A Reference Model of the Distribution Center in Hospital Supply Chain

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ABSTRACT

The eminent increase in demand for healthcare services over the last decade has prompted the need to improve healthcare services systems. The supply chain management plays an important role in increased effectiveness and efficiency of operations in public hospitals, the largest medical service providers in Thailand. To improve the efficiency would start from how the medical products distributed and stored before used. A reference model will assist management in developing a seamless hospital supply chain processes. This research focuses on identifying the current generic supply chain processes within the distribution center of three-large-size hospitals in Thailand and developing a standardized model with a common language of distribution processes for hospital supply chain based on the Supply-Chain Operations Reference model (SCOR) and Business Process Model and Notation (BPMN). This will result in a well-designed operational framework with activities-based for decision making criteria and implementation that can improve performance in various areas.

Keywords: SCOR Model, BPMN, Reference Model, Hospital Supply Chain, Distribution Center

1. INTRODUCTION

Supply chain and logistics management has been continuously developed to improve business performance in organizations over the last three decades. It is undeniably the one of the most critical mechanisms for any industry since the efficient management of supply chain and logistics is the key to success of any suppliers, manufacturers and retailers, for example. Hospital industry, in particular, has been growing with the ever increasing demands for healthcare services. Hospitals serve customers and patients whose demands are varied dramatically; therefore, the supply chain and logistics has been at the heart of hospital management.

However, hospital's supply chain and logistics development is still at the early age as opposed to that of other industries. A typical hospital supply chain is a complex network consisting of the linkage role between vendors, manufacturers, distributors, hospital and internal departments. The co-ordination of material flow and information flow within the chains are subject to individual hospital's strategy and policy. The efficient supply chain management contributes greatly to competitive advantage of any business; hence, the inefficient one may cause the opposite. As a result, hospitals have to align their objective and strategy to maximize patient care while minimizing variable costs and wastes (Everard, 2001: DeScioli, 2005).

In Thailand, most hospitals are owned and managed by government with; the traditional hospital management. The lack of standardized processes of such management cause poor operations and co-ordinations between relevant units in supply chain and may lead to unsatisfied service provided to customers. It is apparent that amidst the increased demands for healthcare services, the number of state health personnel and facilities system could not support them (Ministry of Public Health, 2008-2010). Kritchanchai (2012) highlighted that the top concerns and problems raised by focused parties in healthcare industry in Thailand are inefficient business process, data inconsistency and fragmented supply chain system. This has prompted the need for a proposed framework for Thailand healthcare supply chain which is based on the confirmed problems and intervention improvement; standardization, information sharing and business process re-engineering. The problems of management and operational system at Ramathibodi hospital, a large sized public teaching hospital with approximately 1,000 with continuous increased in number of patients, caused high inventory level, high average storage time, and poor storage conditions in each distribution center due to limited space and facilities support system (Healthcare Supply Chain Excellence Centre (LogHealth), 2012).

Several supply chain management and development studies suggested that distribution center is one of the most significant parts in supply chain because it represents a large amount of costs of material storage and control (e.g. temperature-controlled, distribution process etc.). The uncontrolled storage conditions in distribution center impact materials' quality which inadvertently linked to the chance of patient's survival and recovery. In effect, supply chain and logistics management is crucial for inventory distribution and control in distribution center to achieve optimal accuracy, timeliness, traceability to attain hospital's performance (Hutujuta and Punnakittikasem, 2001; Toba et al., 2008).

To maximize the long term hospitals' competitiveness in patient's safety, business process re-engineering, standardization and information sharing through efficient and effective supply chain and logistics management, the development and implementation of reference model of the distribution center in hospital supply chain is required (Brown et al., 2011). The full-scale model in distribution processes derived from the reference model will connect the role and responsibility of data interfaces and activities in hospital supply chain. The well-designed structure and standardized processes will improve performance, response times and quality of care for decision making as a result. Therefore, the present study focuses on a full-scaled reference process model of the distribution center in hospital supply chain.

The present study is organized as follows: (i) literature review, (ii) purpose of the study, (iii) case observation and analysis, (iv) reference process model design and (v) discussion.

2. PURPOSE OF THE STUDY

The present research studied the existing business process model of distribution center of three large-size-hospitals in Thailand to identify the best practice and development of generic reference process models in the hospitals' supply chains. The purposes of the study is to develop a generic business process models with a set of performance parameters for distribution center that support decision makings and act as a reference model for use in top-down structured organizations.

The research question of this study is how can reference process models be designed for the distribution center for large-size-hospital supply chain in Thailand?

The qualitative research approach applied in the study includes in-depth interviews, additional desk research and observation of the existing distribution process at two public and one private large-scale hospital. The data was collected and analysed to obtain the As-Is pharmaceutical distribution process as a basis for the development of the standardized generic model

3. LITERATURE REVIEW

3.1 Distribution Center

Distribution Center is one type of warehouse where products are kept and transferred in from suppliers and out to customers with quicker response to serve customers' fluctuated demands. It is becoming more and more critical player in supply chain and the implementation of a warehouse management information system (WMS) in any businesses. With the high performance of warehousing operations and controls, it helps company to reduce transportation cost and achieve the market competition. (Faber et al., 2002)

A distribution center is a means to an end – satisfying customers' requirements through distribution processes. As a consequence, it is not necessary that it holds inventory, although it may hold some for short periods of time (e.g. cross-docking). The primary distribution process can be described in the four main sequence of receiving (inbound), storage (put-away), order-picking and shipping (outbound). Similar to the most cases for other industries, distribution center in hospital supply chain is to keep the products with good standard to ensure the quality and readiness of products that reach the patients with no shortage. (Bartholdi and Hackman, 2008; Gu et al, 2006)

3.2 DC design structure

A DC design structure can be classified into three design levels; which are strategic level, tactical level and operational level; within processes, resources and organization's perspective. The strategic distribution decisions mapping is initiating consider capability requirements, network design issues and facility considerations according to Figure 1. (Rouwenhorst et al., 1999; Coyle, 2003)

- Strategic level considers decisions that have a long term impact, mostly concern high investments.
- Tactical level considers a medium term decisions based on the outcomes of the strategic decisions discussed in the proceeding subsection. It has a lower impact than the strategic decisions, but still require some investments that typically concern the dimensions of resources.
- Operational level, each process is to be carried out within the constraints set by the strategic and tactical decisions. It is short term policies decisions that implies to have less interaction.

As mentioned so far, you will see that the Distribution center process and design structure are relate to the decision-making from the top level strategic planning to tactical and operational activities. Kumar et al. (2008) has proposed the business process re-engineering for the central distribution center at Hospitals in Singapore. As a result of the re-designed distribution center structure help improve about 50 percent of utilization in more than half of the activities. Therefore, the design of process flow for both physical and information networks are the keys to success of any distribution centers. One of the most efficient and effective way is by using Reference modeling tools, which will be explained in the next session.

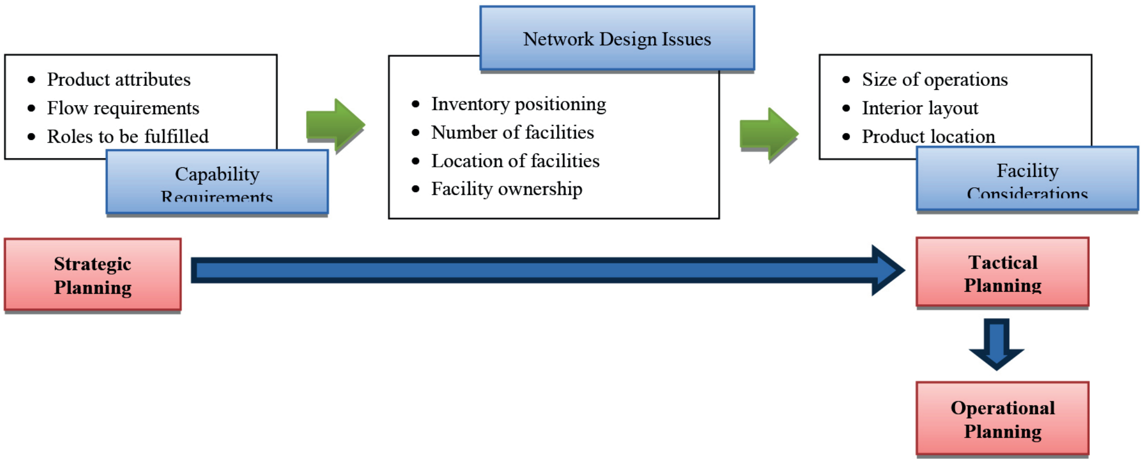

Figure 1 Strategic Distribution Decisions

3.3 Reference Models (RMs)

Reference Models (RMs) are generic conceptual models and framework which represent the business's best practice universally applied in company specific processes or projects. The benefits of implementing Reference Models to business includes cost and time reduction, quality improvement, risk reduction, process transparency, common language and basis for benchmarking (Kirchmer, 2011; Miers, 2008).

The development of process design and continuous sustainably improvement for the company or cross-industry could reuse the RMs in combination or individually, to reduce the development cost and time to company's specific process models (Kalpic and Bernus, 2002; Pajk et al, 2012). Verdouw et al. (2010) brought about an example of Reference Model usage designed for fruit industry in Europe. They analysed fruit-specific knowledge and generic knowledge in cross-industry standards and proposed the business process that could provide fruit companies with personalized configuration in supply chain design and information system implementation.

Similar to hospital supply chain, the reference process model designed using generic process could be applied to hospitals at all scales. The benefits will not be limited to the hospitals themselves but extended to the related players in hospital supply chain and, ultimately, to the patients. The reference processes in the model explain the roadmap for each role and responsibility with step-by-step activities. Besides the operational steps, the reference processes provide control points and key performance of each activity. The outline activities and performance metrics support the management team in decision making and can be adapted to company's needs. In sum, the reference process model engineers the management plan at strategic, tactical and operational levels.

3.4 SCOR Model

The Supply Chain Operations Reference model (SCOR), designed by the Supply Chain Council (2012), is the most widely used business process reference models in various industries. It is one of Supply Chain management tools used to address the overall processes and activities from supplier's supplier to a customer's customers. The SCOR model has five basic processes: Plan (P), Source (S), Make (M), Deliver (D) and Return (R), and provides a standard process model which describes the organization best practice framework of management processes. The model contains a linkage between business objectives to supply chain operations, with standard metrics to measure process performance or KPI at each level of hierarchy.

SCOR Model has four levels of hierarchy: top, configuration, process element and implementation. The top level (Level 1) is the design of process types (Plan, Source, Make, Deliver, Return). The second level (Level 2) involves configuration of the supply chain that is the detailed descriptions of the process types' sub categories, such as 'Make to stock', 'Make to order', and 'Engineer to order' or 'Production execution'. The third level (Level 3) is the decomposition of processes to the process element level, in line with its strategies and performance metrics. The fourth level (Level 4) is the implementation of the supply chain and best practice solution. This level is not included in SCOR framework but can be applied as a sub-process in specific business conditions.

Regarding hospital's supply chain, Martinelly et al. (2009) has proposed a conceptual model for the hospital supply chain using PORTER-SCOR level 1-3 and logical diagrams at level 4. They proposed the optimal process flows with the benchmarks for simulating logical diagram of hospital supply chain. The researchers applied SCOR framework Level 1 to Level 3 to design the reference process model of distribution center in hospital supply chain. Since the SCOR level four requires specific details from each hospital environment for the implementation stage, the proposed reference process model was upgraded to SCOR level 3.5 adopting generic processes. The SCOR level 3.5 takes into account the tactical and operational levels that support management team in making decision as shown in Figure 2.

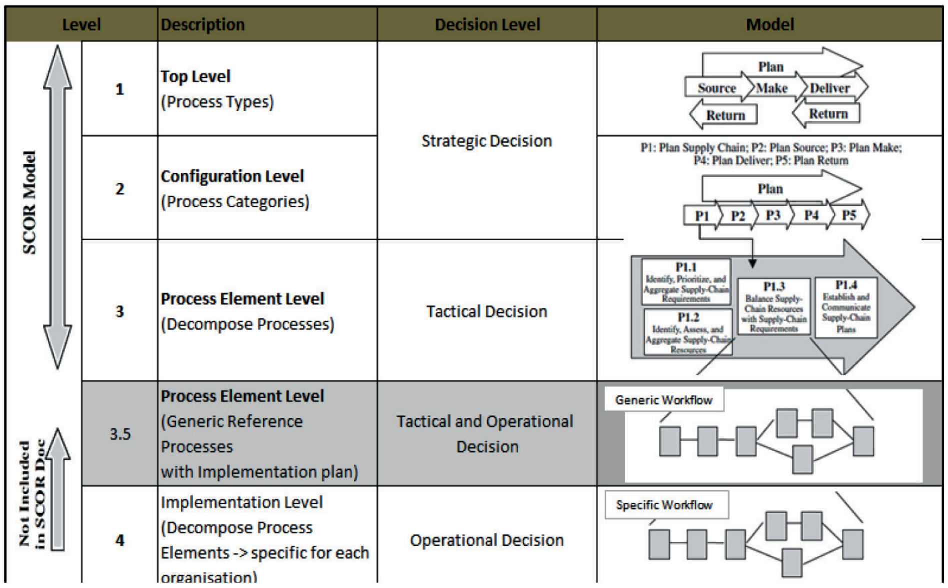

Figure 2 Levels of SCOR Model

3.5 SCOR Performance Attributes and Metrics

The SCOR Model describes supply chain activities for business at each level, and defines a set of performance metrics used to evaluate the processes. There are five dimensions to performance measurement: Supply Chain Reliability, Supply Chain Responsiveness, Supply Chain Agility (Customer-Focused attributes), and Supply Chain Costs, Supply Chain Asset Management Efficiency (Internal-Focused attributes). The SCOR Metrics is a standard measurement guidance for Supply Chain Performance linking metrics to support decision-making process. A good performance measurement system provides key measurement method which incorporates process alignment that aims to achieve strategic goals of organization. (SCOR, 2011)

The SCOR metrics are organized in a hierarchical structure as well as SCOR Model process framework, it describes in level-1, level-2 and level-3 metrics. The relationships between these levels are diagnostic. At Level 1 has ten strategic metrics primary which are the key performance indicators (KPI) for company strategic measurement. It is used as a framework for multiple SCOR processes in supply chain. Level-2 metrics indicate the root-cause of performance gap for level-1 metrics, and level-3 metrics are linked to the operational processes. The efficient and effective process design should consider the correlation of process and performance metrics at sub-levels, referring from the SCOR-based alignment framework and Best Practices.

3.6 Performance Measurement system

Supply Chain Performance measurement system can be developed based on SCOR metrics and Best Practices. The correlations between metrics and processes of the system enable management to comprehend the relationships across the system and accomplish organization's goal and overall performance. Ineffective and inefficient performance measurement system affect the entire supply chain management system as managers could not monitor and gather all necessary information for decision-making. In addition, the performance measurement system could make process improvement possible as Harington (1991) said that "If you cannot measure it, you cannot control it. If you cannot manage it, you cannot improve it."

Performance measurement and metrics have a significant role in Supply Chain Management in determination of company's objectives and future courses of action plans, and in evaluation of performance (Gunasekaran et al., 2004). Kocaoglu et al. (2011) studied a supply chain performance metrics in a hierarchical way, using AHP and TOPSIS methods to weight metrics importance. They found that performance metrics priorities support to the organization's strategic direction. There are various methods used in supply chain performance systems designed to measure operational performance, evaluate effectiveness and efficiency and continuously improving overall supply chain performance to achieve company's competitive advantages. How and what elements to measure are the key questions required clarification while developing performance measurement system depends on which aspects of the key objectives. (Cai et al., 2009)

Healthcare Performance Measurement, in particular, involves performance of several stakeholders and functions such as, suppliers, delivery, customer-service, and inventory management in a supply chain. The target outcomes of healthcare supply chain are, for example, the recovery of patient's health, responsiveness to support during care, quality of services, and productivity of the resources within the healthcare systems. Performance of each stakeholders and functions are complicated to measure and, as a results, are unable to be evaluated by any single performance method (Smith et al., 2010).

3.7 Business Process Modeling Notation (BPMN)

BPMN Version 2.0 was introduced by the OMG (Object Management Group) (2011) as one of the standardized tool visualizing diagrams used to model and interpret the business process diagram. The purpose is to facilitate communication of an end-to-end process to all cross-functional organization units by means of information structure in both professional management and technical IT terms. In this regard, BPMN standardizes blocked-structured process execution languages, between the business process design and process implementation (Cornu et al., 2013). BPMN provides a symbolic diagram notation of each role in a company, divided by lane and pool for individual activity in a process. Figure 3 shows three core elements, which are Event, Activity, and Gateway, that form the structure of and describe the process diagram. (Minoli, 2008).

BPMN is popular in both business and IT communities because its symbolic visuals can provide a simple way to communicate process information to other business users, process implementers, customers and suppliers. Based on a global survey of BPMN process modelers conducted by Recker (2008), approximately 51 percent of the respondents use BPMN for business purposes (process documentation, improvement, business analysis, stakeholder communication); whereas, 49 percent of the respondents use the notation for technical purposes (process simulation, service analysis and workflow engineering). From the survey, Microsoft Visio was the tool used by 18.2 percent of the respondents; therefore, it was applied as the tool for the present study as described in the later section.

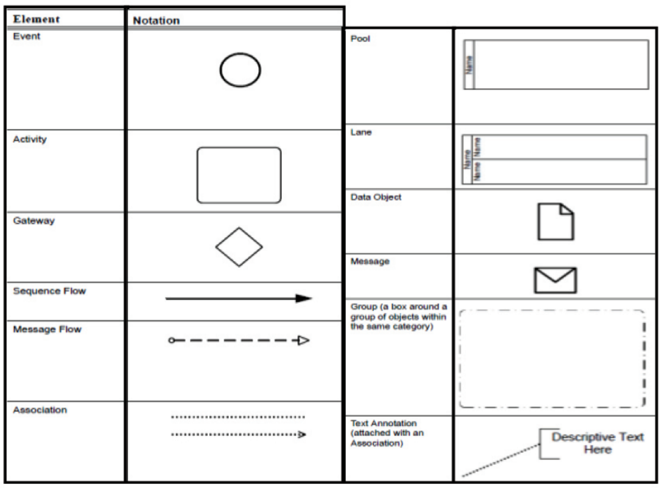

Figure 3 Basic BPMN Modeling Elements

4. CASE STUDY AND RESULTS

4.1 Case observation and analysis

As mentioned in Section 2 that our research has studied the current generic supply chain processes within the distribution centers of three-large-size hospitals as case study environments, and modeled based on the information from the in-depth structure interview conducted with the hospital head officers in related work area and site observation. There are similar patterns and processes are observed in the distribution centers for these three hospitals, with different technology and system or management policy. However, the generic processes are similar and can be potentially applied and extended to the reference model of same direction of control parameters.

4.1.1 As-Is Distribution processes

The case study environments for public hospitals consist of a large-size hospital, which one of those is the oldest and largest hospital in Thailand. Hospital A is one of the largest medical schools in South East Asia. It has a capacity of more than 2,000 beds and more than one million outpatient visits per year. Hospital B has about 1,000 beds capacity with more than 5,000 outpatients served per day. It won the best Thailand's Most Admired Company in 2013 by the Company Magazine, with average score 7.04 in overall for the image of brands owned and lead in innovation in Hospital business in Thailand.

Another location for our case study is the first and the largest private-hospitals in Thailand. Hospital C has grown its branches network to 13 locations around the country and the broader Asian region, offering the most advance and specialized medical treatment technology, under logistics center and lab specialties distribution for all the branches.

The As-Is Distribution processes of these three hospitals, can be divided into two main parts, which are Internal distribution (Outbound) processes and External distribution (Inbound) process. The Internal distribution (Outbound) or Stock-out occurs on schedule weekly plan, starting from the dispensing points update their stock on hand and plan to reserve the drug request to Distribution center.

In Figure 4 shows the As-Is Internal-External Distribution processes of Hospital B, you will see that the 'stock on hand' updates and drug requests are done via ERP system, then the list is passed throughout the Distribution center for further processes. Once orders are picked up, goods is packed and ready to deliver per schedule, dispensing points will check orders when received and Put-away to Storage location. For the External Distribution (Inbound) or Stock-in process, it will begin at Purchasing department running through the stock on hand and placing Orders to Suppliers, then within agreed lead-time the Distribution Center will receive the Goods and proceeds on with the distribution center processes. To verify the medical products specially, suppliers are required to attach the Quality certificate document, or Temperature check equipment (for cold-storage), other than checking goods physical appearance only. If the quality of the Order delivered is not satisfactory, the Distribution center will return goods for the whole batch as per contracts agreement.

4.2 Reference Process design

Product movement types are to identify the products' demand characteristics especially for hospitals that implements stockless supply chain policies. The demands have to be analyzed and modelled on a daily or monthly basis and it can be defined from the frequency of usage and Sales forecast. It can be classified into three levels as Slow-moving, Moderate-moving and Fast-moving, which affects the re-ordering point in order to manage inventory cost to balance with demand.

From the generic processes in the distribution center of general Hospital, the pattern of product movement shows that most of medicines are usually kept stock for daily demand usage and some that are for vital usage are required to be stored in hospital even with no demand. Therefore the 'Reference Process Model' will be designed based on Make-to-Stock model structure using five major processes within distribution center (see Figure 5), which enable suppliers to deliver the products within a short lead-time when Purchasing place the Orders.

4.2.1 SCOR Level 1

When we adopt the SCOR Model to describe the pharmaceutical products flow and information flow within and throughout Distribution center, the activities that are used to determine on process types for SCOR Level 1 as shown in Figure 6.

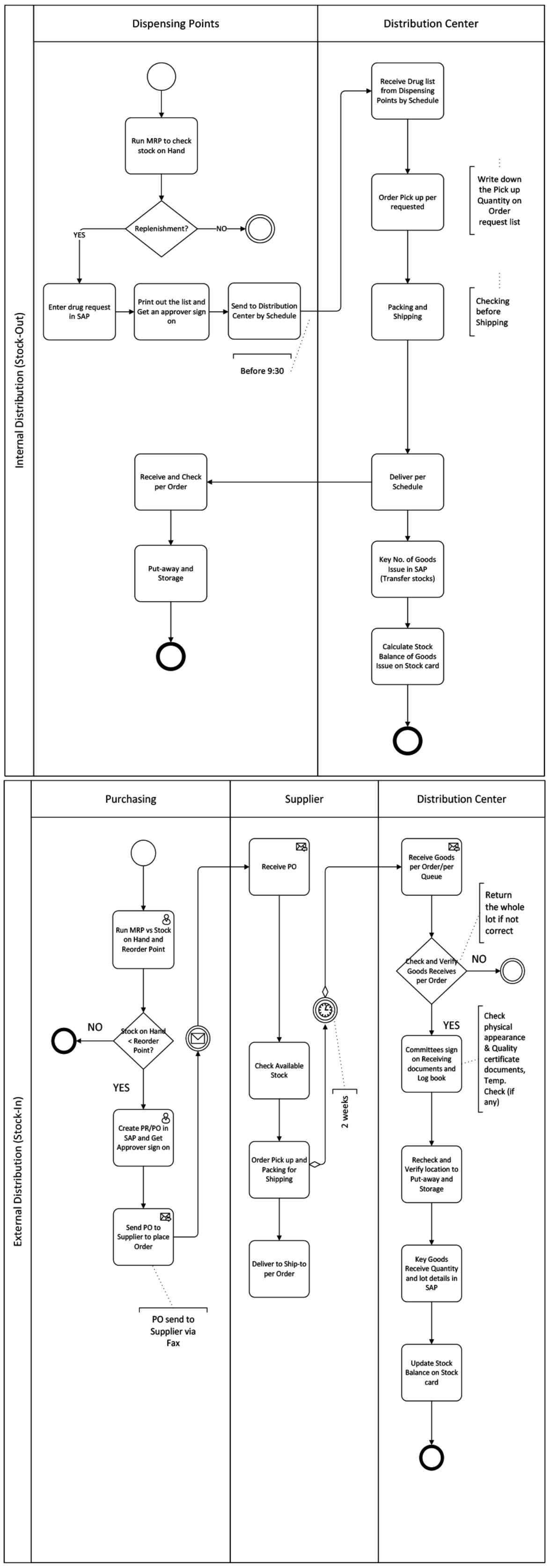

Figure 4 Example of Internal- External Distribution Process from Hospital B

Figure 5 Generic Distribution Center Processes

4.2.2 SCOR Level 2

For process categories, as mentioned earlier that we focused on Distribution center processes (some parts on 'Purchasing' will also be considered), the SCOR Level 2 in Figure 7 is modeled based on Make-to-Stock products, which we rename the process categories to align with distribution processes and hospital supply chain per following:-

- Plan (PL) : the process to determine requirements and corrective action to achieve supply chain objective for Inbound and Outbound logistics
- Receive (RE) : the process of ordering and receiving products, including replenishment inventory and return for defective product
- Put-away (PU) : the process of transferring verified products to storage location
- Order-Picking (OR) : the process of receiving the orders and pick up products to be ready for shipping
- Shipping (SH) : the process of order management and order fulfillment activities to serve customer satisfaction
- Return (RT): the process of moving defective products back through the supply chain or supplier

4.2.3 SCOR Level 3 to Level 3.5

In previous session, SCOR level 1 and Level 2 described how the processes are defined in the high level of Distribution center in Hospital supply chain. SCOR Level 3 will break down processes into a tactical decision level while additional model Level 3.5 will consider the operational decision level of the distribution center using the generic Inbound and Outbound logistics throughout the processes (see in Figure 8).

As mentioned in section 3.4 that we have put in extra effort to upgrade SCOR model Level 3 to Level 3.5, in order to show users the roadmap on how the reference model can be implemented in such environments. Figure 8 Reference Model for Distribution Center Process in Hospital Supply Chain (SCOR-Based Level 3.5) shows us the interface between Purchasing – Distribution Center (Inbound) – Distribution Center (Outbound) – Dispensing Points. It is written in BPMN platforms to represent the start and end processes of information flow and product flow for the whole processes. This is important for the IT part; to design on how each of the information will be link together, and using that to select the proper IT supports to achieve the most efficiency performance. The Reference Model can also be used to support the Capability Requirement, Network Design, Facilities Considerations, and scope down to Operational Planning as mentioned in session 3.2.

Determined the case studies scenarios into reference model based on SCOR Best-practice, we classified the Process Categories according to processes within Distribution Centre as; Plan (PL), Receive (RE), Put-away (PU), Order-Picking (OR), Shipping (SH) and Return (RT). With this classification, the management of hospital can see the operation scale and manage in which position is required for each activity, and design for the organization workforce at each process for the required role to be fulfilled.

At th e beginning, each role will be triggered by receiving information to start the process. For example, Purchasing will start Process PL1.1 from Inventory level, then establish and communicate supply chain plan, PL1.2 (Ordering plans) submit to suppliers with RE1.1 (Product Schedule) to deliver to Distribution Centre (Inbound). The workflow process will continue to the next role and activities respectively, as well as, product and information movement where necessary along the roles and responsibilities.

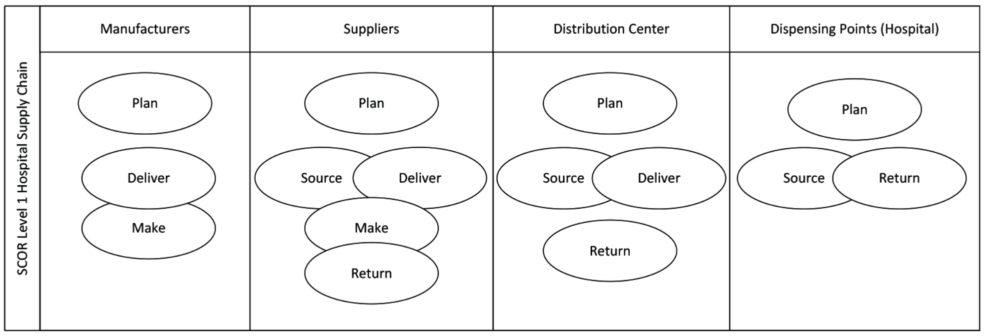

Figure 6 SCOR Level 1 Healthcare Supply Chain

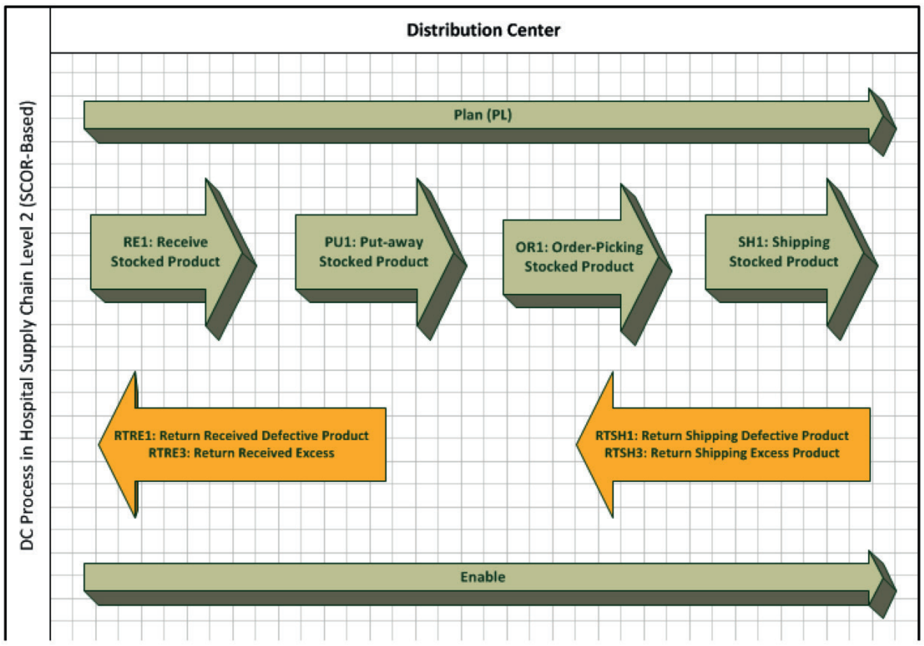

Figure 7 Distribution Process in Hospital Supply Chain Level 2 (SCOR-Based)

However, some processes are the same activities and are defined as same Process ID, such as, RE 1.2, RE 1.3 and PU 1.1 process. These are separated and specified more particularly by roles and responsibilities. Also the performance metrics using at each process, each roles are different by the measuring methods, which will be described in the next section.

4.3 Performance analysis and control

As mentioned in Section 1 in the overview of problem background that hospital supply chain still require a proper improvement and control of inventory with quality of goods storage and distribution practices conditions, those system affect directly to the patient safety and hospital's performance and service level. In this section you will see the performance outcome of Metric ID at each activity based on SCOR Level 3 that impacts the top-down process and decision in terms of time, cost and efficiency.

Hence the Metric is a standard for measurement of the process performance in supply chain, and SCOR Metrics are demonstrated in three-level of pre-defines metrics. For example in Table 1, Performance Attribute - Reliability at Level-1 Metric is RL.1.1 (Perfect Order Fulfillment) as its strategic metric and key performance indicators (KPI). It has four main 'Level-2' metrics and various 'Level-3' metrics identified with the processes. It shows that Process SH1.2 (Load Vehicle & Generate Shipping Docs) at Distribution Centre (Outbound) directly affects the performance 'Level-2' Metric RL2.3 (Documentation Accuracy), and those are part of the KPI at Level-1 metric RL1.1 (Perfect Order Fulfilment). Therefore the analysis of performance of metrics ID from Level-1 through 3 can help manager to find the root cause of overall performance.

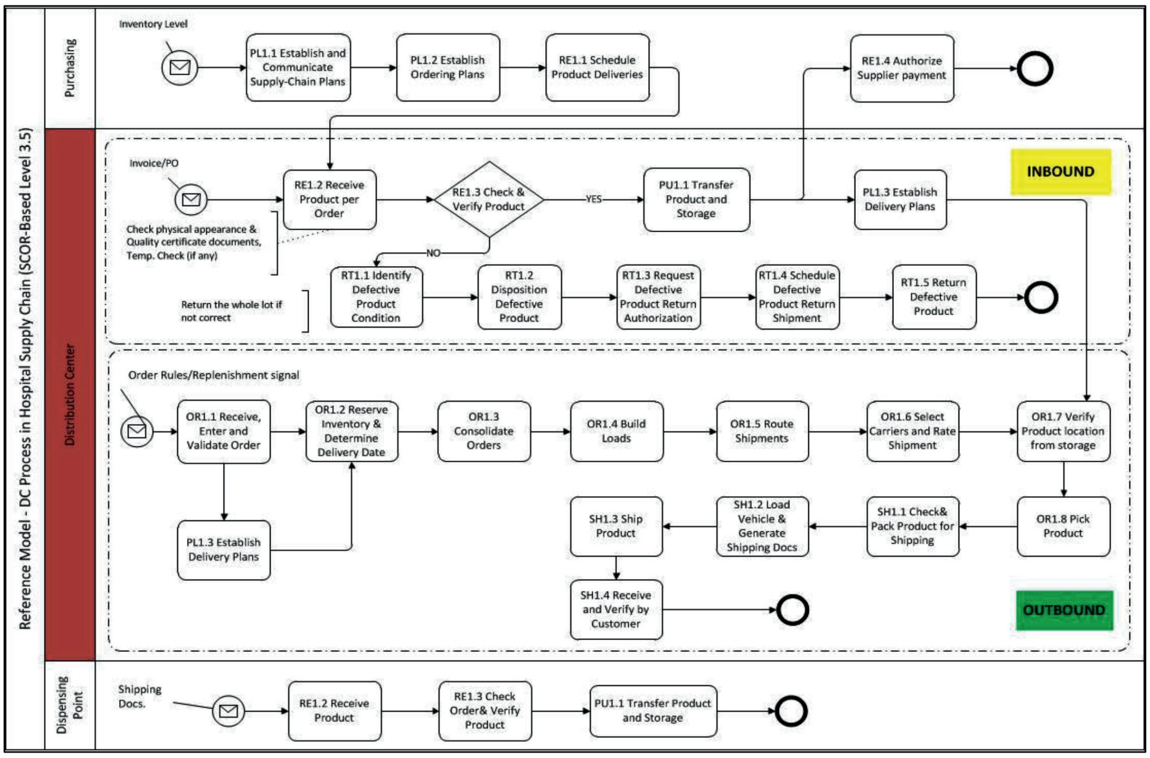

Figure 8 Reference Model of Distribution Process in Hospital Supply Chain (SCOR-Based Level 3.5)

Figure 9 Performance-Process Mapping at Distribution Center (Outbound)

Attribute	Level-1 Metric	Level-2 Metric	Level-3 Metric	Process	Role & Responsibility
Reliability [Total Perfect Orders] / [Total Number of Orders] x 100%	**RL.1.1 Perfect Order Fulfillment**	**RL.2.1 % of Orders Delivered In Full**	RL.3.33 Delivery Item Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
			RL.3.35 Delivery Quantity Accuracy		
		RL.2.2 Delivery Performance to Customer Commit Date	RL.3.32 Customer Commit Date Achievement Time Customer Receiving	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.34 Delivery Location Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
		RL.2.3 Documentation Accuracy	RL.3.31 Compliance Documentation Accuracy	SH1.2 Load Vehicle & Generate Shipping Docs	Distribution Center (Outbound)
			RL.3.43 Other Required Documentation Accuracy		
			RL.3.45 Payment Documentation Accuracy		
			RL.3.50 Shipping Documentation Accuracy		
		RL.2.4 Perfect Condition	RL.3.12 % Of Faultless Installations	N/A	N/A
			RL.3.24 % Orders/lines received damage free	RE1.3 Check Order& Verify Product	Distribution Center (Inbound)/ Dispensing Point
			RL.3.41 Orders Delivered Damage Free Conformance	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.42 Orders Delivered Defect Free Conformance		

Table 1 Level-1 through 3 of Performance Attribute - Reliability and Processes linked

In our research, the designed Reference Model of Distribution center in Hospital Supply Chain is considered at Process / Metrics Alignment level based on SCOR Best Practices. The Performance-Process mapping diagrams show that outbound distribution, starting from order receipt to deliver to customers, is the key function in Distribution center and it has the most impact on overall Performance. Reliability and Responsiveness are the major Performance attributes of the outbound distribution with covering process activities about 40.74 and 44.45 percent respectively; as they are addressed to customer-facing attributes, whereas Agility, Cost and Asset Management Efficiency have a small impact for about 15 percent from total 27 processes in Distribution center (see Figure 9).

Further in this session, from SCOR Model Level 3 we have mapped the processes and Performance Metric IDs for each Role and Responsibility within the Distribution Center Process of Hospital Supply Chain, in order to show the implementation roadmap how the interaction of the process and how the key performance can be measured (see Table A in Appendices).

5. DISCUSSION

From the case study and literature review on Reference Model and Hospital Supply chain, there is still lack of the standardization for the end to end process between parties. There are also critical issue on the Performance Measurement system as it is not yet designed for overall performance to reach company objective. In our research, we have studied the generic processes of three-large-size hospital in Thailand to identify the reference model of Distribution center in Hospital Supply Chain based on SCOR Model and Metrics, with BPMN notation for IT implementation purpose. The usage of only modelling language made it easier compared to existing approaches (Barros et al, 2012). With these results, it can be used to assist the manager on setting standard guidelines for implementation and/or process improvement within Distribution center and toward Hospital supply chain. A well-structured reference model demonstrates key performance indicators at each process and roles can help management to analyze the problem root cause for further development.

In conclusion, this research has reached its objective and shown how a process models can be designed for the distribution center for large-size-hospital supply chain in Thailand, where in the specific areas of Reference Model and Performance Measurement were determined. The SCOR framework applies to main activities in Distribution center; Plan, Receive, Put-away, Order-Picking, Shipping and Return, where specific roles and responsibilities are defined at each process. Detailed process guidelines herewith will be very helpful for managing its operations and performance progress tracking to promote the greater supply chain integration and future development.

6. FURTHER STUDY

In this research has applied the reference process model based on the management point-of-view, policies and existing system accessibility and facilities at the selected hospitals environment, therefore the designed model from this paper will depend on an extensive case study in 3 hospitals (2 publics and 1 private), and be reviewed in-depth by hospital experts. As result, the research could provide solid evidence that the designed model in Hospital Distribution center meet the specific requirements to reference process model for further implementation.

Nevertheless, there may have some important opportunities for future development and research due to limited contribution in public hospitals because of laws and government processes that would affect the designed reference model in term of decision making criteria and processes. Additional research and practice in BPMN notation and programs for implementation may be useful for example BPMN web-based, in specific environment, to adjust the real-time data collection at each process and see how it is impact the key performance indicators at high strategic level.

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APPENDICES

Table A Reference Model designed process mapping based on SCOR Model

Role & Responsibility	Process	SCOR ID	SCOR Re-designed Process for Healthcare	Metric ID	Performance Metrics
Purchasing	PL1.1	sP1.4	Establish and Communicate Supply-Chain Plans	RS.3.30	Establish Supply Chain Plans Cycle Time
				AM.2.2	Inventory Days of Supply
	PL1.2	sP2.4	Establish Ordering Plans	RS.3.29	Establish Sourcing Plans Cycle Time
	RE1.1	sS1.1	Schedule Product Deliveries	RL.3.27	% Schedules Changed within Supplier's Lead Time
				RS.3.9	Average Days per Engineering Change
				RS.3.10	Average Days per Schedule Change
				RS.3.11	Average Release Cycle of Changes
				RS.3.122	Schedule Product Deliveries Cycle Time
	RE1.4	sS1.5	Authorize Supplier payment	RS.3.8	Authorize Supplier Payment Cycle Time
Distribution Center (Inbound)	PL1.3	sP4.4	Establish Delivery Plans	RL.3.36	Fill Rate
				RS.3.27	Establish Delivery Plans Cycle Time
	PU1.1	sS1.4	Transfer Product and Storage	RL.3.25	% Product Transferred On-Time to Demand Requirement
				RL.3.26	% Product Transferred without Transaction Errors
				RS.3.139	Transfer Product Cycle Time
				AM.2.2	Inventory Days of Supply
	RE1.2	sS1.2	Receive Product per Order	RL.3.18	% of Orders / Lines processed complete
				RL.3.20	% of Orders/ lines Received On-Time To Demand Requirement
				RL.3.22	% of Orders/ lines Received with Correct packaging
				RL.3.23	% of Orders/ lines Received with Correct Shipping Documents
				RS.3.113	Receiving Product Cycle Time
	RE1.3	sS1.3	Check Order& Verify Product	RL.3.19	% of Order / Lines Received Defect Free
				RL.3.21	% of Orders / Lines with correct content
				RL.3.24	% of Orders/ lines Received Damage Free
				RS.3.140	Verify Product Cycle Time
	RT1.1	sSR1.1	Identify Defective Product Condition	AM.3.29	Percentage Defective Inventory in Disposition
	RT1.2	sSR1.2	Disposition Defective Product	CO.3.029	Disposition Cost
				AM.3.29	Percentage Defective Inventory in Disposition
	RT1.3	sSR1.3	Request Defective Product Return Authorization	AM.3.30	Percentage Defective Inventory in Return Authorization
	RT1.4	sSR1.4	Schedule Defective Product Return Shipment	RL.3.28	% of Shipping Schedules that Support Customer Required Return by Date
				AM.3.32	Percentage Defective Product Inventory in Scheduling
	RT1.5	sSR1.5	Return Defective Product	RL3.47	Return Shipments Shipped on Time
				RL.3.5	% Error-free Returns Shipped
				CO.3.022	Transportation Cost
				AM.3.21	Rebuild or recycle rate
				AM.3.31	Percentage Defective Product Inventory in Transportation
Distribution Center (Outbound)	OR1.1	sD1.2	Receive, Enter and Validate Order	RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				RS.3.94	Order Fulfillment Dwell Time
				RS.3.112	Receive, Enter & Validate Order Cycle Time

Role & Responsibility	Process	SCOR ID	SCOR Re-designed Process for Healthcare	Metric ID	Performance Metrics
	OR1.2	sD1.3	Reserve Inventory & Determine Delivery Date	RL.3.36	Fill Rate
				RL.2.1	% of Orders Delivered In Full
				RL.2.2	Delivery Performance to Customer Commit Date
				RS.3.94	Order Fulfillment Dwell Time
				RS.3.116	Reserve Resources and Determine Deliver Date Cycle Time
	OR1.3	sD1.4	Consolidate Orders	RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				CO.3.022	Transportation Cost
				RS.3.18	Consolidate Orders Cycle Time
				CO.3.018	Order Management Labor Cost
	OR1.4	sD1.5	Build Loads	CO.3.022	Transportation Cost
				RS.3.16	Build Loads Cycle Time
				CO.3.018	Order Management Labor Cost
	OR1.5	sD1.6	Route Shipments	CO.3.022	Transportation Cost
				RS.3.117	Route Shipments Cycle Time
				CO.3.018	Order Management Labor Cost
	OR1.6	sD1.7	Select Carriers and Rate Shipment	RL.3.16	% of Suppliers meeting environmental metrics / criteria
				CO.3.022	Transportation Cost
				CO.3.018	Order Management Labor Cost
	OR1.7	sD1.8	Verify Product location from storage	RS.3.108	Receive Product from Make/ Source Cycle Time
				RS.3.110	Receive Product from Source or Make Cycle Time
				CO.3.024	Fulfillment Labor Cost
	OR1.8	sD1.9	Pick Product	RL.3.36	Fill Rate
				RS.3.96	Pick Product Cycle Time
				CO.3.024	Fulfillment Labor Cost
	PL1.3	sP4.4	Establish Delivery Plans	RL.3.36	Fill Rate
				RS.3.27	Establish Delivery Plans Cycle Time
	SH1.1	sD1.10	Check& Pack Product for Shipping	RL.3.4	% Correct Material Documentation
				RS.3.95	Pack Product Cycle Time
				CO.3.024	Fulfillment Labor Cost
	SH1.2	sD1.11	Load Vehicle & Generate Shipping Docs	RL.2.2	Delivery Performance to Customer Commit Date
				RL.2.3	Documentation Accuracy
				RL.3.31	Compliance Documentation Accuracy
				RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				RL.3.43	Other Required Documentation Accuracy
				RL.3.45	Payment Documentation Accuracy
				RL.3.50	Shipping Documentation Accuracy
				RS.3.51	Load Product and Generate Shipping Documentation Cycle Time
				CO.3.024	Fulfillment Labor Cost
	SH1.3	sD1.12	Ship Product	RL.2.1	% of Orders Delivered In Full
				RL.2.2	Delivery Performance to Customer Commit Date
				RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy

Role & Responsibility	Process	SCOR ID	SCOR Re-designed Process for Healthcare	Metric ID	Performance Metrics
				RS.3.126	Cycle Time
				CO.3.022	Transportation Cost
				CO.3.024	Fulfillment Labor Cost
	SH1.4	sD1.13	Receive and Verify by Customer	RL.2.1	% of Orders Delivered In Full
				RL.2.2	Delivery Performance to Customer Commit Date
				RL.2.4	Perfect Condition Customer Commit Date Achievement Time customer
				RL.3.32	Receiving
				RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				RL.3.41	Orders Delivered Damage Free Conformance
				RL.3.42	Orders Delivered Defect Free Conformance
				RS.3.102	Receive & Verify Product by Customer Cycle Time
				RS.3.103	Receive and Verify Product Cycle Time
Dispensing point	PU1.1	sS1.4	Transfer Product and Storage	RL.3.25	% Product Transferred On-Time to Demand Requirement
				RL.3.26	% Product Transferred without Transaction Errors
				RS.3.139	Transfer Product Cycle Time
				AM.2.2	Inventory Days of Supply
	RE1.2	sS1.2	Receive Product per Order	RL.3.18	% of Orders / Lines processed complete % of Orders/ lines Received On-Time To Demand
				RL.3.20	Requirement
				RL.3.22	% of Orders/ lines Received with Correct packaging % of Orders/ lines Received with Correct Shipping
				RL.3.23	Documents
				RS.3.113	Receiving Product Cycle Time
	RE1.3	sS1.3	Check Order& Verify Product	RL.3.19	% of Order / Lines Received Defect Free
				RL.3.21	% of Orders / Lines with correct content
				RL.3.24	% of Orders/ lines Received Damage Free
				RS.3.140	Verify Product Cycle Time