthly practical capacity of resource group i. On the other hand, the unit cost enables us to find the activities cost in our TDABC time equations.
Total Monthly Cost_i = minutes cost*weekly minutes_i*4 weeks
Monthly Practical Capacityy_i = 0.8*weekly minutes_i*4 weeks

$$\text{Unit Cost}_i = \frac{\text{Total Monthly cost}_i}{\text{Monthly Practical capacity}_i} \quad (3)$$

Step 6: Time drivers for each activity in medical products operations

The time drivers for each activity conducted during Healthcare supply chain procedures can be identified together with the activities and resources. Time drivers are measurement of a supply chain procedure activity that drive the amount of time it consumes to complete the activity. Choosing the correct time driver is relevant to accurately allocate resource costs to activities.

Step 7: Time equations for each activity in the medical products operations

Time equation can be developed through direct observation and multiple interviews with employee/manager (Demeere et al., 2009). Based on the study of general time equation needed by the event E of the activity A with p of possibility is given by:

$$T_{E,A} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_p X_p \quad (4)$$

$T_{E,A}$ = time require for executing the event E in term of activity A
β_0 = Constant amount of time for activity A
β_1 = time consume per unit of time driver 1
X_1 = time driver 1
X_p = time driver p
P = number of driver need to run for activity A

Step 8: Calculate the total cost per activity

Calculates the total cost of each medical product; which associations the information obtained from the previous seven steps. By using the unit cost of each resource and the time equation of each activity, the total cost can be calculated by the formula: Total Cost = total time used * cost per time unit (5)

3.4 Information flow system development

An information system is the system of persons, data records and activities that process, including manual processes or automated processes. In this study, we focus on the way to improve the internal information flow between supplier and customer. Order processing is the process related to information flows, work flow and a number of operations in

the system. A sales order process normally consists of internal receipt generation within an organization with the aim to manage sales operation. So that, development of an advanced order processing system could reduce the total order cycle time and cost. In addition, the improved information flows could allow controlling to perform the warehousing and transportation more efficiently.

The context diagram data flow chart diagram is identified as the basic system model. The diagram is the starting point of the software application design. The data flow chart diagram depicts the global picture of the system modelled as the process of outer entity-system interaction. In this case study, the context diagram for the healthcare management information system in hospital. One of the most widely used system analysis process models is the data flow diagram. A Data Flow Diagram (DFD) is a tool that illustrates the data flow through a system and the work and processing performed diagrams represent the external bodies sending and receiving information. The diagram Figure 1 gave us an understanding of the structure in the process of medical supply and medicine products. The next step was to analyze each information and physical material flow. The process 1: the order is to check the stock and then prepare the product name before order. The process 2: The staff need to sign in using their account to use this system, but if it is wrong account number, they will not be able to login. The process 3: After successfully login, the order can create order via three features such as add product to order which retrieve product name from the product catalog, remove product from order, and edit product quantity. The process 4: after creating an order, the ordering information will store in stock room verification (database). The process 5: in this process, the system will generate information and send to inspector, so the inspector can check order form as well as decide to approve or reject. If the inspector approves, the workflow continues to next steps and completes. If reject this form, the information via SMS, email, or system notification are sent back to the staff. The process 6: request is sent to the material organization; approver becomes an "assignee" for request. The material organizer can check order form as well as decide to approve or reject. If the material organizer approves, the workflow continues to next steps and completes. If reject this form, the information via SMS, email, or system notification are sent back to the inspector. Finally, the request is sent to the staff who are working in warehouse department and she prints the receipt from delivery receipt data store.

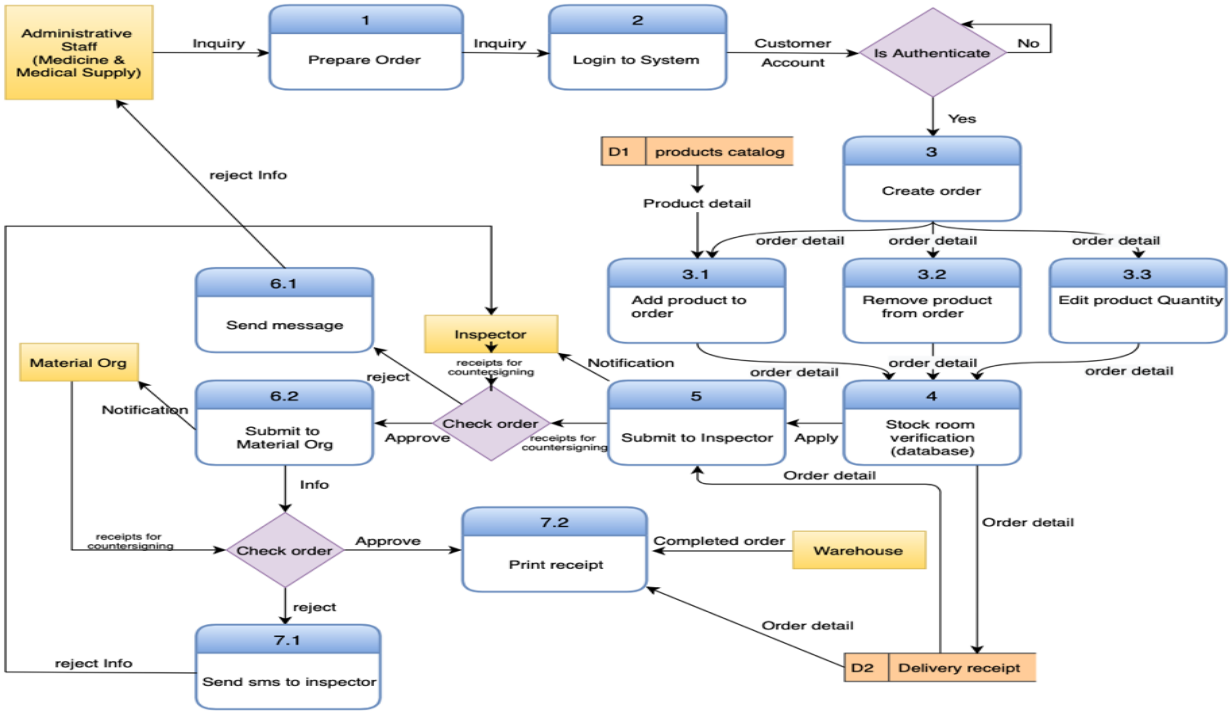

Figure 1. Data flow chart of system

The diagram Figure 2 gave us an understanding of the structure in the sterile products process. The next step was to analyze each information and physical material flow. The process 1: the order is checked the stock and then prepare the product name before order. The process 2: The staff need to sign in using their account to use this system, but if it is wrong account number, they will not be able to login. The process 3: After successfully login, the order can create

order via three features such as add product to order which retrieve product name from the product catalog, remove product from order, and edit product quantity. The process 4: after creating an order, the ordering information will store in stock room verification (database). The process 5: in this process, the system will generate information and sent to inspector so the inspector can check order form as well as decide to approve or reject. If the inspector approves, the workflow continues to next steps and completes. If reject this form, the information via SMS, email, or system notification are sent back to the staff. The process 6: request is sent to the staff because the request form has a problem need to revise. Finally, If the inspector approves, the request is sent to the staff who working in warehouse department and she prints the receipt from delivery receipt data store.

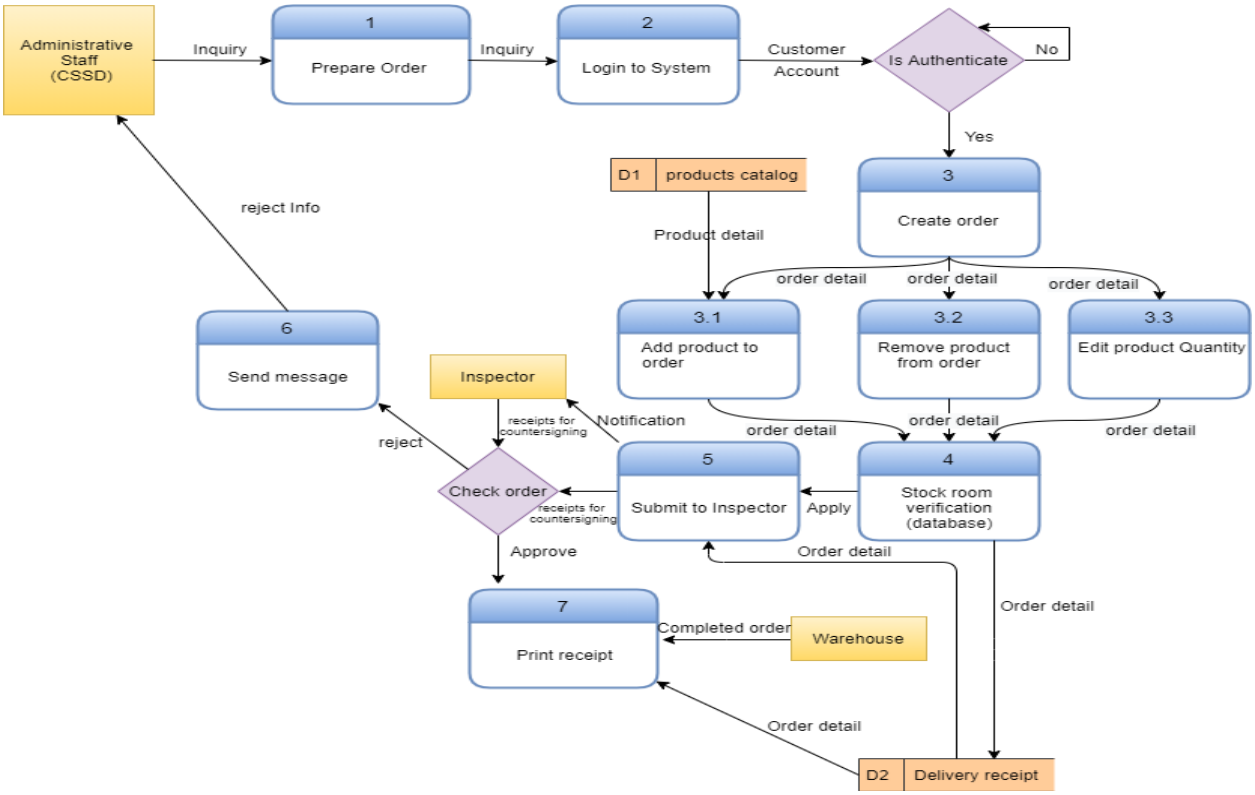

Figure 2. Data flow chart of system

4.Results and Discussions

4.1 ABC and TDABC Model Development

4.1.1. Activity analysis

For medical supply product, the activity flow between warehouse and ward were identified which possibly extended by several options depending on the different service. First, the administrative staff (AS) checks the stock and write receipt into a notebook. Next, she brings the notebook from ward to nursing office. At the same time, she keys list the receipt into SAP and prints out from the system and then brings the receipt from the nursing office back to the receipt unit/ward. Second, the head of ward/representative checks the receipt and sign name to confirm. The AS brings the receipt to the nursing office, inspector checks the receipt as well as the head of office inspect and signs name to confirm. Third, the housekeeper brings the receipt to the medical supplies warehouse and she enters the number and details in the notebook at the medical supplies warehouse. The pharmacist assistant arranges items according to the receipt order into the cart and also checks for correction. After that, move medical supplies to the waiting area and the housekeeper go off to pick up items at medical warehouse. During this time, there is an inspection of receiving items. Finally, delivery of items returns to unit/ward and store items into the stock.

For medicine product, two main activities were identified which possibly extended by several options depending on the different services of activity at ward and activity at medicine room. Activity at ward, the registered nurse (RN) checks the stock and the AS lists of the receipt into a notebook and brings the notebook from ward to nursing office and then she keys list the receipt into SAP and print out from the system. At the same time, she brings the receipt from

nursing office back to the receipt unit/ward. Second, the head of ward/representative checks the receipt and signs name to confirm. The AS brings the receipt to the nursing office and supervisor checks the receipt and sign name to confirm. Third, the housekeeper brings the receipt to warehouse and also screen the receipt as well. After that, the pharmacists 'assistant (PA) distributes receipt the based on SAP system and then inspects medicine according to the receipt order. Finally, the housekeeper delivers items back to unit/ward. During this period, pharmacist assistant facilitate/ tracking medicine reception and the RN prepares for storage. For activity at medicine room, the pharmacist run the MRP with edit receipt/immediate receipt. The pharmacist assistant (PA) distributes medicine according to the receipt as well as check medicine. The housekeeper packs medicine to prepare for delivery and delivers medicine to the medicine room. Finally, the pharmacist checks the medicine from the warehouse and the pharmacist assistant stores items into the stock.

A case of sterile product (disposable), the AS checks the stock and prepares receipt. Then, the RN checks the amount of receipt administrative and makes a receipt through SAP system. After that, the AS goes to nursing office for key SAP system and she keys list the receipt into system and prints out. She brings the receipt from nursing office back to the receipt unit/ward. The RN checks the receipt and signs name to confirm as well as there is one person to check and sign too. The housekeeper receives the receipt at the unit and brings the receipt to sterile product warehouse. In addition, the PA distributes the receipt based on SAP system and arranges the items based on the receipt as well as receives the items and inspects. The housekeeper examines the equipment according to the receipt and she brings the equipment to the unit. Finally, the AS receives and checks the equipment and also stocks the equipment.

4.1.2 Resource group identification and total cost of each resource

There are two main resource groups including fix cost and activity cost. The fix cost consists of inventory value (cost of product) and inventory holding cost (depreciation cost of equipment, Material cost, building cost). The activity cost consist of transportation cost (cost of loading and unloading, driver 'wage cost, material cost and equipment cost) and administration cost. The total cost of each resource is summarized in table 2.

Table 2. Total cost of each resource (baht/year)

Product	Cost of logistic per year (in baht)			
	AS-IS (in baht)			
	Inventory value	Inventory holding cost	Transportation cost	Administration cost
Medical supply	84,624,832.70	21,156,208.18	4,917,728.05	711,056.80
Medicine	486,362,109.50	121,590,527.40	8,198,928.56	974,157.91
Sterile product (disposable)	2,291,196.76	527,799.20	13,583,448.6	2,289,185.40

4.1.3 Practical capacity and cost driver rate

We assume the practical capacity of working time is 85% of theory capacity. The service time of regular warehouse and ward service started from 8 AM until 4 PM, so the total service time per day is 7 hours, which exclude 1 hour of lunchtime. There is 52 weeks per year. So, the theory capacity per year of each service can be determined as follows:

(1) Theory capacity of each resource = 7*230*60 = 96600 min/year

Therefore, the practical capacity of each resource group = 85%*96600 = 82110 min/year

The ABC model, Activity cost drivers (ACD) can be defined as the factors of transactions that are significant determiners of costs. Activity cost drivers in this research consist of duration drivers (amount of time required to perform an activity). So, the cost driver rate per year of each service can be determined as bellow:

(1) Service time of each resource = 7*230*60 = 96600 min/year

4.1.4 Capacity cost rate and cost driver rate

Capacity cost rate is determined by dividing the total resource cost by practical capacity. The activity cost driver rate can be calculated by dividing the total cost of each activity by its cost drivers. So, we can get; the unit cost of each resource group as shown in table 3.

Table 3. The unit cost of each resource group in baht/min/year

location / Unit	ABC model			TDABC model		
	Medical supply	Medicine	Sterile product (disposable)	Medical supply	Medicine	Sterile product (disposable)
Pharmacists cost	4.42	4.42	4.42	5.20	5.20	5.20
Pharmacists' assistant cost	3.03	3.03	3.03	3.57	3.57	3.57
Register nurse cost	4.50	4.50	4.50	5.30	5.30	5.30
Housekeepers cost	1.92	1.92	1.92	2.26	2.26	2.26
Administrative staff cost	2.17	2.17	2.17	2.54	2.54	2.54

4.1.5 Time equation for each activity in the medical products operation

Activity time will be estimated by collecting the time observation of each activity in the medical products operation. Onsite observation is conducted, firstly, to collect more data related to the time need to process each activity of medical supply warehouse, medicine warehouse and sterile product warehouse in the hospital. Data is summarized in table 4.

Table 4. Time equations and variable

Loading operation Delivering order + picking + checking the load	$T_{j1} = 8.35 * X_1 + 1.12 * X_2 + 3.73 * X_3 + 2.57 X_3 * 3.03 * X_3$ X_1= Number of times to check X_2= Number of receipt order picked X_3= Number of time verify and approve
Unloading operation Arranging + inspecting + receiving and storage	$T_{j2} = 8.33 * X_4 + 1.13 * X_5 + 12.38 * X_5 + 1.73 * X_6 + 15.83 * X_7$ X_4= Number of prepare items into the cart X_5= Number of time verify receipt X_6= Number of time pick up the goods X_7= Number of time to sort products
Transport (driver's wage cost) Deliver product to location, reach floor and room	$T_{j3} = (12.57 + 1.48 + 11.37 + 12.17) * X_8$ X_8= Number of trip
Payroll preparation Enter stock order into notebook + electronic medical record + printing the receipt order + send the receipt order	$T_{j4} = 5.73 * X_9 + 3.45 * X_{10} + 5.83 * X_{11} + (1.12 + 2.53) * X_{12}$ X_9= Number of enter stock X_{10}= Number of record X_{11}= Number of print out X_{12}= Number of sends

4.1.6 Total cost of each resource logistics activity

Total cost of each activity was calculated by multiply the unit of each resource cost by its activity time. The AS-IS cost was calculated by TDABC model and TO-BE cost was calculated by combine the ABC and TDABC models. The data was analyzed TO-BE cost based on adopt Information flow system in the process and adopt a central transport model which are the influence on each product activity cost. The total cost of each resource shown in the table 5.

Table 5. Total cost of each resource (baht/year)

Resource	Medical supply product		Medicine product		Sterile products (disposable)	
	AS-IS (in baht)	TO-BE (in baht)	AS-IS (in baht)	TO-BE (in baht)	AS-IS (in baht)	TO-BE (in baht)
Administrative staff	1,923,220.04	5,165,604.71	93,574.82	167,036.50	2,170,468.61	6,682,557.12
Registerd nurse	707,912.10	2,372,365.22	260,179.98	1,300,899.84	514,651.20	1,181,688
Houskeeper	13,378,121.63	10,209,369.56	9,375,845.55	1,307,015.86	20,691,475.20	9,070,012.80
Pharmacists' assistant	748,222.88	2,507,456.05	240,973.30	1,204,866.43	792,368.64	2,547,095.04
Pharmacist	N/A	N/A	113,675.34	568,376.64	N/A	N/A

4.2. Data Analysis

4.2.1 Activity cost of medical products operation in the hospital

The resource analysis was the most efficiency and effectiveness indicators in the activity based costing and time driven activity-based costing. The time spent on each resource did not include the waiting time in each product. For medical supply product, it consists of four resource activities. In this study, we found ways how to develop TO-BE logistics cost via adopt Information flow system in the process and adopt a central transport model which are the influence on TO-BE cost system in the hospital. The result of the study shows that the housekeeper cost is the biggest proportion which takes 79.83% of total cost compare with other resource cost. The next proportion of resource cost is the administrative staff cost, pharmacists' assistant cost and the registered nurse cost which take 11.48%, 4.47% and 4.22% of the total cost, respectively. For medicine product, it consists of five resource activities. The following highest cost is housekeeper cost, registered nurse cost, pharmacists' assistant cost, pharmacist cost and the administrative staff cost, which consumed 92.98%, 2.58%, 2.39%, 1.13%, and 0.93% of the total cost respectively. For sterile products, it consists of four resource activities. The following highest cost is housekeeper cost, administrative staff cost, pharmacists' assistant cost, and registered nurse cost, which consumed 85.61%, 8.98%, 3.28% and 2.13% of the total cost respectively. In summarize, the variable of resource cost is the significant sign which is the influence on each product activity cost. Therefore, the hospital's manager need to consider all these factors to control the cost management in each product. For solution to reduce the labor cost, the hospital need to adopt Information flow system in the process because after that we adopt IT can be managing sale transaction the whole process, reducing the load and it can minimize the error risk of pulling wrong receipt order in each product flows. So that the hospital can automate the receipt order that drive business process. The result of IT concept the resource that works related to sale transaction will reduce the activity which manual activity day to day operations. Additionally, the hospital needs to adopt a central transport model into the hospital. This model sets up a new schedule and routing for delivery product from warehouse to ward. This solution can reduce the processing time, waiting time, improve the process flow for improving best quality care and also reduce the resource used in each activity. The total cost of each resource show in the table 6.

Table 6. Total activity cost of each resource (baht/year)

Resource	Medical supply product				Medicine product				Sterile products (disposable)			
	AS-IS (baht)	AS-IS (%)	TO-BE (baht)	TO-BE (%)	AS-IS (baht)	AS-IS (%)	TO-BE (baht)	TO-BE (%)	AS-IS (baht)	AS-IS (%)	TO-BE (baht)	TO-BE (%)
Administrative staff	1,923,220.04	11.48%	5,165,604.71	25.50%	93,574.82	0.93%	167,036.50	3.67%	2,170,468.61	8.98%	6,682,557.12	34.30%
Registerd nurse	707,912.10	4.22%	2,372,365.22	11.71%	260,179.98	2.58%	1,300,899.84	28.60%	514,651.20	2.13%	1,181,688	6.07%
Houskeeper	13,378,121.63	79.83%	10,209,369.56	50.40%	9,375,845.55	92.98%	1,307,015.86	28.74%	20,691,475.20	85.61%	9,070,012.80	46.56%
Pharmacists' assistant	748,222.88	4.47%	2,507,456.05	12.38%	240,973.30	2.39%	1,204,866.43	26.49%	792,368.64	3.28%	2,547,095.04	13.07%
Pharmacist	N/A	N/A	N/A	N/A	113,675.34	1.13%	568,376.64	12.50%	N/A	N/A	N/A	N/A

4.2.2 Logistics Cost of each medical product

The data used in the analysis of logistics cost analysis were considered from inventory value, inventory holding cost, transportation cost and administration cost. The results imply that the logistics cost (AS-IS) and logistics cost (TO-BE) are directly proportional. For medical supply product, the result shows that inventory value and holding cost are reducing cost which take 38,072,712.23 baht/year or 56.03% and 9,518,178.06 baht/year or 14.01% of total cost (TO-BE), respectively. These mean that the inventory value and holding cost are reducing compare with cost of inventory and holding cost, which take 84,624,832.7 baht/year or 75.96% and 21,156,20818 baht/year or 18.99% of total cost (AS-IS), because we observed that product is moved from warehouse to ward more frequency based on a new scheduling and routing condition with using specific the number of housekeeper and also it helps improving the lead time inventory supply. So that the hospital secures stock inventory management and also reduce inventory carrying costs and other related. But the transportation cost and administration cost are increasing compared with cost of transportation cost and administration cost (AS-IS), which consumed 19,068,278.86 baht/year or 28.06% and 1,291,569.72 baht/year or 1.90% of total cost (TO-BE), respectively. These mean that the activity of resource performance based on rate of product move from warehouse to ward with time driver of each activity increase, and its main cause affect the cost will grow based on the number of time driver. So, the hospital need to invest more cost on transportation cost and administration cost in order to balance demand and resource usage. However, the result shows that the total logistics cost of Medical supply product, can benefit 43,459,086.86 baht/year. For medicine product, the result shows that inventory value and holding cost are reducing cost, which consumed 228,590,191.50 baht/year or 76.70% and 57,147,547.88 baht/year or 19.17% of total cost (TO-BE). But the transportation cost and administration cost are increasing, which consumed 11,183,357.14 baht/year or 3.75% and 1,122,459.03 baht/year or 0.38% of total cost (TO-BE). The total logistics cost of Medicine product, can benefit 319,082,167.82 baht/year. A case of sterile products, the result shows that inventory value and holding cost are reducing cost, which consumed 1,890,695.57 baht/year or 9.38% and 472,673.90 baht/year or 2.34% of total cost (TO-BE). But the transportation cost and administration cost are increasing, which consumed 15,141,726.41 baht/year or 75.11% and 2,655,636.19 baht/year or 13.17% of total cost (TO-BE). The total logistics cost of sterile products, they need to invest more cost around 1,412,102.10 baht/year. However, the total cost of three medical products, they still can benefit 361,117,152.58 baht/year. The total logistics cost is illustrated in table 7.

Table 7. Total logistics cost of each medical product

Product	Cost of logistic per year (in ฿)											
	AS-IS (in ฿)				TO-BE (in ฿)				Improving Process			
	Inventory value	Inventory holding cost	Transportation cost	Administration cost	Inventory value	Inventory holding cost	Transportation cost	Administration cost	AS-IS (in ฿)	TO-BE (in ฿)	Cost Saving (in ฿)	Cost Increasing (in ฿)
Medical supply	84,624,832.7	21,156,208.18	4,917,728.05	711,056.80	38,072,712.23	9,518,178.06	19,068,278.86	1,291,569.72	111,409,825.73	67,950,738.87	43,459,086.86	0
Medicine	486,362,109.5	121,590,527.4	8,198,928.56	974,157.91	228,590,191.50	57,147,547.88	11,183,357.14	1,122,459.03	617,125,723.37	298,043,555.55	319,082,167.82	0
Sterile products (disposable)	2,291,196.76	572,799.20	13,583,448.61	2,289,185.40	1,890,695.57	472,673.90	15,141,726.41	2,655,636.19	18,736,629.97	20,160,732.07	0	1,424,102.10

5. Conclusion

This paper reviews the implementation of ABC and TDABC in the transport, administrative and logistics activities and describes the development of ABC and TDABC in a hospital in Thailand. It aims to explain the Activity Based Costing and Time driven Activity-based costing development in each medical product in the hospital. These result indicated that healthcare's manager or administrator that tend to take responsibility for using medical product which reduce logistics cost should concern with the real cost driver such as the time spent in each activity which is the cost driver for resource cost and the activity which consumed the highest cost. The design of information flow system will be a solution to eliminate inefficiency associated with the manual method and enhance speedy retrieval of receipt's record. So that this research helps to turn the light for researchers or the ones who are new in field of healthcare product to take their consideration and improvement their confidence to do further research by taking concept of ABC and TDABC model. ABC and TDABC in this study do not only affect to the cost, but also include performance measurement, activity time, activity cost and performance data provide information for hospital management to

determine the effectiveness and efficiency of reducing logistics cost, improving quality and efficiency of service, facilitating elimination of non-value added activities and improve process flow.

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