SUPPLY-PROCESSING-DISTRIBUTION MODELS FOR HOSPITAL SUPPLY CHAIN – A CASE STUDY OF HOSPITAL SUPPLY CHAIN IN THAILAND

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ABSTRACT

SPD, in term of supply chain management, is abbreviated from Supply, Processing and Distribution management. This model is first published about its application in healthcare segment. It is a new model which incorporates processes of supply-procurement, inventory management and material processing and distribution to unify hospital logistics management to enhance hospital supply chain management effectiveness. This adaptable model is successfully adopted and continuously developed by Japanese and Chinese Hospitals as the internal-hospital department function with suggestion about the adjusted application for more flexibility and corresponding to actual hospitals situations. In Thailand, SPD model is usually used in network of private hospitals and each hospital outsources 3PL to handle these activities in its department of inventory management. Though 3PLs are able to perform logistics functions well with their expertise, in practice, they still face some inevitable problems because each-site has to separately perform logistics activities by itself. With its competitive advantage, flexibility and some internal-hospital practice constraints, this paper aims to design potential external-hospital SPD models managed by 3PLs for the private hospital network in Thailand. The results, nine potential models are constructed which could be the 3PLs' improvement opportunities in appropriate adoption for their contexts.

Keywords: SPD model, Hospital supply chain, Private hospital network, Third party logistics provider

1. INTRODUCTION

Nowadays patient knowledge has been increasing from easier diverse information access in everywhere and at any time. While health-related technology is continuously developed to become more advance, more efficient, more convenient and lower price. These imply that hospitals, especially private hospitals, need to change their strategy by focus and continuous improving their core competencies and delegating other activities they are not proficient, such as logistics management, to some partners to keep the essential role and survive in this specifically professional field. Aforementioned things telling us that outsourcing in some activities for more effectiveness and cost saving is very important strategy which should be applied.

Third party logistics providers, or 3PL / TPL for abbreviation, are the external companies who handle some parts of or entire logistics functions that have traditionally been performed within an organization (Lieb, 1992). Such logistic activities they manage professionally, for

example, sourcing and procurement, inventory management and distribution, are very important processes that connect every party in a supply chain together and definitely generate cost which may significantly impact on the enterprise financial position (Nowak, 2004; Caban, 2001). Hence, to ease the efficient logistics management, hospitals outsource 3PLs to deal with these tasks to get excellent outcome. Besides customers' extremely high expectation, the high risk from vital or life threatening support, much more complexity from variety of products and being very unpredictable of healthcare sector (Helfat & Peteraf, 2014), 3PLs are challenged to develop their capability to survive and prove themselves to gain more trust from every party among supply chain, especially, outsourcers.

Many supply chain management models or strategies have been proposed. Some of them are well known for ages, for example, vendor-managed inventory (VMI) that retailers let the vendor(s) access their real-time inventory level and decide to continuously replenish each product to maintain the appropriate stock on hand. Although VMI gives both upstream and downstream a lot of competitive advantages, such as, VMI offers retailers higher service level and lower inventory monitoring and ordering cost (Waller et al., 1999; Achabal et al., 2000) whilst it helps vendors to reduce bullwhip effect (Lee et al., 1997b; Disney and Towill, 2003a, b), there are some limitations that can decline the VMI benefits or lead to failures in its practice. The examples are: product promotions are not included in the VMI programs (Simchi-Levi et al., 2003) or customers are not satisfied with the forecasting ability of VMI vendors (Fiddis, 1997).

The next example is "collaborative planning, forecasting and replenishment (CPFR)" which needs all parties in a supply chain to together forecast demands, plan for productions, purchasing and inventory replenishments. With these processes, CPFR can eliminate many problems that are faced in VMI adoptions (Aviv, 2002). However, to succeed in CPFR implementation, it requires dramatic change in terms of more intensive organizational-resources, including cost, higher mutual trust of many relevant members (Barratt and Oliveria, 2001; Fliedner, 2003), even or the ways of doing business (Sari, 2008). Because of its complexities in adaptation, CPFR is limited in a small set of product categories or trading partners (see e.g. Baird, 2003; Program may build CPFR momentum, 2005).

Another familiar strategy is known as Just In Time (JIT) or zero inventory management which developed at the Toyota Motor Company (M. Saito, 1994). This stockless concept requires much flexibility and collaboration between suppliers and users that means it increase in transportation and call frequency (Haan J., Yamamoto M., 1999) and also cost of operations. Moreover some inventory, for example life threatening product, could absolutely not be managed by JIT strategy.

Though its concept was proposed by Gordon A. Friesen since early 1960's, in 2016, LIU et al. published a new logistics management model for medical consumables in hospital called "SPD" which is abbreviated from Supply, Processing and Distribution. Many Japanese hospitals have been studied and developed it until successfully applied for 20 years and resulted in reducing of huge logistics cost and increasing of logistics management effectiveness. With regarding to its competitive advantages by incorporating processes of supply-procurement, inventory management and material processing and distribution to unify hospital logistics management, China put the effort to apply the SPD Model in several Chinese hospitals where the research found that the traditional SPD model should be improved for more flexibility for corresponding to actual hospitals situations. (Tongzhu LIU et al., 2016)

In Thailand, SPD model is usually used in network of private hospitals and each hospital outsources 3PL to handle these activities in its department of inventory management. Though 3PLs are able to perform logistics functions well with their expertise, in practice, they still face

some inevitable problems because each-site has to separately perform logistics activities by itself.

One hand, because its newness accompanies with impressive outcome, the traditional processes and its adoptions just only in hospitals still have limitations. In the other hand, because SPD concept is like a new strategy of supply chain management stressing on logistics activities which are the core competency of 3PL. They lead to interesting question: what the outside-hospital SPD-based logistics management model(s) for hospital supply chain that managed by 3PL could be. That is the objective of this research.

2. LITERATURE REVIEW

2.1 3PL Characteristics

3PL / TPL or Third Party Logistics has no single consistent definition (Marasco, 2008). Lieb (1992) mentioned that TPL involves ‘‘the use of external companies to perform logistics functions that have traditionally been performed within an organization. Murphy and Poist (1998) gave the meaning of TPL that it involves ‘‘a relationship between a shipper and third party, which, compared with basic services, has more customized offerings, encompasses a broader number of service functions and is characterized by a longer term, more mutually beneficial relationship’’. Berglund et al. (1999) said that Third-party logistics are activities carried out by a logistics service provider on behalf of a shipper and consisting of at least management and execution of transportation and warehousing. Van Laarhoven et al. (2000) define 3PL as traditional ‘‘arm’s length’’ sourcing of transportation and/or warehousing. Bask (2001) describes TPL as ‘‘relationships between interfaces in the supply chains and third-party logistics providers, where logistics services are offered, from basic to customized ones, in a shorter or longer term relationship, with the aim of effectiveness and efficiency’’. These definitions are broad or narrow from different perspectives which includes any form of outsourcing of logistics activities previously performed ‘‘in-house’’ or separates logistics functions into a transaction-by-transaction basis.

3PL definition referenced in this study is the use of external companies to perform logistics functions that have traditionally been performed within an organization (Lieb 1992), or in hospital for this case.

According to 3PL activities, third party logistics providers provide their services differently upon their expertise. Selviaridis & Spring (2007) published that originally third-party logistics providers involved just in warehousing and transportation. But in the early 1990s, firms which formerly specializing in express parcel deliveries entered the arena (e.g. DHL, UPS, TNT and FedEx), followed by firms originally focusing on financial services, IT-services, and management consulting, which brought in their competences related to information system and supply chain planning. Zachary O. & Murtaza (2010) noted that in shipping, services offered by 3PLs can include public warehousing, contract warehousing, transportation management, distribution management, freight consolidation, and increasingly the management of entire supply chains. Wang and Sang (2005) also mentioned that a 3PL firm is a professional logistics company profiting by taking charge of a part or the total logistics in the supply chain of a focal enterprise. 3PL also connects the suppliers, manufacturers, and the distributors in supply chains and provide substance movement and logistics information flow. Furthermore, many researches related to or talked about activities offered by 3PL during last 10 years were quite little different.

3PL activities which mentioned in many former years are listed in the table 1.

Table 1. 3PL Activities in many former years

Reference	Year of study	3PL Activities												
		Transportation	Warehousing	Inventory Management	Distribution Management	urement / Purchasing Service	onnect the parties in supply chain	Sourcing	Supply chain Management	Financial Service	acturing / Supplying Management	formation related activities, ex. Tracking & tracing	value added activities, ex. 2nd assembly & product installation	Freight consolidation/forwarding	Entire logistics process
Berglund et al.	1999	√	√	√					√			√	√		
Lieb and Randall	1999		√		√						√			√	
Murphy & Poist; Persson & Virum	2000 & 2001														√
Bonacich	2003			√											
Ulengin & Ulengin	2003	√	√												
Wang and Sang	2005	√					√					√			
Lieb and Bentz	2005					√				√	√				
Christopher	2005	√	√		√								√		
Arroyo et al.	2006	√	√												
Selviaridis & Spring	2007	√	√						√						
Marasco,	2008	√	√												
Zachary, O., & Murtaza,	2010	√	√		√									√	√
Jayaram & ChoonTan	2010	√	√	√	√										
Domingues & Macário	2015	√	√		√									√	
Batarlienė & Jarašūnienė	2017	√	√	√	√	√							√		

Reference	Year of study	3PL Activities													
		Transportation	Warehousing	Inventory Management	Distribution Management	Procurement / Purchasing Service	Connect the parties in supply chain	Sourcing	Supply chain Management	Financial Service	Manufacturing / Supplying Management	information related activities, ex. Tracking & tracing	value added activities, ex. 2nd assembly & product installation	Freight consolidation/forwarding	Entire logistics process
Lui et al. with SDP Model	2016	√	√	√	√	√	√	√	√	√	√	√	√	√	√

According to data from the table 1, it obviously shows that 3PL mainly perform some logistics mission in supply chain, majorities are transportation, warehousing and distribution. Apart from that, such as procurement, sourcing, financial service or other value added activities, is just a little part. Anyway, the interesting one is the last one, Lui et al. who studied about SPD-based Logistics management model of medical consumables in Chinese hospitals demonstrated that 3PL manage almost all activities in supply chain, which lead to this study.

2.2 Healthcare Supply Chain Characteristics

Many studies explain healthcare supply chain characteristics in many ways, both abstract and concrete perspectives. But in terms of structure, healthcare supply chain is mentioned in a few differences. An interesting model demonstrated in the study of Rossetti M. and Lui Y. in 2008, the hospital group has its own group purchasing unit and central warehouse which purchase, receive and handle all products directly from all suppliers and distribute these materials directly to every hospital in its responsibility. This created supply chain division is called Resource Optimization and Innovation (ROi) which is claimed for providing greater value for related trading parties and converting of cost center to revenue center by revenue generating from its activities. In 2014, Kumara and Kumarb, who studied about the Iron Folic Acid tabs in state government owned rural healthcare systems in Indian healthcare supply chain, noted that there are central healthcare unit called state drug store provides some facilities and also medicines or medical supplies for rural drug stores. The rural drug store supplies other rural healthcare centers with those stuffs. The other rural healthcare centers which are supported by rural drug store are women hospital and community health centers. The women hospital supplies community health centers. The community health centers supply primary health centers. The primary health centers supply sub centers. The respectively supplied medicines or medical supplies from women hospital, community health centers, primary health centers and sub centers are provided for patients. And some specialized manufacturers directly supply those pastoral units with some kinds of vital life support.

A study of Nabelsi and Gagnon in 2015 that need to discuss relationship between messy

data and business process reengineering failure, showed multi-tiers of the hospital pharmacy supply chain loops. First level is manufacturers who act 3 ways of medicines supplying: 1. through regional Group Purchasing Organization (GPO), third party logistics providers in the second level, who deal with the manufacturers and distributors for effective purchasing opportunities, 2. to the third level, distributors who consolidate and distribute medicines to hospitals and 3. direct to hospitals which is the fourth level. Furthermore, there is medicine supplying in the same level between hospitals in case of urgent need. After medicines from suppliers, distributors, GPO or another hospital receiving, those medicines are stored in hospital pharmacy warehouse and then distributed to central pharmacy. The central pharmacy will dispense medicines to patients and also distribute medicines to corresponding care units which use those medicines in their care processes given to patients.

The published literature review research in 2017 of Volland J. et al. concluded that material distribution in hospitals is typically multi-echelon inventory system. Traditional model is suppliers send medicines, medical consumables, or else to hospitals' central warehouse and those stuffs are then distributed to pharmacy departments, sub-warehouses and / or points of use which are closed to the patient care locations respectively. The second system, called "semi-direct delivery", is suppliers skip sending materials to hospitals' central warehouse and deliver them directly to the point-of-use location as orders they received. The third one is "direct delivery", which medical goods from suppliers are refilled at the point-of-use as patient demand.

Imrana, et al.'s research in 2018, which had the objective "to formulate and optimize a multi-period, multi objective medicine supply chain model for an integrated healthcare system", wrote some characteristics of healthcare supply chain that: the first model consist of manufacturers, distributors or pharmacies, clinics, and finally the patients. This model, manufacturers distribute medicines to distributors. The distributors distribute those medicines to clinics and pharmacies. The medicines from these clinics and pharmacies are dispensed to patients. The second channel has manufacturers, hospitals, hospital pharmacies, and patients. The manufacturers distribute their medicines directly to hospitals. The medicines are distributed to hospital pharmacies and then dispensed patients through the hospital pharmacy departments.

Moons K., Waeyenbergh G. and Pintelon L., worked together and published in 2019 about the existing researches on performance measurement of the internal hospital supply chain, explained 2 healthcare supply chain models in their study: Firstly, suppliers ship their products to distributors then distributors distribute the products to hospital's warehouse. And secondly, a newer one used in Mercy is defined as complete in-house management model (Rossetti M. and Lui Y., 2008), distributor is replaced with centralized warehouse and hospital warehouse can be eliminated. Direct delivery from suppliers occurs at this center, which is accountable for material processing (e.g., breaking down original package into smaller units and repackaging for hospital use) and supplying to hospitals. If the hospitals are far from this centralized warehouse, the shipments are managed by cross-docking in an intermediate location (Rossetti M. and Lui Y., 2008). This model could reduce holding cost and goods handling cost and improve inventory management efficiency.

The reviewed healthcare supply chain characteristics reveal that the associated parties can be divided into two major groups. They are internal and external hospital parts. The internal hospital units that listed in these supply chain models are hospital warehouse, hospital pharmacy warehouse, central pharmacy, pharmacy department and corresponding care unit or patient care unit. The external hospital stakeholders are supplier, distributor, sub-distribution center or regional hub, Group Purchasing Organization (GPO), centralized warehouse, cross dock and health center. These external hospital elements, the supplier, (authorized) distributor and health center of which

some functions directly relate to patients, are excluded from the potential 3PL-managed parties in healthcare supply chain.

2.3 SPD management model

From several supply chain management concepts application to improve medical supply chain management efficiency, prototype of SPD model was presented in 1960s by Gordon A. Friesen. Thirties years later, in 1990s, Japanese researchers introduced the Toyota Motor Corporation's Just In Time (JIT) Production, the system that can lead to achieve numerous goals of logistics management such as cost reduction, lead-time reduction, quality assurance, and respect for humanity (Monden, 2002), to healthcare field and first proposed the SPD model for hospital logistics. After that, this model has been successfully applied in many hospitals in Japan and China with obviously good result (Tongzhu LIU et al., 2016).

Traditionally, SPD is a model for the logistics management department of hospital (Tongzhu LIU et al., 2016), which formerly focused on procurement, inventory management and distribution of medicine, and then of medical consumables. According to the research of Tongzhu LIU et al. in 2016, they designed a new SPD-based logistics management model for medical consumables, which developed from core concepts of the existing practices. This model has 3 components including of S : Supply management, P : Processing management and D : Distribution management, which are incorporated to unify the hospital logistics management with the aim of worthy medical supply chain resources utilization.

Physical features of the designed SPD model

First S is supply management. Its procedures are to construct supply-procurement platforms, classify items into different purchasing categories, and evaluate and integrate suppliers. Several important features of Supply management are: its platforms use online processing to deal with transactions that show the real-time status of items and fund flow, the item classification by using the appropriate procurement strategy (Kraljic Model, for example, classifies products into 4 categories from their supply risk and profit impact. The 4 groups are strategic items, leverage items, bottleneck items and non-critical items) lead to differentiate buying and supply plans, supplier integration and relatively centralized procurement adopting reduce the department workload in purchasing and settlement, give price advantage and guarantee sufficient goods providing, and supplier evaluation by suitably measurable criteria, which based on timeliness, quality and availability of products, ease the organization to choose correctly and keep long-term cooperation or establish collaboration with the high-scores suppliers. These simplify and increase efficiency of supply and procurement process.

Next part, P, represents the procedures of Processing Management. This has 4 important indications need to be adopted. Firstly, central warehouse establishing for short-term storage of goods and processing activities such as inspection, putaway or repacking. Secondly, processing of 2 tailored-packings according to department's consumption pattern, first type is called Amount-Based Packages (ABP), for normal departments and second one is Procedure-Based Packages (PBP), for specific department with specific operations. Thirdly, barcode attachment on those packages for scanning during the steps which indicates the item status and consumption recording. This scanning also triggers the settlement between the firm and suppliers. And the last one is setting up of inventory controlling system, such as demand forecasting and inventory management efficiency related factors analysis, enable the logistics department to figure out of safety stock, reorder point, order amount and order cycle. These optimize stock level and let the firm achieve

effective inventory management.

D: Distribution Management which needs timely and precise processes to ensure the medical activities safety, has some procedures and is supported by technologies to handle it effectively. With the established logistics management platform and barcode technology utilization, the organization can monitor stock consumption, trace or track inventories status, and manage them at all levels. Additionally, after the consumption data obtained from this combination is analyzed, ABPs and PBPs are generated and distributed reasonably in term of quantity and punctually to individual point of use.

Just a year later (2017), Tongzhu LIU et al. did and published further study about "The Application of Collaborative Business Intelligence Technology in the Hospital SPD Logistics Management Model" to improve weakness of the model's intelligence and collaboration which obstruct the SPD management model application to large extent. In term of model's intelligence, it is from relatively low data utilization rate and the information support system does not meet the data mining, especially, in the complex logistics data. About the collaboration, it lacks of information linkage between hospital and its outside partners in the supply chain. The researchers encourage the adoption of SPD logistics management model because it has severally outstanding benefits. Firstly, the standardization and automation of procurement are improved. Secondly, inventory and associated management cost and risk reduce from the scientific and coordinated arrangement of inventory related factors, such as the ordering point, safety stock, maximum inventory and lead time. Thirdly, the proper distribution, which is based on inventory optimization, can decrease waste and significantly lessen the material-processing workload whilst increase the clinical efficiency. And, from this study, the integration of BI technology can not only enhance the business collaboration of hospital logistics management but also lead to achieve the expected goals of management level improving and logistics costs reduction.

3. METHODOLOGY

3.1 SPD Model Design

Model design is initially drawn from theoretical basis. The review of healthcare or hospital supply chain characters provides the model original backbones, external-hospital stakeholders, their functions, interaction and benefits in supply chain. The parties this research supposed that 3PL could manage are sub-distribution center or regional hub, Group Purchasing Organization (GPO) that may be shrunk to just a unit or department of an organization, centralized warehouse and cross dock. Each of them is assigned the assumed SPD functions and specific characters based on the theoretical review of healthcare supply chain characteristics, SPD and 3PL activities in the healthcare supply chain. There are four theoretically and potentially primary structures: ROi division which consists of Group Purchasing Unit (As GPO) and centralized warehouse from Rossetti & Lui study in 2008, supply system with sub-distribution center or regional hub of Kumara and Kumarb in 2014, 3PL managed Group Purchasing Organization (GPO) in the research of Nabelsi and Gagnon study, 2015 and Mercy model which has centralized warehouse and regional cross dock from Moons K., Waeyenbergh G. and Pintelon L. (2019) study (citation of Rossetti M. and Lui Y., 2008). Then the proposed potential SPD-based logistics management models are derived by adjusting, modifying and applying of those initially theoretical backbones.

All models are assumed that medical supplies are the studied items and delivered directly to points of use which applied from the models of Volland J. et al. (2017) study and no hospital / pharmacy warehouse inside hospital.

3.2 Model Validation

This research confirms the validation of designed models by using expert evaluation. The participated experts were asked to evaluate the designed models that could be the potential models. Five experts were invited. Two are a top executive with 12 year-experience and a middle manager with ten year-experience in a third party logistics provider firm where has delivered its services to network of private hospitals for at least 12 years. One is an academician in logistics field. And last two experts are from large tertiary private hospital. One of them is the executive and another one is middle-level manager. Their experience in healthcare section is more than ten years.

4. RESULT AND DISCUSSION

4.1 General information of hospital network as a case study

Our case study is the largest and the most famous hospital networks in Thailand and the Asia-Pacific region. Its ranking is top five private hospital groups in the world. In March 2019, this network has 48 hospitals with more than 8,000 beds across its network, in Thailand and other countries. These 48 hospitals are separated into groups. Each group is leaded by the same CEO with different strategies to establish the group's competitive advantage. Each hospital in the group is independently managed by its hospital director. All hospitals in the network do intend to improve their medical service quality both of specialization and comprehensiveness continuously.

Apart from hospital groups, it also has non-hospital affiliated companies and factories where support non-hospital functions for the hospitals and provide non-hospital services for other healthcare parties.

Current process of inventory management in these hospitals, SPD application takes place in each hospital as inventory management unit and its forward and reverse logistics functions are handled by 3PL. Each supplier delivers medical supplies to each hospital as its purchasing orders and these goods are the hospital's own. Each purchasing order lead time depends on each ordered item and each supplier which is rather uncertain. In term of settlement, each hospital has to pay according to goods quantity it received within due time. Apart from on-site service of inventory management, this 3PL has central team in head quarter to support its teams by processing some tasks for sites such as item price negotiation, new material code generating, material code adding into each plant system, PO approval and releasing to suppliers and other value added activities for its customers and its on-site teams. And each hospital may allocate its medical supplies to others for network supporting or collaboration. Key performance indicators used to evaluate the 3PL achievement are inventory day on hand, stock out to patient, inventory write off and inventory record accuracy. After month end, the hospital is charged for management fee with constant rate according to service agreement.

According to as-is practice of the research case study, there are two major problems 3PL is confronting. Firstly, inefficient management i.e., low inventory turnover and expiration of some items, speed of emergency response and demand fluctuation support, too much variety without standardization of items which leads to confused and difficult administration and high staff cost. Secondly, low negotiation power in terms of price, ordered quantity and goods return.

4.2 The designed and validated models

With the particular characters and functions of each studied stake holder, eight SPD-based logistics management models are designed. After investigation of these models by the experts,

they are all validated as the potential models for hospital supply chain which managed by 3PL. However, three potential structures with at least centralized warehouse and Group Purchasing Organization that shrunk to a unit in this case and regional hub or cross dock are specially preferred by the experts because of their expected outperformance which could generally satisfy the customers. Moreover, they suggested further one potential model which consists of centralized warehouse, group purchasing unit, regional hub and cross dock. These nine models are concluded heir external-hospital parties which managed by 3PL and some particular differences in table 2.

Table 2. Eight potentially designed and one expert suggested SPD models for hospital supply chain

Model No.	External-hospital stakeholders managed by 3PL	Particular functions	Source of references	Remarkable characters
1	Group Purchasing Unit (As GPO)	-Negotiate purchasing contract with suppliers to deal the best price for all members. -Track overall utilization rate for re-negotiation to always get better and more suitable deal.	Rossetti M. and Lui Y., 2008 and Nabelsi and Gagnon, 2015	-Theoretically simplify the healthcare supply chain and could generate revenue from its activities (Rossetti & Lui study, 2008)
	Centralized Warehouse with SPD function	-Perform all SPD-based functions for all responsible hospitals	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	
2	Regional SPD Hub	-Perform all SPD-based functions to serve hospitals in responsible region	Kumara and Kumarb study, 2014	
3	Group Purchasing Unit (As GPO)	-Negotiate purchasing contract with suppliers to deal the best price for all members. -Track overall utilization rate for re-negotiation to always get better and more suitable deal.	Nabelsi and Gagnon study, 2015	-The least facility or asset model of 3PL which may be appropriate in some situations -Perform Supply management functions for its responsible hospitals. -Manage and utilize visible information and coordinate with all parties to complete logistics service commitment -To complete the SPD activity services for hospitals, this model is given further assumptions that 3PL outsources other firms to handle Processing and Distribution management
4	Centralized Warehouse with SPD function	-Perform all SPD-based functions to serve regional cross docks and some nearby hospitals	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	-The model is duplicated from Moons K., Waeyenbergh G. and Pintelon L., 2019 study. (citation of Rossetti M. and Lui Y., 2008) -Theoretically increase of logistics management efficiency in terms of stock out elimination which decreases the urgent need from fluctuation demand support. -Less on hand inventory and flexibility of emergency support than the same condition model with regional hub.
	Regional Cross dock	-Perform some P & all D-based functions for hospitals in responsible region with cross docking patterns	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	

5	Group Purchasing Unit (As GPO)	-Negotiate purchasing contract with suppliers to deal the best price for all members. -Track overall utilization rate for re-negotiation to always get better and more suitable deal.	Nabelsi and Gagnon study, 2015	-Newly proposed by author -More outstanding than the original model (model 2) in term of the best item price and cost efficiency (Mckone-Sweet et al., 2005; Nyaga et al., 2015; Burns and Briggs, 2018) for regional SPD hubs and their hospital members from incorporating of Group Purchasing Unit function.
	Regional SPD Hub	-Perform all SPD-based functions to serve hospitals in responsible region	Kumara and Kumarb study, 2014	
6	Centralized Warehouse with SPD function	- Perform all SPD-based functions to serve regional SPD hubs and some nearby hospitals	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	-Newly proposed by author -With regional hub storage-function, this model has more prominent character of response speed and flexibility to uncertain and emergency demand than the initial model (model 4).
	Regional SPD Hub	-Perform P&D-based functions to serve hospitals in responsible region	Kumara and Kumarb study, 2014	
7	Group Purchasing Unit (As GPO)	-Negotiate purchasing contract with suppliers to deal the best price for all members. -Track overall utilization rate for re-negotiation to always get better and more suitable deal.	Nabelsi and Gagnon study, 2015	-Newly proposed by author -When compare to its prototype (model 4), the superior performance of this model is the item price and cost efficiency (Mckone-Sweet et al., 2005; Nyaga et al., 2015; Burns and Briggs, 2018) which comes from Group Purchasing Unit function. -Cross docking reduces inventory carrying cost
	Centralized Warehouse with SPD function	-Perform all SPD-based functions to serve regional cross docks and some nearby hospitals	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	
	Regional Cross dock	-Perform some P & all D-based functions for hospitals in responsible region with cross docking patterns	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	
8	Group Purchasing Unit (As GPO)	-Negotiate purchasing contract with suppliers to deal the best price for all members. -Track overall utilization rate for re-negotiation to always get better and more suitable deal.	Nabelsi and Gagnon study, 2015	-Newly proposed by author -According to the model initial-structure (model 1), regional SPD hub functions provide more this model response speed to urgent need and uncertain situation support. -When compare to model 5, Centralized Warehouse with SPD function makes this model has more negotiation power from massive demand and more capacity for variety and uncertainty support. -When compare to model 7, this model has more flexibility and ability to buffer fluctuation demand from more on-hand inventory which is stored in regional hub.
	Centralized Warehouse with SPD function	-Perform all SPD-based functions to serve regional SPD hubs and some nearby hospitals	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	
	Regional SPD Hub	-Perform P&D-based functions to serve hospitals in responsible region	Kumara and Kumarb study, 2014	
Suggested model by experts	Group Purchasing Unit (As GPO)	-Negotiate purchasing contract with suppliers to deal the best price for all members. -Track overall utilization rate for re-negotiation to always get better and more suitable deal.	Nabelsi and Gagnon study, 2015	-Newly proposed by author -This model integrates all stake holders and their particular functions to maximize advantage from each element notability.
	Centralized Warehouse with SPD function	-Perform all SPD-based functions to serve regional SPD hubs and some nearby hospitals	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019	

	Regional Cross dock	-Perform some P & all D-based functions for hospitals in responsible region with cross docking patterns	Rossetti M. and Lui Y., 2008 and Moons K., Waeyenbergh G. and Pintelon L., 2019
	Regional SPD Hub	-Perform P&D-based functions to serve hospitals in responsible region	Kumara and Kumarb study, 2014

According to the three most interesting models in the expert opinion, they are model 1, 7 dna 8.Model 1 is duplicated its structure from hospital supply chain with Resource Optimization and Innovation Division (ROi) in the study of Rossetti M. and Lui Y., 2008. ROi has centralized warehouse to perform supply, processing and distribution of materials to points of use in all hospital members in the network. Centralized procurement and reserving maintain the benefit of negotiation power from massive demand and capacity for variety and uncertainty support. And it also has the group purchasing unit to deal the best price for all its members to increase competitive advantage in terms of item price. This division, which implies to this model, not only theoretically simplifies the healthcare supply chain but also generates much revenue from these activities (Rossetti & Lui study, 2008). The current study, centralized warehouse and group purchasing unit are presumed as managed by 3PL with SPD function.

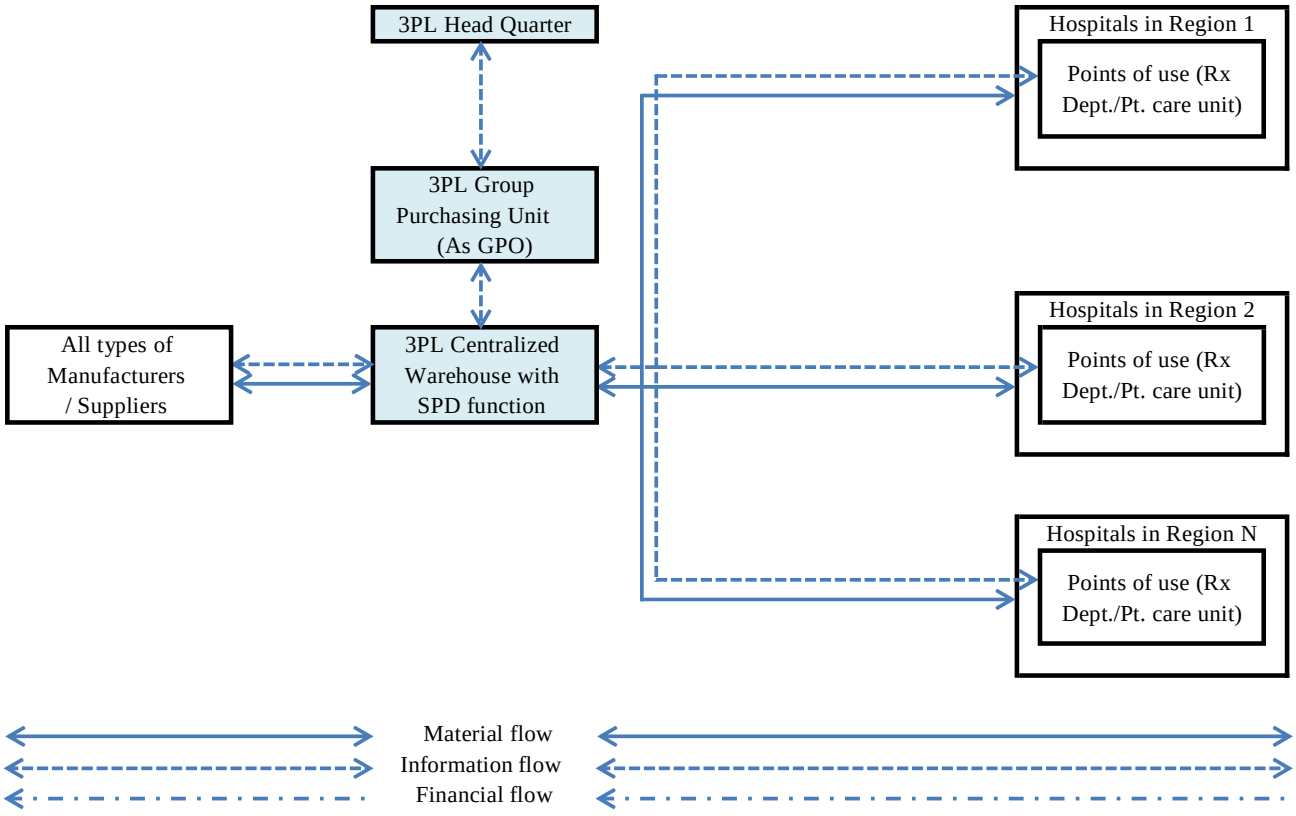

Figure 1. Model 1

Model 7 is derived from integration of centralized warehouse with cross dock from Rossetti M. and Lui Y. in 2008 and Moons K., Waeyenbergh G. and Pintelon L. in 2019 studies and GPO functions from Nabelsi and Gagnon study in 2015 to enhance supply cost efficiency

(Mckone-Sweet et al., 2005; Nyaga et al., 2015; Burns and Briggs, 2018). On the other hand, it is like model 1 (Rossetti M. and Lui Y., 2008) added with regional cross docks to perform partial processing and distribution activities for distant hospitals. In this model, centralized warehouse is also assumed to perform majority of SPD functions to support the regional cross docks and some hospitals. Without hospital warehouse, the medical supplies are delivered directly to each point of use in the hospitals. Each cross dock deals with materials from centralized warehouse through processing management and distribution activities to deliver those medical supplies to the hospitals. Massive ordering by the centralized warehouse for serving all hospitals in the network, this model has much negotiation power. Especially, by adding bargaining function of group purchasing unit does increase much price benefit. Refer to Rossetti and Liu study in 2008, the prototype of this model, which has only centralized warehouse and cross docks with streamlining their logistics processes, produces remarkable outcome that is increasing of logistics management efficiency in terms of stock out elimination. This competitive advantage decreases the urgent need from fluctuation demand support. Apart from no hospital warehouse, no storage in cross dock makes overall inventory lower than the next model.

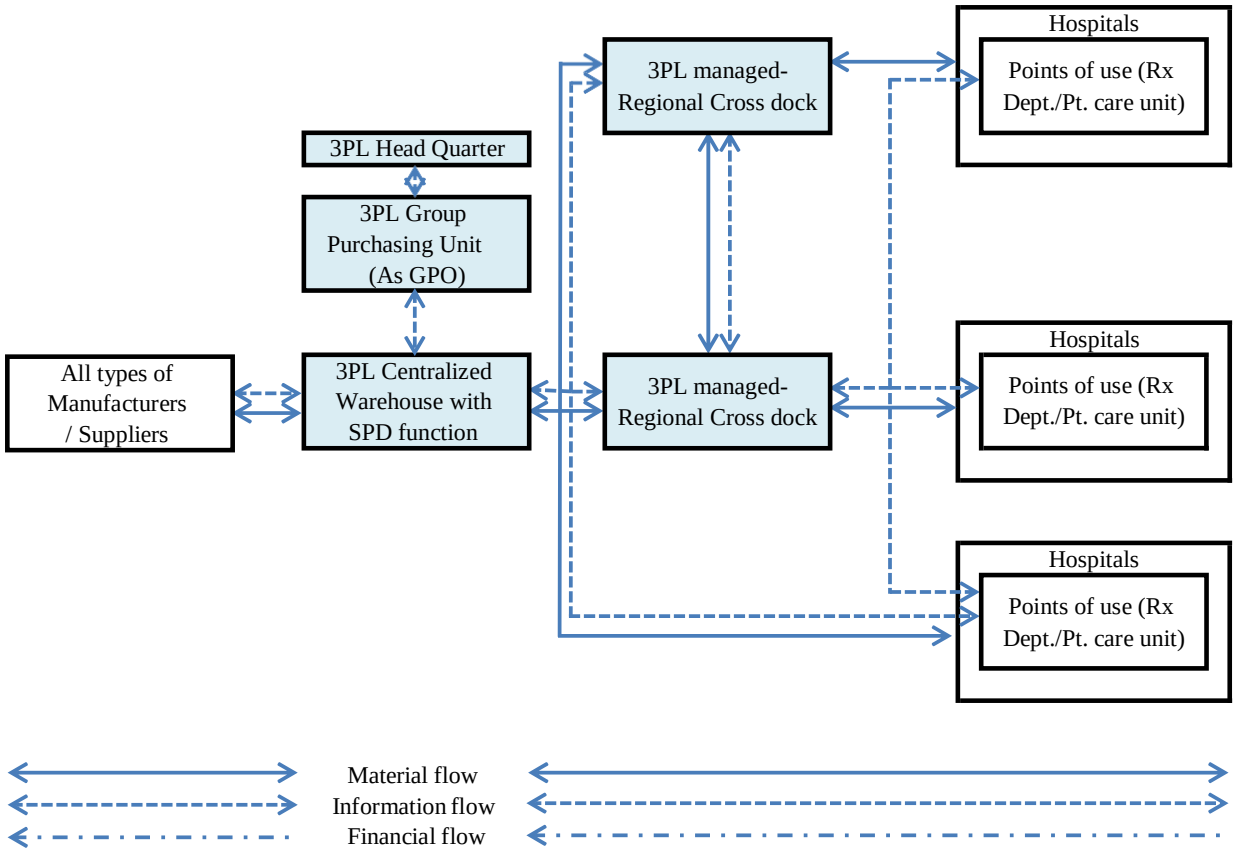

Figure 2. Model 7

Model 8 is also adjusted by replacing regional hub from Kumara and Kumarb study in 2014 instead of the cross dock in model 7 or by adding regional hub and its general functions from Kumara and Kumarb study in 2014 into the ROi Model of Rossetti M. and Lui Y., 2008 study.

Some different characters of regional hub could differentiate and improve the model efficiency. Because of its storage function (Hu et. al., 2018) and they are located nearer hospitals than centralized warehouse as the research assumption, holding inventory in these hubs could buffer uncertainty situation from hospital demand fluctuation or emergency need more efficiently and rapidly than model 1 which has only group purchasing unit and centralized warehouse. This makes model 8 has more flexibility to support hospitals in case of unpredictable demand than model 7. Though this available stock in regional hub could buffer some uncertain situations, it increases the model overall on hand inventory and management complexity, such as inappropriate distribution or amount carrying may lead to stock out or excess quantity in some locations (Kumara & Kumarb study, 2014).

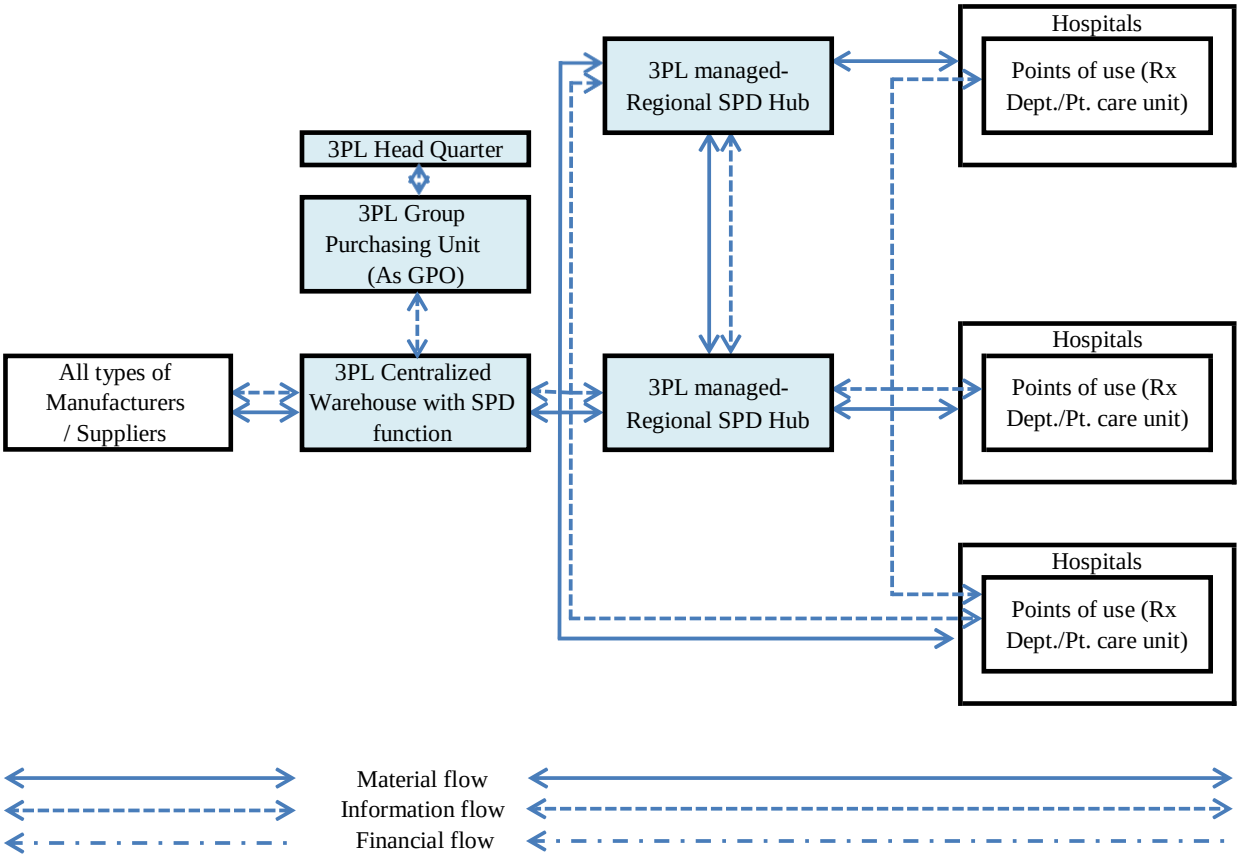

Figure 3. Model 8

Expert Suggestion Model

The participated experts gave some opinions after the designed model validation. Because of some differences in terms of particular functions of each external-hospital party managed by 3PL which could positively and negatively impact the operation efficiency in different way. In some cases, especially in large network that its hospital members are localized in several regions, integrating of every party and applying its specific characters appropriate to regional context could lead to a further potential model. They suggested that the model could consist of centralized warehouse to maintain strong power of negotiation, group purchasing unit to maximize competitive advantage in terms of item price, reginal cross docks to support hospitals in the region

which each of them is located close to others and regional SPD hubs to supply medical supplies to the hospitals of which location is far from another.

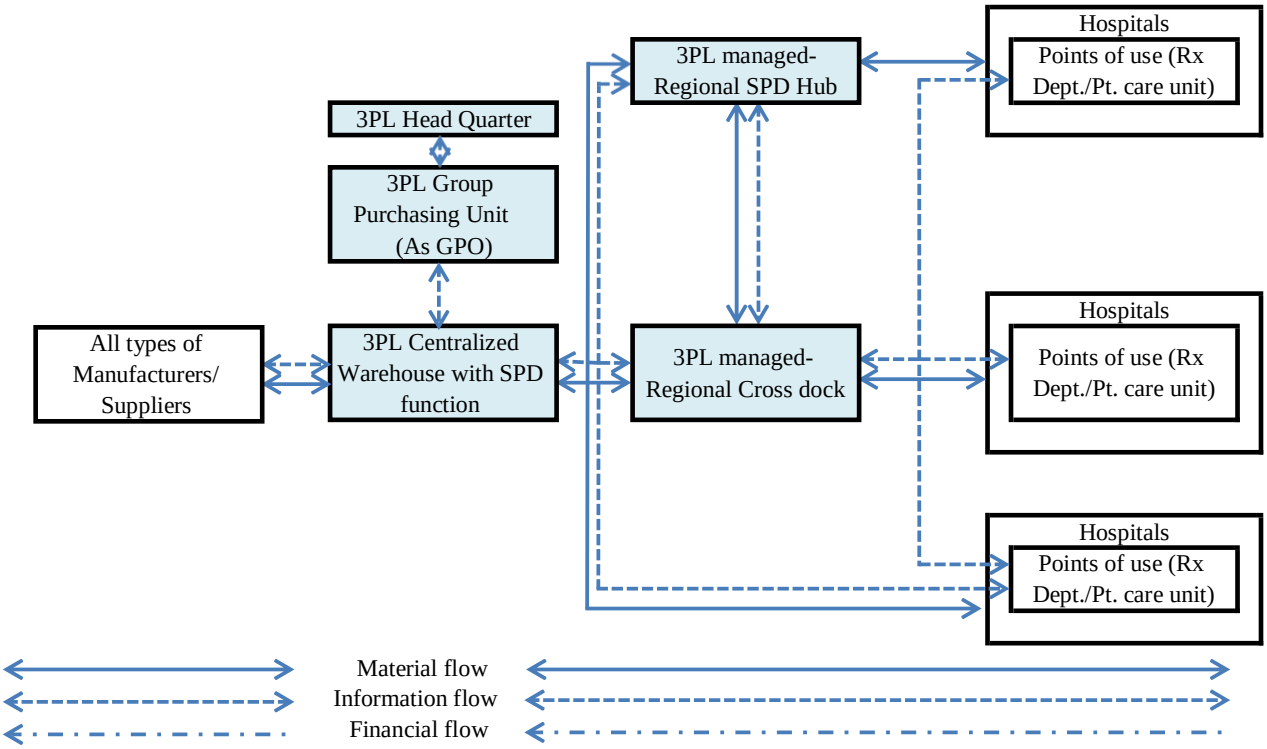

Figure 4. Expert Suggestion Model

The nine potential models give the potential elements and functions 3PLs could apply to manage and service their customers which are hospitals or hospital network. The different efficiency of each model is from each party that has particular functions accompanied by operative costs. The models with regional hubs have more flexibility characters in terms of urgent support and more rapid time, while regional cross docks are less flexible for uncertainty case because they do not stock goods inside. However, the models with cross docks have less inventory cost and some management costs than the models with hubs. All the models which consist of group purchasing units have more advantages in terms of the better price for all its members than without them. And the models with centralized warehouse, extreme bargaining power is their profit but it imply that inventory carrying cost is high. These are the issues 3PLs have to consider concurrently with customer expectation and service-level agreement in case of model adoption.

5. CONCLUSION

SPD-based management is the new concept of supply chain management strategy which has been proved its efficiency by many Japanese and Chinese hospitals as the functions performed in the logistics department in the hospital for many years. In Thailand, SPD model is usually applied as the activities in the inventory management unit in private hospital network which managed by 3PL and still has some limitations in general practice. The eight designed models and another one suggested by the experts who evaluated the models are the potential models which

could improve those restrictions and increase hospital supply chain management performance. According to the network of private hospitals; as the case study, three models outperform others. They are model 1, model 7 and model 8. Further one which is from expert opinion is suggested especially for large network. These four models have important characters needed in the hospital network service by 3PL i.e., power of negotiation for the best price and efficient logistics management of inventory turnover, response speed and ability to support the urgent demands from any reason, standardization of service items and some cost saving. To maximize benefit and gain customer trust, 3PLs should take all related factors into account and adopt the most appropriate model for both their and their customer context.

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