HEALTHCARE SUPPLY CHAIN OPERATIONS IMPROVEMENT IN THAILAND

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ABSTRACT

In general, it was difficult to obtain operational performance and collaboration of healthcare supply chain due to lack of data standards, lack of visibility and fragment of IT systems. So far, however, there has been little discussion about the interventions to successful operational performance and collaboration enhancement.

Therefore, the motivation for this study was to investigate the stakeholders' difficulties and to propose the interventions to overcome these difficulties. To identify such difficulties, interviews, focus group and surveys were considered to gain a thorough understanding of stakeholders' difficulties. The findings indicated two main problems : differentiation of IT systems. Once the analysis were completed, a datapool was developed to overcome those difficulties and experimented at a hospital in Thailand to evaluate the interventions. The results of this experiment indicated that a datapool contribute to operational performance and collaboration for stakeholders in 3 areas including enabling real-time visibility, increasing information quality and reliability; and increasing operational performance through automatic collation processing function. In addition, it is also found that implementing a datapool with an EDI system could reduce 39 minutes on PO cycle time or Baht 915,975 cost savings annually.

KEY WORDS: HEALTHCARE SUPPLY CHAIN / DATAPOOL / EDI / SUPPLY CHAIN COLLABORATION

266 pages

การพัฒนาประสิทธิภาพกระบวนการโซ่อุปทานสุขภาพในประเทศไทย
HEALTHCARE SUPPLY CHAIN OPERATIONS IMPROVEMENT IN THAILAND

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ปร.ด. (การจัดการโลจิสติกส์และวิศวกรรม)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: ดวงพรรณ ศฤงคารินทร์, Ph.D., ปานใจ ธารทัศนวงศ์, Ph.D., นพ. ชูศักดิ์ โอกาสเจริญ, Ph.D., M.D., ธนากรณ์ แน่นหนา, Ph.D.

บทคัดย่อ

โซ่อุปทานสุขภาพมีการเชื่อมโยง แลกเปลี่ยนข้อมูลระหว่างกันน้อยมาก ผลการทบทวนวรรณกรรมและผลวิจัยเบื้องต้น พบว่าอุปสรรคที่สำคัญต่อการเชื่อมโยง แลกเปลี่ยนข้อมูลประกอบด้วย 1) รหัสบ่งชี้ผลิตภัณฑ์และข้อมูลเกี่ยวกับผลิตภัณฑ์มีความหลากหลาย 2) ระบบสารสนเทศที่ใช้งานในแต่ละสมาชิกแตกต่างกัน และ 3) ข้อมูลเกี่ยวกับผลิตภัณฑ์มีความสำคัญมากต่อคุณภาพของการให้บริการ

ด้วยเหตุที่กล่าวมา ผู้วิจัยได้เสนอแนวคิดในการพัฒนาฐานข้อมูลกลาง โดยใช้ GTIN 13 เป็นรหัสมาตรฐานบ่งชี้ผลิตภัณฑ์ และจัดการข้อมูลที่มีผลต่อประสิทธิภาพในกระบวนการโลจิสติกส์ และความปลอดภัยของผู้ป่วยที่ใช้ผลิตภัณฑ์นั้นมารวมไว้ในฐานข้อมูลดังกล่าว ขณะเดียวกัน ผู้วิจัยได้ทดสอบการประยุกต์ใช้งานแนวคิดนี้ร่วมกับระบบแลกเปลี่ยนข้อมูลอิเลคทรอนิกส์ ในโรงพยาบาลรัฐแห่งหนึ่งเป็นเวลา 8 สัปดาห์ระหว่างธันวาคม 2557-มกราคม 2558 ซึ่งผลทดสอบแสดงให้เห็นว่ารหัสมาตรฐานบ่งชี้ผลิตภัณฑ์ และข้อมูลมาตรฐานที่จัดเก็บในฐานข้อมูลกลางช่วยยกระดับความสามารถในการเชื่อมโยง แลกเปลี่ยนข้อมูล และติดตามสถานะการเคลื่อนไหวของผลิตภัณฑ์ผ่านระบบแลกเปลี่ยนข้อมูลอิเลคทรอนิกส์ ลดการแทรกแซงข้อมูลที่เกิดจากคนในระหว่างสื่อสารข้อมูลระหว่างกัน ส่งผลให้ข้อมูลมีความถูกต้องแม่นยำมากยิ่งขึ้น ขณะเดียวกันก็เป็นการเพิ่มประสิทธิภาพการดำเนินงานของบุคลากร โดยลดรอบเวลาในการสั่งซื้อลงจากเดิม 39 นาทีต่อใบสั่งซื้อ ส่งผลให้ค่าใช้จ่ายในการดำเนินการลดลงปีละ 915,975 บาท

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CHAPTER I
INTRODUCTION

1.1 Healthcare Supply Chain Background

Today, healthcare supply chain was under increasing pressures from all sides—patients, reimbursement agencies, government to reduce operating costs, increase efficiencies and also provide high quality of care (Norris, 2002; NACIS, 2013 and Battini et al., 2009). Womack et al. (2005) and Bentley et al. (2007) have studied lean in healthcare industry in the United States and mentioned that over 16% of GDP spent in health expenditure. This idea supported by Hendrich et al. (2008), they argued more in details that 50% of caregiver time spending on paperwork instead of patient-care provision. Discussing on the operational productivity, Nolte and McKee (2008) studied for the Commonwealth Fund National and mentioned that 20 to 30% of patient care service spending is wastes such as overtreatment of patients, failure to coordinate care, administrative complexity, burden rules, fraud, etc. Similar to Jimmerson (2010) and McManus (2012), they highlighted that only 31 to 34% of nurse time spent with patients and 80% or more of that particular time is waste.

Facing with these situations, it leaded healthcare stakeholders to put their primarily efforts on eliminating wastes, reducing cost, and increasing efficiencies. Due to the complexity of healthcare supply chain, cost control and optimization of information and material flows of pharmaceuticals had been interested among researchers and numerous studies, approaches and methods had been suggested in literatures. For instance, streamline health-related business process with lean tools, cost reduction through initiatives of just-in-time technique or stockless inventory management (McManus, 2012; Rivard-Royer et al., 2002; Kammani, 2004; Nicholson et al., 2004; Landry and Philippe, 2004; Schweikhart and Dembe, 2009), implement JIT approaches in hospitals (Chunning and Kumar, 2000), cost containment efforts to lower acquisition price of pharmaceuticals instead of lowering the total delivered cost (Kumar et al., 2008; Agwunobi and London, 2009), form a consolidated service center

to centralize hospital's contracting, procurement, distribution, and logistical operations (Parker and DeLay, 2008), focus on outsourcing of inventory management (Kazemzadeh et al., 2012; Rosser, 2006 and Kazemzadeh et al., 2012).

Lapierre et al. (2007) and Pasin et al. (2002) recommended for using simulation to improve scheduling decision for pharmaceuticals. Moreover, Rosetti and Selandari (2001); Dey Hariharan (2006); Hariharan et al. (2004); Wu et al. (2007) and Miah (2103) convinced on using the multi-objectives KPIs to measure the healthcare supply chain performance. Rosetti et al. (2008); O'Neill et al. (2001) and Callahan et al. (2004) recommended healthcare stakeholders to consider on pharmaceutical demand forecasting. Moreover, Weiss et al. (1978), Elstein and Schwarz (2002) and Arocha et al. (2005) suggested for DSS applications such as model-based method for medical decision making, clinical problem solving, and discovering reasoning strategies in medical decision making. Colleti (1994) identified that the opportunity to manage costs is changing process to eliminate non-value added administrative tasks and also supply chain process activities and their costs. Norris (1998) noticed on investigating the total operating costs and considering supply chain costs instead of unit costs. Nachtmann and Pohl (2009) identified for portion of healthcare costs that one-third to two-third of all healthcare operating costs often remains in supply chain operations especially in holding inventory and order management. This is supported by some researchers, for instance, Haavik (2000) stated that supply chain costs accounted to as much as 40% of the patient care provision costs in some hospitals. Additionally, Byrnes (2004) notified that about 25 percent of patient care costs are product supply-related. Nathan and Trinkus (1996) and Danas et al. (2000) indicated that the inefficiency of inventory management in any hospitals accounted from 17% to 35% of hospital's revenues. In the meantime, Bernard (2006) further argued that hospitals spent an average of 12.5% on pharmaceuticals.

Discussing on healthcare supply chain, it is one of the most complex supply chain, remained immature in level of collaboration and it comes to expenses with millions of pharmaceutical products movement along the chain; starting on manufacturers through distributors, hospitals and ending at patients (Pleasant, 2009**;** Ventola, 2011 and Kritchanchai, 2012). In healthcare supply chain, mostly of health expenditures are subsidized by the government and it increasing steadily. Hence, this

aspect causes government aims to cut unnecessary reimbursed health expenditures or costs. Due to those challenges, in particular with operating costs, quality of patient care provision and health expenditure reduction, it causes healthcare stakeholders in the entire healthcare supply chain shifting their focus on increasing logistics and supply chain efficiencies.

Furthermore, in the past, a challenge to reduce adverse events (AEs) such as medication errors in prescribing and administration become the top agenda among healthcare providers. The Institute of Medicine reported that 34% of medication errors occurred in hospitals and 10% of all medication error has its root causes from lacking of data standardization (IOM, 2000). In the meantime, the main characteristics of healthcare is service, and the nature of service is fully relied on human interactions. Unlike general service industries, healthcare is recognized as professional service. Therefore, it is not only relied on human resources but in an intensive information. In healthcare supply chain, an inefficiency could occurs in any links along supply chain networks. It required operators to collect data or relevant information on papers that must then be entered into the computer—a double touch of data that introduces ample opportunity for errors.

To survive over these aspects, Nachtmann and Pohl (2009) recommended the healthcare stakeholder must take benefits on increasing level of information sharing, coordination, collaboration and increasing supply chain maturity by focusing on infrastructure development. Haavik (2000) convinced that better management could save 4.5% on inventory carrying cost. This idea is supported by Chandra and Kachhal (2004), they pointed out that the cost savings could range from 6 to 13.5% according to implement better inventory management as well. While Roark (2005) and Shou (2013) indicated that redesigning supply chain networks could save $12.5 to $30 million from $500 million supply budget. Furthermore, Global Healthcare Exchange argued that the integrity of product master is one of the most important initiatives in healthcare supply chain since it is the glue that holds business and patient care processes altogether (GHX, 2013). The Mckinsey stated in their study that implementing of data standards in healthcare supply chain could reduce medical inventory of $60-94 billion and reduce the costs of managing and storing inventory by $10 to $14 billion (Mckinsey, 2012). The Canadian Institute for Health Information

indicated that 20 to 30% of operator' time in hospitals is spent on fixing data errors and they continue to manually order and re-label pharmaceuticals due to lack of integrated data standards and they further argued that up to 70% of purchase orders contain an error that required a lot of manual interactions (CareNET, 2009). This is similar to the Center for Healthcare Supply Chain Research, they have studied the issues in healthcare supply chain and highlighted that a critical issue is the ability to manage and share pharmaceutical data among healthcare stakeholders (HDMA, 2007). While Ford and Scanlon (2007) recommended that IT systems capable of effectively managing data and information are not widespread, nor fully integrated in the supply chain.

Due to the specialty of healthcare supply chain, information quality, integrity and reliability such as lot integrity and tracking, is one of the crucial characteristics (Byrnes, 2004). It's important is to be ensured that patient receives safe pharmaceuticals. On the other hand, supply chain integrity is also another key problem. Park et al. (2006) indicated that one of the healthcare characteristics is the data driven or information intensive. Bipartisan Policy Center indicated that specific information of a pharmaceutical both scientific and clinical indications also plays a critical role to ensure safe provision of care (BPC, 2013). In the process of patient care provision, the cost of errors is so high and it could resulted to someone's disabilities or even loss of patient's life (WHO, 2014). The Efficient Healthcare Consumer Response (EHCR) stated that the U.S. healthcare systems wasted $15.5 billion annually due to either entirely lacking or not as widely used or well-structured data in a standardized format. In addition, the EHCR pointed out that inefficiencies in healthcare supply chain contribute for $11 billion or 48% out of the total annual supply chain cost of $23 billon (Toba et al., 2008). Worse yet, a groundbreaking report on patient safety issues by the Institute of Medicine in 1999 cited staggering statistics about medical error, and found that hand written reports or notes, manual order entry, non-standard abbreviations and poor legibility lead to substantial errors and injuries (IOM, 1999; Leape and Berwick, 2005). The Centers for Medicare and Medicaid Services (CMMS) has analyzed trends on health expenditure and estimated that the United States spend over $2.5 trillion on health expenditure in 2009, compared with Japan at 8.1%, the United Kingdom at 8.4%, Canada at 10%, and Germany and France at around 11%.

Furthermore, many healthcare supply chain experts are concerned that this number will grow to around 20% of United States GDP by 2015 (Bustamante and Chen, 2012).

Not much differ to other industries, the healthcare stakeholders are attempting to better collect and manage their data, improve product visibility, reduce inventory and streamline processes. Based on these challenges, it is a clear movement towards data standards adoption across the entire healthcare supply chain. However, the readiness of healthcare stakeholders to implement data standard in the near future is not obvious. The Medical Device Interoperability Coordinating Council convinced that using data standards can prevent adverse events (AEs) and could save approximately $430 million per year for excluding long-term care expenditures (MDICC, 2013 and Saunders et al. 2013). Nachtmann and Pohl (2009) and Joseph (2013) indicated that lack of data standards in together with poor quality of information are the major barrier to reach an acceptable level of information sharing and collaboration among healthcare stakeholders.

Hence, to share consistent and up-to-date information relevant to pharmaceuticals across the entire HSC is crucial to all parties—from manufacturers to healthcare providers. In supply chain perspective, the characteristics of a pharmaceutical such as storage condition, packaging dimension or unit weight are important to logistics practitioners in term of operational efficiency, good storage and also distribution practice. In providing patient care provision, medical professionals also need pharmacological information such as active ingredients and substance, adverse drug reactions, indications as an input for better decision during the provision of care. The absence of information in any stages could introduce errors and lead to patient's harms. Therefore, the standard data is the significant contribution to operational efficiency that could effects to high health expenditure.

To summarize, these previous studies hint us that standard data sharing with good management play a key role in the emerging concept in healthcare supply chain. This strike us to explore more in two keywords; healthcare supply chain and information sharing and collaboration. According to Mustaffa and Potter (2009); Burns et al. (2002) and Shou (2013), they described that the typical healthcare stakeholders are manufacturers, logistics providers, healthcare providers and patients

or consumers. The diagram depicted for healthcare stakeholders illustrated in Figure 1.1.

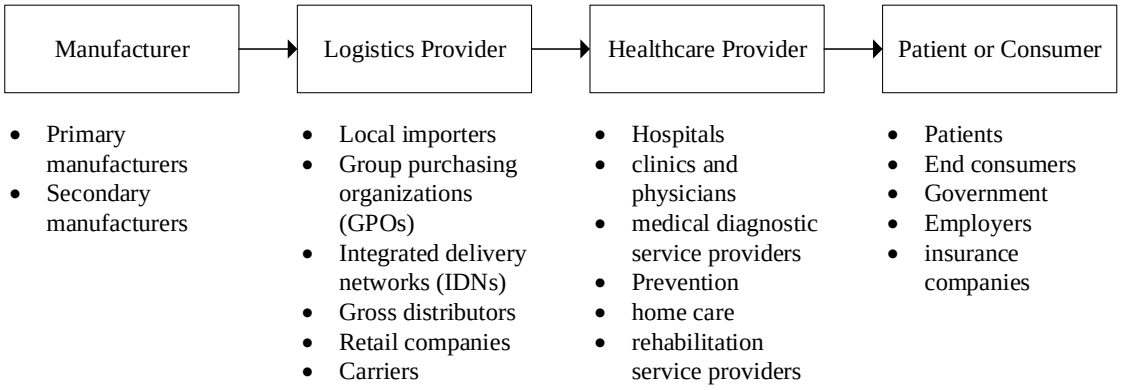

Figure 1.1: Diagram of a healthcare supply chain. Source (Adopt from Mustaffa and Potter, 2009; Burns et al., 2002 and Shou, 2013)

Manufacturer including primary and secondary manufacturers. The primary manufacturer refers to any manufacturers that involved in the production of active ingredients composed in a pharmaceutical. Meanwhile, the primary manufacturers act as a supplier of secondary manufacturers. After obtaining active ingredients, the secondary manufacturers are responsible for transforming active ingredients into consumable forms of pharmaceuticals such as capsules, tablets, solution and etc. In some cases, the secondary manufacturers obtains the intermediate pharmaceuticals into their production bases and packs it into consumable forms.

Then, a pharmaceutical can delivers to healthcare providers in 2 different channels: it distributes with manufacturer's vehicles adopting to a number of hospitals. There are number of manufacturers that handling transportation their own pharmaceutical products. This allows them to leverage margin on self-produced products to discount the distribution fee. This might solve the problem caused by the 3PLs logistics deliver the substituted products to the healthcare providers. In another channel, the distributor buys pharmaceutical products from secondary manufacturers and sells it to healthcare providers. Therefore, in this situation, both manufacturers and distributors are source of supplies for healthcare providers. However, as it occurs in

several cases, the distributor cut its inventory stocks according to reducing costs on carrying inventory. In case the stock-out occurs, the healthcare provider may be forced to switch to the readily available of supply sources of pharmaceuticals. Unlike other supply chains, stock out could increases the risk and may critical in providing patient care as there may be no alternative treatment for the patient. Discussion on healthcare provider's roles, it is functioned as both suppliers and customers of pharmaceuticals. The healthcare provider is the customer since it purchases pharmaceuticals. In the meantime, it also acts as a supplier; adding value to the flow of pharmaceuticals through the process of patient care provision (Dobrzykowski and Vonderembse, 2009).

Being this complex system, information needed in management practice by each stakeholder are various with varieties. However, none of the previous literatures illustrated that which information effected to increase operational efficiencies and enhance HSC collaboration within and across healthcare stakeholders.

1.2 Information Sharing in Healthcare Supply Chain

As described in section 1.1, Porter and Teisberg (2006) pointed out that the healthcare supply chain is a high complexity supply chain. Then, identifying stakeholder involves in healthcare supply chain is needed. Some researchers have studied the healthcare supply chain and focusing on its stakeholders and its particular features and characteristics. Mustaffa and Porter (2009) indicated four major types of players as mentioned in section 1.1. Gebicki et al. (2014) described that healthcare supply chain consisted of product suppliers, hospitals and patients. While Lawton (2002) and Woosley (2009) highlighted that healthcare supply chain has five stakeholders including ingredient supplier, manufacturer, distributor, hospital and patients. Rossetti and Liu (2009) identified that suppliers, logistics intermediaries, healthcare providers and patients are the major stakeholders in healthcare supply chain. Jennifer (2005) described that the participant in healthcare supply chain including supplier, distributor, hospital and patient. While Shah (2004) explained that the healthcare supply chain consisted of the one or more of the following nodes: ingredient suppliers, manufacturers, wholesalers and distributors, and retailers or

healthcare providers. Burns et al. (2002) stated that healthcare stakeholders composed of five main actors: healthcare producers, healthcare product intermediaries, healthcare providers, healthcare fiscal intermediaries, and purchasers. Burns et al. (2002) argued that the healthcare supply chain composed of patients, payers, healthcare providers, distributors and manufacturers. Rosetti et al. (2008) described the healthcare supply chain stakeholders includes manufacturers, logistics intermediaries, healthcare providers, patients and payers.

From literatures described above, in this study, all those stakeholders conceptual divided into three groups and composed of six major stakeholders. The conceptual healthcare stakeholders in this study explained as follows:

1. Prime stakeholder; this group of stakeholders is directly contacted with pharmaceuticals including manufacturers, logistics providers, healthcare providers and patients.

2. Payer or Reimbursement; this group of stakeholder is indirectly contacted to pharmaceutical products but they accountable for managing health expenditures. In some cases, they also a buyer of pharmaceutical products and supplies to healthcare providers and,

3. Regulator; this group of stakeholders is mainly involved in policy management, control or monitor the logistics of pharmaceutical products along the entire healthcare supply chain in Thailand.

Those healthcare stakeholders and their relationships are depicted in Figure 1.2.

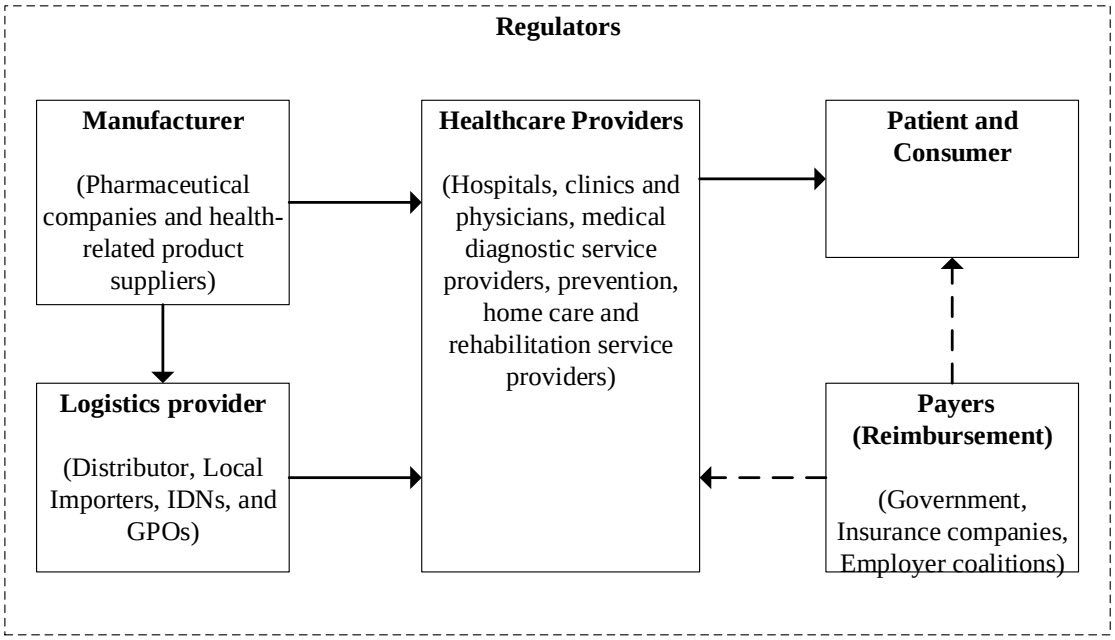

Figure 1.2: Healthcare supply chain stakeholder in Thailand

In Figure 1.2, the healthcare supply chain stakeholders and their participations could be described as follows;

Manufacturer	Includes pharmaceutical companies, biotech companies, medical equipment suppliers and health-related product suppliers.
Distributor	Includes group purchasing organizations (GPOs), integrated delivery networks (IDNs), gross distributors and retail companies, like pharmaceutical distributors, pharmacies and drugstores, and non-prescription drug retailers.
Healthcare provider	Includes hospitals, clinics and physicians, medical diagnostic service providers, prevention, home care and rehabilitation service providers.
Patient and Consumer	Includes physicians, patients, and end-consumers.
Regulator	Includes regulators, government, employers and insurance companies
Regulator	Includes government agencies responsible for control and monitoring of pharmaceutical product movement such as Food and Drug Administration, Thai Customs

In healthcare system, the supply chain process starts with secondary manufacturer blends active ingredients, adhesives, and favors from primary manufacturers in order to produce pharmaceuticals in consumable forms such as pill and liquids. Next, the pills or liquids are packed into secure packaging. The packages are then delivered to distributors or directly delivered to a number of healthcare providers. During the shipment, each package or bottle has been tracked along its movement to distribution center or hospitals. In the distribution center, the kitting, de-kitting and repacking may be occurred to meet healthcare provider's requirements. When pharmaceuticals arrived in the warehouse of healthcare providers, it has been tracked for the quantity for both inbound and outbound logistics, identifying the quantity, unit of measure and storage location. They are also tagged for the bottles or packages to ensure the pedigree of each pharmaceutical. In dispensing process, the pharmaceutical products are then supplied to patients at pharmacies or clinics or physicians, and also supplied at retail stores, and healthcare institutions. In the event of recalls or returns, pharmaceutical products make their way back directly to its manufacturers.

From the process described above, then the supply chain roles and responsibilities for each stakeholder in healthcare supply chain context could be summarized in Table 1.1.

Table 1.1 Role and responsibility of HSC stakeholder

Stakeholder	Roles and responsibilities in supply chain operations
Manufacturer	Responsible to produce, store, distribute and generate information pertaining to pharmaceutical products
Logistics provider	Responsible to aggregate a large number of demands from healthcare providers in attempt to leverage the economics of scale, store, repackage and re-label, creates and manipulate information to meet healthcare provider's needs, and eventually distribute into healthcare providers for the patients

Table 1.1 Role and responsibility of HSC stakeholder (cont.)

Stakeholder	Roles and responsibilities in supply chain operations
Healthcare provider	Responsible to store, consume the pharmaceutical products, provide patient care, fulfill patient needs and create and manipulate information to meet reimbursement needs
Patient and Consumer	Responsible to consume the pharmaceutical products
Regulator	Responsible to pay for the pharmaceutical products, manage, control and monitor the movement of pharmaceutical products

Firstly, the literatures are surveyed in order to ground understanding and explore information sharing among healthcare stakeholders. The process of conducting literature survey is begun on general context and later narrative to information sharing.

Hays and McLaughlin (2008) defined healthcare as a kind of service industries. Brown (1992) further explained the definition of service as it consumed at the moment of production and cannot be inventoried for use at a later time. Thonemann (2002) and Posey and Bari (2009) stated that information sharing and collaboration is a must to reduce cost, stock level and reduce bull-whip effect in any supply chains. This idea supported by Behzad et al. (2011), they mentioned that one of the significant issues that may increases cost in healthcare supply chain is the bullwhip effect; consequently leads to excess inventory as well as unused or overused inventory and also a serious supply and demand mismatches and deterioration in customer service level. In the study of Sahay (2003), he studied the collaboration between customer-supplier and presented the collaboration model for cost cutting. Xu et al. (2005) and Xu and Beamon (2006) suggested that a successful collaboration needs for the transparent availability of accurate and pertinent information in the right format to the proper users, at the right time to ensure that decision-making can be made in a timely manner. Dongsoo (2005) argued that one of the most important critical success factors towards added value in managing any supply chains is the facilitation of efficient and effective information sharing or collaborations among supply chain

stakeholders. Pagell (2004) identified that one reason for lacking of collaboration is caused from lacking of knowledge on how to transform collaboration into practice. Dutta and Bilbao-Osorio (2012) pointed out that the primary reason struggling the information sharing and collaboration is due to the lack of a solid underlying infrastructure to facilitate the collaboration, variety of IT systems and also interfacing standard data. Smeltzer and Ramanathan (2002) and Chakraborty et al. (2014) argued that IT systems is the key factor in any supply chain improvements, information sharing and collaboration. Uusipaavalniemi (2009) stated that guidelines to implement information sharing and collaboration is important in thus a complex supply chain.

Then an effort has been put to investigate the information needed for sharing among healthcare stakeholders. Firstly, supply chain roles for each healthcare stakeholder are reviewed. Generally, the overall process of production and distribution of pharmaceutical is similar to that of other supply chains; including purchasing, storage, inventory management, order management, billing and post-marketing supports or recalls. Each of those logistics activity utilized into category and presented in Table 1.2.

Table 1.2 Link logistics activity and information needs in supply chain operations

Logistics activity	Information needs
Purchasing	• Product name, its relevant information and also specifications such as product code, product name, forms, strength, marketing pack sizes, minimum order quantity and etc.
Purchasing	• Supply chain information such as name and address of manufacturers or distributors, ship-to location, handling instructions, and etc.

Table 1.2 Link logistics activity and information needs in supply chain operations(cont.)

Logistics activity	Information needs
Storage and Inventory management	• Product name, its relevant information and also specifications such as product code, product name, forms and etc. • Logistics information such as packaging weight, package size, barcode, storage conditions, handling instructions and etc.
Order management	• Pharmacological properties such as product name, its relevant information and also specifications such as product code, product name, forms, strength, marketing pack sizes and etc. • Supply chain information such as manufacturers, brand owners • Clinical information such as indications, contra-indications, route of administration and etc. • Logistics information and product characteristics and specifications such as package size, storage conditions, images and etc.
Billing	• Product name, its relevant information and also specifications such as product code, product name, forms and etc. • Logistics information and product characteristics and specifications
Safety and Surveillance	• Pharmacological properties such as product name, forms, strength, and marketing pack sizes and etc. • Logistics information such as package size, storage conditions, images and etc.

As a matter of fact, to utilize those groups of information, healthcare stakeholders depicted in Figure 2 tended to build their own databases for storing product relevant information subjected to their needs or utilization. Therefore, the majority of data attributes kept in databases mainly limit to their specific needs and may not useful to other stakeholder's needs. As mentioned earlier, the scientific and logistics data attributes are brought into critical objectives for all healthcare stakeholders. This idea supported by Sada et al. (2015); Woodward and Psych (2000) and Wuerdeman et al. (2005), they pointed out that the up-to-date information must be provided during the patient care provision, also the pharmaceutical relevant information must be utilized for ensuring product availability and system efficiency among healthcare stakeholders. However, from the section 1.2, it is suspected that some necessary information for healthcare supply chain collaboration is missing, and there are no collaboration and standardized format exist.

In Thailand, healthcare as a whole has two major pharmaceutical databases existed with divergent objectives according to its owners. These are FDA and Ya&You databases. Having analyzed each database structure and level of information details, both databases are unable to conform to each other. Table 3 presented the characteristics of these two existing databases. These databases are constructed based on different objectives and target for different users. Medical professionals could acquire pharmacological information via FDA database of the Food and Drug Administration. For patients and retail drug stores, they can perceive information of pharmaceuticals through simple understanding description from Ya&You database of PhaReD Foundation. The comparison of both existing databases is presented in Table 1.3

Table 1.3 National pharmaceutical databases in Thailand

Content	FDA Database	Ya&You Database
Information details	Pharmacological in writing format for pharmacists.	Mostly contains pharmaceutical indications or instruction of uses in simple description subject to public understanding, target users are end consumers
Main objective	To provide pharmacological and substance of registered pharmaceuticals according to FDA's requirements	To provide pharmaceutical relevant information mainly focusing on indications and instructions in case of adverse reactions
Target information user	Mostly information useful to manufacturers and pharmacists.	Patients, end consumers and retail drug stores
List of data attribute	Thirteen attributes including; • Registration number • Trade name (Thai) • Trade name (English) • Dosage form • Product classification • Legal category • Manufacturer's licensee • Manufacturer and address • Active ingredients • Strength and strength unit • License per invoice granted by Thai Customs	Nine attributes including; • Trade name (English) • Generic name • Dosage form • Indications • In case of AEs, information notified to the doctors or pharmacists • In case of AEs, instruction for mistaking pharmaceuticals • Adverse drug reaction (ADR) • Storage condition

Table 1.3 National pharmaceutical databases in Thailand (cont.)

Content	FDA Database	Ya&You Database
Limitation	Mainly of data attributes contains relevant information according to pharmacological properties.	Some data attributes related to pharmacological and clinical information in order to promote self-awareness of consuming pharmaceutical products.

Source: FDA database (2012) and PhaReD (2012)

Noticeably from the information needs of each healthcare stakeholder in particular with logistics activities in Table 1.2, comparing to these pharmaceutical databases, it indicated that almost data attributes in existing pharmaceutical databases are not sufficient. It is unable to provide sufficient information needed among healthcare stakeholders in the form of information sharing and collaboration particularly the logistics information.

1.3 Problem Statement and Research Assumptions

In section 1.2, it is noticed that information sharing and collaboration constructs from data standards, standard data attributes in order to increase operational performance in information sharing among healthcare stakeholders. Nevertheless, the preliminary study stated that no such a single database that contains data standards and standard data attributes has been occurred in Thailand. This affects directly on introduction of operational performance and efficiencies in healthcare supply chain. Hence, the foundation of infrastructure for exchanging information and collaborative of material and information flows is in need. Moreover, information sharing among healthcare stakeholders as well as collaboration tools supporting for visibility of pharmaceutical movement along the chain must be developed. From this, a single integrated datapool for pharmaceuticals could be a solution for data standards,

standard data attributes, and standard exchange data attributes among healthcare stakeholders. Then, our first assumption in this study is:

“an integrated datapool could lead to enhance HSC collaborations and operation performance improvement”

As a matter of fact, Nachtmann and Pohl (2009) indicated that lack of data standards and the integrity of data are the major barrier to reach an acceptable level of collaboration among healthcare stakeholders. This is supported by the study of Premier Healthcare Alliance (2009), they pointed out that healthcare supply chain is remained immature in level of information sharing and collaboration driven by lack of data standards and paper-based documents. In order to establish an information sharing and collaboration, it needs a well-defined foundation. This is because of the complexity of healthcare supply chain: numerous stakeholders being involved in many interactions and also the variety of pharmaceuticals. The relevant information of pharmaceuticals is a significant component in this datapool. This information must be standardized and shared across healthcare stakeholders. Then, the information sharing and collaborations can be achieved. Even though the supply chain interoperation flow can be achieved by the use of proprietary direct collations, one intermediate and standardized format could bring more efficient flows. Therefore, the second assumption is:

“**the data standards could lead to increase HSC collaboration and operation performance improvement”**

Next, in Chapter 2, literatures related to healthcare supply chain are reviewed particularly to explore the assumptions identified in this chapter. Furthermore, case studies that helped on constructing more rigid solutions according to the assumptions. Also, the research questions are derived from the assumptions in this chapter and the intervention improvement concepts proposed from the literatures.

Then, in Chapter 3, the research methodologies for providing the intervention improvement concepts are explained, in particular to the methodology for constructing this concept to reality are described.

Lastly, in Chapter 4, the data collection process to develop an integrated datapool will be clarified including data standards development, datapool attributes selection as well as datapool requirement and specification configuration.

CHAPTER II
LITERATURE AND EXISTING CASES REVIEWS

2.1 Healthcare Supply Chain

Mentzeret al. (2001) described that supply chain is the integration of information and logistics activities across stakeholders purposely creating and delivering products and services that provide value to consumers.Recently, the concept of supply chain management has become increasingly important as supply chain perspectives has led the industry to see through the process integration from upstream to downstream. Due to this strategy, it enhancedits stakeholders toexchange information and enhance collaboration in order to improve efficiency, productivity and cost savings of the entire supply chain. This idea supported by Turhan and Vayvay (2009), they mentioned that effective co-ordination among stakeholders played an important role in focusing on the innovation, flexibility and speed that bring about the competitive advantage necessary for survival in a competitive business world.

However, supply chain management become more complex in healthcare industry because of its stakeholders have to do highly accurate jobssince cost of errors might be someone's life (Mustaffa and Potter, 2009; Turhan and Vayvay, 2009). The Institute of Medicine reported on "*To Err Is Human: Building a Safer Health Care System*"that the preventable medication errors caused 44,000 to 98,000 preventable deaths each year, with an associated cost of $17 to $29 billion (Bleich, 2005).

In Thailand healthcare industry, supply chain concepts had been regarded partially adoption and unfortunately, the operations and co-ordinations across healthcarestakeholders have been neglected. It could be said that the supply chain concepts have just been introduced at an early stage. It could evidence that the HSC in Thailand still suffering from inefficient operations, waste time and costs, inconsistent and inaccurate information. This situation was supported by a leading public hospital's case study in Thailand.In that case study, it showed that they still lack of proper

inventory management and inefficient internal supply chain management (Kritchanchai and Suwandechochai, 2010).

Gattorna (1998) describedthehealthcare sectoras it is provided by variety of products such asmedical consumables, pharmaceuticals, catering, laundry cleaning, waste management, home-care products, information technology, vehicle fleet management, general supplies and etc. This idea supported by numerous researchers that healthcare supply chain wasa complex networks consisting of many different stakeholders at various stagescreating value along the entire chain (Kritchanchai and Suwandechochai, 2010; Rossettiet al., 2008; Mustaffa and Potter, 2009; Turhan and Vayvay, 2009; Burns et al., 2002).

2.1.1 Healthcare Supply Chain Insights

The healthcare industry has viewed itself as operates differently from other industries. Gibbons (2009) stated for information quality, he mentioned that making decision based on poor or inaccuracy information resulted in ineffective patient care provision which negatively affects to the outcome of treatment for patients and hospitals with significant avoidable costs.The study regarding to implanted medical devices in Shanghai stated that three major aspects lead to traceability problems. Firstly, information recorded during the process was inaccurate. Secondly, manufacturers hardly collect the actual use data from hospitals so that they are not able to fulfill their post-market responsibilities. Thirdly, the information pertaining to IMD used was not transparent so that it is really hard to protect patient safety, rights and interests(Yan, 2009). This study is supported by the report of European expert group. They studied on safe medication practices in2007 andpresented that the medication errors occurred in European countries caused by sound-alike or look-alike pharmaceutical names, similarities in the outer appearance of pharmaceuticals' packages and labeling as well as unclear or incomplete labeling information (Cheung, 2009).

In the United States, healthcare industry was also suffered from inconsistent and inaccurate product related information which negatively impacts to the rest of supply chain. Each year more than $11 billion of waste has been spent due to inefficient process, purchase order and invoice errorsthrough outdated IT

systems(Pleasant, 2009). This is similar to NHS, one of the biggest healthcare provider in United Kingdom, they faced the difficulty regarding to the lack of data standards. There are too many data silos. Whiledata was available in a large volume whereas quality information is in short supply. From the NHS databases, it contained 130 different descriptions of one single product. Due to this problem, it means that the analysis of expenditure and demand requirement across their organizations is very costly in term of process time and resources (Gibbons, 2009).

Worse, HSC existedwith highly fragmented IT systems in which manufacturers, distributors, and hospitals operate independently from one to another IT system. Dobrzykowski and Vonderembse (2009) and Burns et al. (2002) argued that these fragmented IT systems lead tomorecomplicated tasks of connection due tothousands of stakeholders involved at every stagesalong the chain. Burns et al. (2002) addressed that mainlyof stakeholders in HSC still lack on coordinated effort, strategic alliance formation and knowledge sharing. Reidet al. (2005) and Gibbons (2009) statedthat healthcare industry was an information intensive or data-driven environment and the availability of qualified information is essential for the delivery of safe and effective patient care provision. Due to lack of information sharing, the supply chain acts more to push products down the chain rather than pull them from the customer (Burns et al., 2002). DeScioli(2005) has also argued for current, aggregate and “one-size-fits-all,” strategies are inappropriate and discussed for the importance of adding more data attributes to the product master files to enable further supply chain enhancement.According to the push strategy, the Orthopaedic Centre’s supply model, where stock is held on consignment, was hugely inefficient and manufacturers are typically applying a 15 to 20% on cost as a result (Medwell, 2009).

In addition, it indicated that those inefficient processes resulting on poor operational productivity and increasing on operating costs in term of purchasing, distribution, and management of supplies. Kumar et al. (2008) stated that the inefficient processcost one third of the operating costs in a hospital. The Glaxosmithkline, one of the pharmaceutical companies, highlighted that enabling hospitals to manage their inventory in their warehouses made them unable to handle changing demand and higher on shipment costs due to inefficient planning to suppliers determining their production capacity (Danese, 2004). The Chapel

AllertonOrthopaedic Centre in United Kingdom had an inefficient inventory management so that it contributed to overstock problems (Medwell, 2009). The center spent on inefficient inventory management exceeds £3 million per year (Medwell, 2009). The problems found in healthcare supply chain worldwide are illustrated in Table 2.1.

Table 2.1Problem in healthcare industry

Study	Highlighted key findings	Problem category
McGrath and More (2001)	Poorly integrated information systems	• Data inconsistency • Fragmented IT systems
Burns et al. (2002)	All stakeholders in healthcare industry still lack on coordinated effort, strategic alliance formation and knowledge sharing	• Data inconsistency • Fragmented IT systems
Danese (2004)	The traditional customer managed inventory leads to the inability to meet changing demand pattern and increased transportation costs	• Data inconsistency
EFPIA (2008)	Medication errors occurred in European countries caused by sound-alike or look-alike pharmaceutical names, similarities in the outer appearance of medicines' packages and labeling as well as unclear or incomplete labeling information	• Data inconsistency

Table 2.1Problem in healthcare industry (cont.)

Study	Highlighted key findings	Problem category
Dobrzykowski and Vonderembse (2009)	A fragmented system in healthcare industry limited communication among all parties	• Fragmented supply chain systems
Gibbons (2009)	Decision based on poor quality information provides ineffective healthcare services which negatively affects the outcome of treatment for patients and provide to the healthcare providers with significant and avoidable costs	• Data inconsistency
Medwell (2009)	The Chapel AllertonOrthopaedic Centre (CHOC) experienced high stock levels and system integrity	• Fragmented IT systems
Pleasant (2009)	In the US, healthcare industry also suffers from inconsistent and inaccurate product information which negatively impacts the rest of supply chain	• Data inconsistency
Yan (2009)	Traceability problems in Implanted Medical Devices (IMD) in Shanghai	• Data inconsistency

From Table 2.1, it seen that the highlighted problems in healthcare supply chain are data inconsistency and fragment IT systems among its stakeholders. Noticeably, these problems are inter-related. Data inconsistency leads to fragmented IT systems. In the meantime, fragmented IT systems also result in data inconsistency as well.

2.1.2 Healthcare Supply Chain Improvements

According to the current situation described in Section 2.1.1, then another perspective of literaturesand case studieswere investigated to seek how healthcare stakeholders adopt the strategy to alleviate these problems and improve their operational performance. To improve operational performance and enhanceHSC collaborations, data standards is of concerns.

Kreysa and Denecker(2009) stated that implementation of data standardsin any supply chains contribute to information synchronization so that all supply chain stakeholders are able to speak the same language. This idea was similar to European Federation of Pharmaceutical Industries and Associations (EFPIA)'s report, they argued forEuropean countries have experienced implementing data standardization (EFPIA, 2008). Each country has developed and implementeda coding system to identify pharmaceuticals for enhancing logistics performance at aninitial stage, currently, this coding system has extendedfor administrative as well (EFPIA, 2008). In 2007, an American Healthcare Industry Provider(AHIP), announced a single Unique Device Identification (UDI) system in the U.S. medical devices and regulated their suppliers to affix certain standards in sourcing process (Pleasant, 2009).

In addition, the Shanghai Food and Drug Administration implemented the traceability systemof implantable devices such as high-risks devices such as orthopedic internal fixation devices, orthopedic implants, synthetic crystals, breast implants, and pacemakers, more than hundred hospitals in Shanghai involved in this project (Yan, 2009). In Australia, the pharmaceutical supply chain was adoptedGS1 data standards for enabling e-commerce business(McGrath and More, 2001).To improve safety and reduce errors, Altmanet al., 2004; Jayaramanet al.,2011; and Jayaramanet al.,2015noted on development of data standards for patient safety information, establishment of a national health informationinfrastructure, and

comprehensive patient safety programs in healthcare organizations.Zirkleet al. (2012) suggested that it is the time for healthcare stakeholders to follow the steps of leading organizations and begin preparing their supply chains for standards adoption.The Pharmaceutical Extranet Gateway (PEG) provided a single common electronic ordering system that allows pharmaceutical wholesalers and suppliers to transact their business through the internet with the use of a common GS1 barcoding system or standardized numbering system (McGrath and More, 2001). The NHS in United Kingdom stated that the implementation of common data standards across the procurement and commercial systemenables information to easily transfer betweenthe IT systems. This enables interoperability between IT systems, allowing automation which reduces the number of resources, removes human errors, increases compliance and reduces risks (Gibbons, 2009).

Additionally, Gibbons (2009) highlighted that more effective process andbetter relationships could provide a higher quality supply chain. To enable the effective process leading for delivery of high quality information on the demand and supply sides, Rossetti (2008) recommended that the healthcare network must be able to exchange data or share information. Currently, hospitals attempted to integrate upstream with the manufacturers, wholesalers and distributors (Rossetti, 2008). For instance, after implementation ofeProcurement system at the NHS, it provided them with important opportunities to significantly enhance their capacity to manage procurement information, improve its commercial and procurement processes and also remove waste and duplication (Gibbons, 2009). In Australia, the Project Electronic Commerce and Communication for Healthcare (PeCC) is developed to introduce e-commerce practice in the healthcare industry with almost 700 suppliers, automating collation processing their pharmaceutical and other medical supplies to hospitals. In last recent years, the communication in supply chain was majority operated via an internet-based platform in order to createhigher efficient partnerships among the medical retail stores, pharmacies, wholesalers, suppliers and manufacturers (McGrath and More, 2001). In China, the Shanghai Food and Drug Administration launched thetraceability system of implantable devices. This system helpedhospitals on reporting the related information for the use of implantable devices via an internet-based platform. Then, the manufacturers could retrieve information regarding to the

use of their implantable devices. This data enhanced the traceability of implantable devices for post-market safety (Yan, 2009). The Leed teaching hospital worked with their suppliers through GHX, one of the e-commerce company, to capture theirsupply chain supply chain. Based on those implementation, the hospital received many benefits such as financials, better clinical information, cost cutting, and these implementation also brought the shared-benefits to suppliers and supply chain as the whole (Medwell, 2009).

It noticed that the product relevant information was critical in patient care provision and also impact to quality of care. Therefore, hospitals strived to implement the information and communication system (ICT) so as to enable their patients to access information easier than before. The subject of e-health service is a massive one. Dean(2003) illustrated for the NHS Direct cases, NHS has developed a website and granted access to medical advice and information. This website could enhanced awareness for their patients on consuming pharmaceuticals (Gann, 2003). In Sweden, telemedicine has implemented for over a hundred IT systems. One of the most advance in telemedicine area was radiology, the x-ray tomography and magnetic camera images were shared among radiologists for consultation (Eriksson, 2003). This manner enhanceda horizontal integration among hospitals, private clinics, and private radiologists. The radiologist from the entire Nord Pas de Calais region have decided to participate in order to exchange x-ray tomography information (Hansske, 2003). In the study of Hansske (2003), hehighlighted some concerns on protecting confidentiality and user's perceptions may pose threat to information sharing and also collaboration.

Germany was taking the first step to develop and implement a nationwide telematic infrastructure. The major benefits will spring mostly from the integration of ERP systems and the development of integrated data flow that supports to centralize patient care information (Mainz, 2003).Similar to Italy, Servizio Sanitario Nazionale, the national healthcare service has developed the new national healthcare IT systems (NSIS) taken place in the context of gradual change. The NSIS would become a "connectivity backbone" between regional IT systems which empower the SSN more efficient and also delivering better services to the individual (Bergamachi, 2003). Kaiser Permanenete, the largest non-profit health maintenance organization in the United States with 8.4 million members nationwide which signed a £1.6 billion

contract in early 2003 for a highly pervasive electronic health record system (Mori, 2003).

As described above, the intervention improvements in healthcare supply chain could be summarized as data standardizations was the backbone to increase information sharing and HSC collaboration. These intervention improvements were illustrated in Table 2.2.

Table 2.2Intervention for HSC improvements

Study	Highlighted key findings	Intervention category
McGrath and More (2001)	PEG provides a single common electronic ordering system that allows pharmaceutical wholesalers and suppliers to transact business through the internet with the use of a common EAN-based bar coding or standardized numbering system	• Information sharing and HSC collaboration • Data standardization
Bergamachi (2003)	The development of the new national healthcare information systems (NSIS) in Italy	• Information sharing and HSC collaboration
Dean (2003)	Healthcare providers implement information technology so as to enable their patients to access information easier	• Information sharing and HSC collaboration
Eriksson (2003)	Telemedicine has been tested and/or used in over 100 applications in Sweden	• Data standardization

Table 2.2Intervention for HSC improvements (cont.)

Study	Highlighted key findings	Intervention category
Gann (2003)	NHS Direct has implemented a website to provide clinical advice and information	• Information sharing and HSC collaboration • Data standardization
Hansske (2003)	Develop an internet-based platform for consultation onx-ray information among radiologists	• Information sharing and HSC collaboration
Mainz (2003)	Integrate ERP system with data flow to support patient-centered care information	• Information sharing and HSC collaboration
Mori (2003)	Implementing EHR program in United States	• Information sharing and HSC collaboration • Data standardization
EFPIA (2008)	European countries have experienced in implementing standardization	• Data standardization
Gibbons (2009)	The implementation of common data standard across the procurement and commercial systems by NHS trusts in United Kingdom with information transfer between systems	• Information sharing and HSC collaboration • Data standardization
Rossetti (2008)	Healthcare providers strengthen relationship and integrate information vertically upstream with its suppliers	• Information sharing and HSC collaboration

Table 2.2Intervention for HSC improvements (cont.)

Study	Highlighted key findings	Intervention category
Medwell (2009)	The Leed Teaching Hospital works with the suppliers through GHX, the healthcare e-commerce exchange provider, to enrich the data used throughout the supply chain	• Information sharing and HSC collaboration
Kreysa and Denecker (2009)	The implementation of GS1 standards in healthcare industry	• Data standardization
Pleasant (2009)	The premier healthcare alliance implements global standard in order to improve its operational performance	• Data standardization
Yan (2009)	The tracking system plays a crucial role in addressing the post-market surveillance of those high-risk medical devices	• Information sharing and HSC collaboration • Data standardization

The intervention for HSC improvementsgathered from literatures above can be mapped with the problems highlighted earlier in Table 2.1. It indicated that data standardizations can be a platform for the consistency of data. Information sharing is the way for bridging between fragmented IT systems and HSC collaboration enhancement. The mapping between problems and intervention improvements for the entire HSC is illustrated in Figure 2.1.

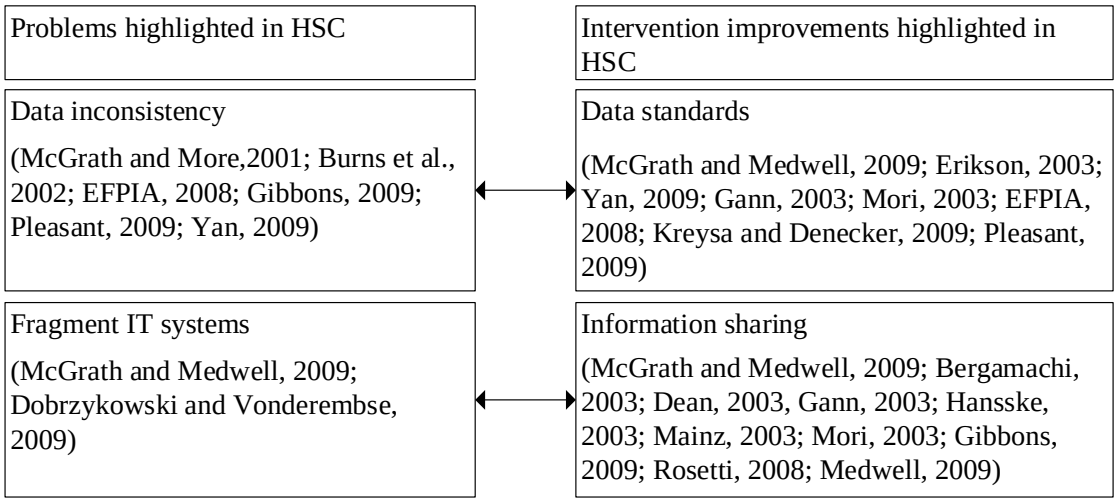

Figure 2.1: Problems mapping to the intervention improvements in HSC

2.1.3 Literature Analysis

It could be seen in literatures that information sharing is the initial step of HSC collaboration and can be achieved by the integration of data. The literature and case studies presented common practices in pooling the product-related information needed among healthcare stakeholders into one integrated system.

Bergamachi (2003), Gann (2003) and Gibbons (2009) explicitly indicated the use of national healthcare IT systems in Italy and United Kingdom. Hansske (2003), Mainz (2003) and Mori (2003) mentioned on implementing a local datapool application according to their uses of data. Gibbons (2009), Rossetti (2008) and Medwell (2009) indicated the application of a single integrated pool of data across supply chain stakeholders.On the other hand, the consistence of data can be achieved by data standards begin with standardized product identification and product-related information pertaining to a pharmaceutical. McGrath and More (2001), Kreysa and Denecker (2009) discussed the GS1coding system for product identification in healthcare at the supply chain level. This is supported by Pleasant (2009) and Yan (2009), theyrecommended the use of global standards to coordinate data at operational level as well as track and trace systems. Importantly, most of the literatures and case studies indicated the need of data standards to construct the datapool forincreasing level of information sharing and collaborations among healthcare stakeholders.

Considerably together with the background of healthcare supply chain described in Chapter 1.Next, problems, supply chain impacts and proposed solutions to overcome these problems are presented in Figure 2.2.

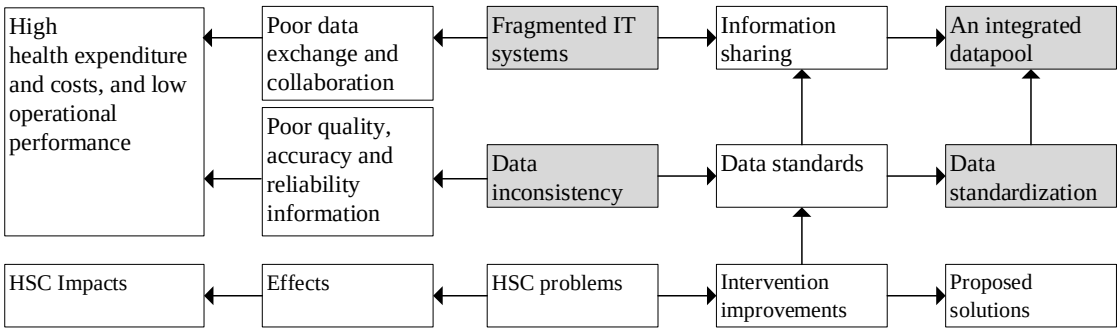

Figure 2.2: Links problems, effects and solutions in HSC

In Figure 2.2, it could be described that the fragmented IT systems among healthcare stakeholders cause poor information exchange and collaboration while data inconsistency resulted in poor informationquality. Both problems were one of the primary factors lead to higher health expenditureand supply chain costs.On the other hand, the fragmented IT systems could be solved by formulating astandardized infrastructure supportingfor information sharing among healthcare stakeholdersresulted in HSC collaboration enhancement. In the meantime, data standards could solved the data inconsistency problems. It purposed that the information sharing can be achieved by implementing an integrated datapool. The data standards could be the mean to achieved data standardization which is the essential foundation for the building block of an integrated datapool.

In the next section, theintervention concepts were developed based on literature and case studies reviewed and then proposed for this study.

2.2Information Sharing and Data Standards

From the literatures above, it convinced to the assumptions: "*an integrated datapool in together with data standards could lead to enhance HSC collaborations and operation performance improvement*"as described in Chapter 1. In this section, the literatures and case studies are reviewed for developing an intermediate form in

order to provide the concepts of operational performance improvement and HSC collaboration enhancement. The information sharing using the datapool are reviewed and the data standards applied in case studies are presented.

2.2.1 Information Sharing through the Datapool

Wickramasinghe(2013)stated that implementing of information sharing is visibility, common, acceptable, comprehensive and well-defined information structure are crucial to facilitate efficient information sharing, integration, and collaboration among healthcare stakeholders. However, the information pertaining to apharmaceutical is very dynamic and highly impacts to someone's life. The huge amount of information has been compressed in any pharmaceuticals and these information may be changed from time to time according to any new information found such as ADEs, safety updates and surveillance information etc.

To draw the HSC stakeholder map in Thailand, an attempt was made to tie the relationship between participants, in associated with the HSC definition described by Mustaffa and Potter (2009) and Burns et al. (2002) are taken into account, as illustrated in Figure 1.1 and Figure 1.2 in Chapter 1. Therefore, thestakeholders map modeling forHSC in Thailand is proposed in Figure 2.3.

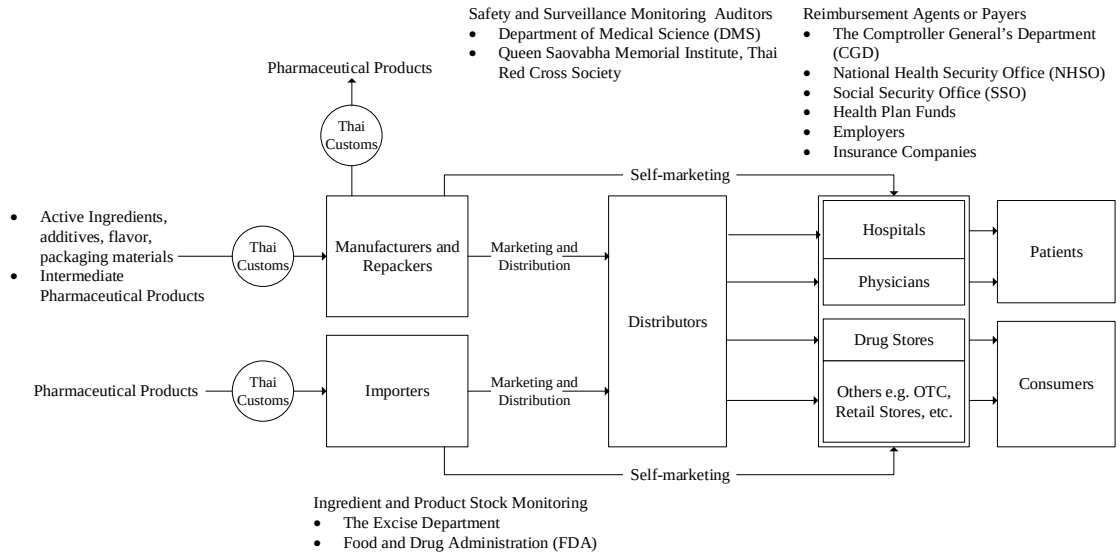

Figure 2.3 Thailand HSC stakeholder map

Before producing or importing a pharmaceutical to trial use or market in Thailand, the manufacturer and importer are regulated tosubscribe for licenses from the Food and Drug Administration.In this stage, the pharmaceutical's physical packages and also its relevant informationsuch as active ingredient, additive ingredient, packaging materials, etc. are declared for authorization. In case, the product is approved based on FDA's criteria, alicense number is granted so call "FDA's registration code". Only licensed pharmaceutical products can be produced, imported, trial use and market in Thailand.

In case of imported pharmaceuticals, the importer needed to declare all ingredients, intermediated and finished products to the Thai Customs for tariffs clearance. Here the license per invoice numberwas granted from time-to-time and information related to product name, description, volume of imported or exported and so on are recorded.However, ifthose ingredients, intermediate and pharmaceutical products contains or compose of additive substances, the manufacturer and importer needed to declare its composition and volume to Thai Royal Police. This was similar to The Excise Department; the ingredients, intermediate and pharmaceutical products contains or compose of controlled substances such as sugar and alcohol are needed to be declared as well.

Then, thepharmaceutical products were delivered through distributors and healthcare providerssuch as hospitals, physicians, retail stores, pharmacy shops and etc. For the movement of pharmaceuticals,all healthcare stakeholders reportedits inventory availability to the Food and Drug Administration on regular basis. It noticed that the information related to pharmaceuticalswereimportant in every stages along the entire HSC. Each healthcare stakeholder may needs different information. However, some of them are commonly use such as product identification, lot number, expiry date, etc. for their daily transactions.In hospital's point of view,the pharmacological and clinical informationwere significantimportant during the patient care provision. Discussed to distributors, they also needed information regarding to logistics information such as barcode, storage and handling instructions, package dimension, product weight, and so on. Furthermore, patients and end consumers; at the end of supply chain are needed information regarding toindications and instructions of use. Apart from that, the payer including government, employers, insurance companies are

also needed the information related to their health expenditure reimbursement. According to information describe above, it stated that information related to a pharmaceutical product is very concerned and needed along the entire supply chain from point-of-origin through the point-of-consumption.

To understand information needed in each healthcare stakeholder, the information used ineach healthcare stakeholder transactionsare reviewed. The product relevant information needed by each stakeholder are identified in Table 2.3

Table 2.3 The information needed by HSC stakeholders in Thailand

Stakeholder	Information needs
Manufacturer, Distributor	• Trade name • Presentation unit • Unit conversion • Barcode number and symbology • Storage condition • Unit weight • Unit volume or content • Packaging dimension
Manufacturer, Distributor	• Image or presentation • Manufacturer • Shelf life from Production • Handling instructions
Healthcare Provider	• Trade name • Generic name • Dosage Form • Route of administration • Active ingredients or substance • Strength and Strength unit • Manufacturer

Table 2.3 The information needed by HSC stakeholders in Thailand (cont.)

Stakeholder	Information needs
Patient, End consumer	• Indications • Contraindications • Dosage • Overdosage • Adverse drug reactions • Drug interactions • Administrations • Precautions • Special precautions • Pregnancy category • Picture of product
Patient, End consumer	• Trade name • Indications • Dosage • Overdosage • Adverse drug reactions • Administrations • Precautions • Special precautions
Food and Drug Administration	• Trade name • Generic name • Dosage form • Route of administration • Active ingredient or substance • Strength and strength unit • Manufacturer • Distributor

Table 2.3 The information needed by HSC stakeholders in Thailand (cont.)

Stakeholder	Information needs
Thai Customs	• Unit volume or content of products • Start and end marketing date • Importer license number, name and address information • Product name • Package dimension • Gross weight • Imported quantity/unit • Unit price • Manufacturer and Country of origin • Harmonization code • Registration code granted by the Food and Drug Administration • Marketing date • Harmonization code and harmonize group description
Royal Thai Police	• Trade name • Unit of production or import • Production or import unit of measure • Production date or Import date
Royal Thai Police The Excise Department	• Manufacturer or Importer name and address • Product Availability • Trade name • Unit of production or import • Production or import unit of measure • Production date or Import date • Manufacturer or Importer name and address

Table 2.3 The information needed by HSC stakeholders in Thailand (cont.)

Stakeholder	Information needs
The Department of Medical Science, Queen Saovabha Memorial Institute	• Product Availability • Registration code granted by the Thai FDA • Generic or Trade name • Dosage Form • Active ingredient or substance • Production lot and Expiry date • Manufacturer or Importer name • Source of adverse events occurred • Report of incidences
The National Health Security, The Comptroller General's Department	• Generic name • Dispensing quantity and unit of measure • Product cost • Dispensing date • Manufacturer or Importer name

From Table 2.3, it indicated the variety of information needed among healthcare stakeholders. Compared to existing pharmaceutical databases, there are only two pharmaceuticaldatabasesnamely "FDA" and "Ya&You". Both databases provided information strictly to pharmacological and clinical information. Unfortunately, the information resisting in both databases are subjected to specific users. Additionally, the information related to logistics and supply chain operationsare not included. Therefore, it brought us to review further on the worldwide healthcare databases in order to investigate readiness pharmaceutical databases. It can be seen that among internationalhealthcare databases, it provided information in 3 categoriesas follows:1)pharmacological information regarding to ingredients, dosage forms, composition and etc., 2)clinical indications for medical treatments and use and, 3)logistics informationrelated to product name, unit of measure, storage conditions and etc. The information of each group further explained as follows: the pharmacological

information deals with the proprietary of pharmaceutical products, while the clinical information provides information regarding totherapeutic indications for use in patient care provision. Additionally, logistics information dealing with handlings and storage conditions that are effected to logistics operationperformance and supply chain collaboration. Among these information, there are some from pharmacological and logistics information important in exchanging information between healthcare stakeholders.

The informationpertaining to pharmaceutical productsdescribed inFDA and Ya&Youdatabases, in together with the informationreviewed from international databases are presented in Table 2.4.

Table 2.4 Pharmaceutical information in International Databases

Database	Data attributes
FDA	• Trade name • FDA classification • Dosage form • Active ingredient or Substance • Strength and Strength unit • Brand owner and address • Registration code • Indications
MIMS https://www.mims.com/Thailand/home/index	• Trade name • Generic name • Unit volume or content of products • Dosage form • Active ingredient or Substance • Strength and Strength unit • Manufacturer • Actions

Table 2.4 Pharmaceutical information in International Databases (cont.)

Database	Data attributes
	• Indications • Contraindications • Dosage • Overdosage • Administration • Precautions • Adverse reactions • Drug Interactions • Cautions for usage • Pregnancy category • Nomenclature • Storage conditions • Image or presentation of products
NDC, United States http://www.accessdata.fda.gov/scripts/cder/ndc/	• National Drug Code • Trade name • Registration unit • Active ingredient or substance • Strength and strength unit • Route of administration • Manufacturer • Brand owner • Start and end marketing date
MIMS https://www.mims.com/Thailand/home/index	

Table 2.4 Pharmaceutical information in International Databases (cont.)

Database	Data attributes
NDC, United States http://www.accessdata.fda.gov/scripts/cder/ndc/	• Registration code • Trade name • Manufacturer • Nomenclature • Active ingredient or Substance • Strength and strength unit • Start and end marketing date • Dosage form • Route of administration
NPC, NeTHA Australia	• Identification code • Trade name • Dosage or prescription unit • Unit volume or content of products • Manufacturer • Brand owner • Barcode • Image or presentation of products • Packing instructions • Unit weight • Packaging dimension • Storage conditions • Shelf life from Production

Table 2.4 Pharmaceutical information in International Databases (cont.)

Database	Data attributes
ECCnet, CareNET Services Inc.	• Identification code • Trade name • Dosage or prescription unit • Manufacturer • Barcode • Packing instructions • Weight • Volume or Content • Packaging dimension
Ya&You, PhaRED Foundation	• Trade name • Generic name • Dosage form • Instruction for use • Precautions • Indications • Overdosage • Adverse reactions • Storage condition

From Table 2.4, all information or data attributes are analyzed according to its objectives and functionsincludeusing for providing pharmacological properties, therapeutic indications and product storage purposes. Finally, all data attributes can be categorized into three categories as follows; pharmacological, clinical and logistics information.

Due to healthcare is specialty supply chain. Hence, to describe data attributes, the namingconvention and meaningprovided bythe Food and Drug Administration are used to describe pharmacological and clinical information. In case

of logistics information, the meaning provided by GS1 are accounted.Therefore, the meaning of data attributesare described in Table 2.5.

Table 2.5 Pharmaceutical product information

Data attribute	Meanings
Pharmacological information	
Registration code	Indicates the registration code assigned by the FDA to a pharmaceutical product.
Trade name or trademarks	Indicates the trade or brand name under a proprietary, trademark-protected which the pharmaceutical product is marketed.
Generic name	Indicates the generic name or active ingredients of pharmaceutical products.
Dosage form	Indicates the physical form in which a drug is produced and dispensed e.g. tablet, capsule, powder, etc.
Chemical structure	Indicates the composition of pharmaceutical products
Actions	Indicates the pharmacodynamics and pharmacokineticson the human body
Dissolution	The act or process of resolving or dissolving of pharmaceutical chemical into parts or elements
Route of administration	Indicates the way of administering a drug to a site in a patient e.g. oral, topical, intramuscular, rectal, etc.
Dosage or prescription Unit	Indicate the unit of measurement of the lowest level of drug formulation hierarchy intended or labeled for individual presentation forms e.g. tablet, capsule, etc.
Active ingredient or substance	Indicates the component that provides pharmacological activity in the diagnosis, cure, mitigation, treatment, or prevention of disease, or to affect the structure or any function of the body of man.

Table 2.5 Pharmaceutical product information (cont.)

Data attribute	Meanings
Strength and strength unit	Indicates how much of the active pharmaceutical ingredient is presented in a dosage unit e.g. 5 millilitre [mL] or 15 mL.
Nomenclature	Nomenclature is the classification of pharmaceutical products regarding to ATC and AHFS schema
Clinical information	
Indications	Indicates those diseases, signs and symptoms that may be treated by using a specific pharmaceutical product.
Contraindications	Indicates those conditions, physical, mental or emotional state as well as other signs and symptoms which may be present where a specific drug should not be used.
Dosage	Guideline the amount of drug taken at any one time. This can be expressed as the weight of drug (e.g. 250 mg), volume of drug solution such as (e.g. 10 mL, 2 drops), the number of dosage forms (e.g. 1 capsule, 1 suppository) or some other quantity (e.g. 2 puffs)
Overdosage	Describes the ingestion or application of a drug or other substance in quantities greater than are recommended or generally practiced.
Adverse drug reactions	Guidance an expression that describes harm associated with the use of given medications at a normal dosage during normal use.
Drug interactions	Guidance the effects, either beneficial or harmful, that may arise from the mix of chemicals from different substances.

Table 2.5 Pharmaceutical product information (cont.)

Data attribute	Meanings
Administrations	Indicates the way the dosage form is given. Common routes of administration include oral, rectal, inhalation, nasal and topical.
Precautions	Describes related to a specific drug serves as notice to inform the patient that there may be risk in using the drug in certain diseases or medical states.
Special precautions	Guidance for professionals in making appropriate decisions about drug therapy in pediatric, geriatric, pregnant, or lactating patients.
Pregnancy category	Recognize drug therapy that may not be appropriate for pregnant women
Logistics information	
Presentation unit	The form of presentation in which drugs are formulated and supplied e.g. tablet, box, bottle, and etc.
Unit conversion	The numerical factors that enable to perform transactions in units other than the prescription unit of the drug being transacted e.g. a box contains of 100 tablets.
Barcode number and symbology	A numeric barcodes used to uniquely identify presentation form of pharmaceutical products and its symbology of barcode marked.
Storage condition	Guidelines for temperature control of pharmaceutical products during storage and transportation.
Unit weight	A weight unit of measurement e.g. gram, kilogram and etc.
Unit volume or content	The volume for one presentation unit of the pharmaceutical products e.g. 60mL, 120mL and etc.

Table 2.5 Pharmaceutical product information (cont.)

Data attribute	Meanings
Packaging dimension	A dimension unit of measurement e.g. millimeter, meter and etc.
Image or presentation	Attach the images of product packages.
Brand owner	Indicates the name and address of brand owner of pharmaceutical products
Manufacturer	Indicates the name and address of manufacturer of pharmaceutical products
Distributor	Indicates the name and address of distributor of pharmaceutical products
Start and end marketing date	Indicates start and end marketing date of pharmaceutical products
Shelf life from Production	The number of days of pharmaceutical products after production
Handling instructions	The instructions on handling or transport of pharmaceutical products

2.2.2 Data standardizations

In the study of Bissiriou andChaou(2014); Charlebois et al.(2014); Ben-hai et al.(2010) and Opara (2002), all of them stated that theuniqueidentification is essential in order to track and trace product movement in any supply chain networks. Of that, some researchers pointed out the important of standard identification codes. For instance, GS1 (2015) and Rosa (2015) argued that the National Fisheries Institute encouraged the adoption of GTINs for product identification and barcodes with extended product data for electronic sharing of product identification information between stakeholders.

Potocher et al. (2012) have studied in seafood supply chain, they recommended product identification at production batch level. Cimino and Marcelloni (2012) have studied collaboration on winery supply chain and stated for the need of

product identification is term of fundamental requirements of winetraceability. There are some researchers have studied product traceability in meat, beef and also food supply chain and highlighted the important of unique identifications (Charlebois et al., 2014; Ben Hai et al., 2007; Sun et al., 2007; and Ben-hai et al., 2010). This is argued by Yordanovand Angelova (2006) and CAPI (2012). They have studied the meat and meat product traceability in its supply chain networks and raised that to identify meat from farm to pork requiredanimal identification code and carcass body identification code.This idea supported by McEntire (2012), she studied food supply chain and pointed out that the fruit ID, origin, and information datapool are needed to increase operation efficiency and supply chain collaboration. Joshi (2000) stated that unique product identification is a building block for information visibility and data exchange in supply chain.Moreover, Moe(1998) stated for the basic component of traceability system composed of product identification and essential information describing that particular product such as type, form, proximate analysis and quality attributes. While Ilie-Zudor and Kemeny (2009)have studied on tracking products in changing environment and they indicated that each product must be given its own globally unique identification code. This identification code is the primary key to connect the product individual to its information.

From literature above, it stated that unique identification code is mandatory to track and trace product movement in any supply chain networks. Of that to HSC, in order to operateefficientinformation sharing and collaboration among healthcare stakeholders, first of all, a standard identification forpharmaceutical products must be presented in order to increase level of information sharing and collaboration resulted in enabling track and trace its movement through the entire HSC.

In Thailand HSC context, several product identifications are existed and in use to identify pharmaceuticals. As mentioned in the section 2.2.1, the pharmaceuticals are under heavily controlled by government regulations. Therefore, all pharmaceuticals that are manufactured or imported for trial use and marketinThailand needed to get authorization prior start its trial use and marketing. From this, the first and foremost product identification is the FDA’s registration code. Its structure can be varied from 4 to 11 digits in order to identifyproduct classification,

clinical status and licenseddate in Buddhist Era. The main purposes are to provide pharmacological properties and prevent product sub-standard or counterfeits. Therefore, mainly of information are rigid to substance or active ingredients, dosage forms, and owners of pharmaceutical products.

Furthermore, in Thailand, majority of health expenditure is funded by the government, so that several product identificationshave been developed to collect data regarding to purchased volume and health expenditure reimbursement. The TMT code is announced to all government's hospitals use fortracking any purchasedquantity made for pharmaceutical products. The NHSO's 24 digit is also introduced for collectinghealth expenditure reimbursement amount. Both product identification are unique at generic name of pharmaceutical products. The reasons behind is reimbursement is paid against generic name instead of product trademarks. Apart from NHSO's 24 digit, the Comptroller General's Department is also issued their own product identification; similar to NHSO reimbursement codes, but it limited to health expenditure reimbursement only for government officers. This is similar to the Social Security Office, they has their own identification codes to reimburse health expenditure for employee. To manage health expenditure budgetary, the Comptroller General's Department issued the GPSC code. The GPSC code is taxonomy of products to classify products in the eGovernment procurement system. It is a five-level hierarchy code contains 22 digits used for identifying product group such as pharmaceutical products, medical devices, and etc.To report productsafety updates and surveillance, the Department of Medical Science issued another identification code used to communicate information regarding to ADES, safety and surveillance in post-market stage. The DMS code contains 11 digits identifying forhealthcare organizations who reported ADEs, safety issues, manufacturer, and active ingredients of pharmaceutical products (NHSO, 2012)

Like other trade products, pharmaceuticalsby nature is global supply chain. Therefore, some pharmaceuticals sold in Thailand are imported. In the meantime, some pharmaceuticals are also exported to other countries as well. From this, the Thai Customs is involvedregarding to tariff taxes for all imported and exported pharmaceuticals.The Thai Customs issueda16 digits harmonization codeused for

collecting statistical information according to product movement in and out Thailand (Yu, 2008).

From literature reviews above, it found that to identify a pharmaceutical, numerous identification codes aredeveloped and in use with divergent objectivesdepending to its issuers. Each issuer tended to announce its own identification codes and supposed that others could benefit from it as well. The identification codes used among healthcare stakeholdersin Thailand are summarized in Table 2.6.

Table 2.6 National Identification Codes in Thailand

Identification code	**Classification**	**Identification level**	**Purpose**
Registration code	Product identification	Trade name	Provide pharmacological and clinical information of drugs
NHSO's 24 digit	Product classification	Generic name	Health expenditure reimbursement
GPSC	Product classification	Classification	Procurement budgeting management
CGD	Product identification	Trade name	Health expenditure reimbursement
DMS	Product classification	Generic name	Update safety and surveillance information
Tariff harmonization code	Product classification	Classification	Tax clearance of imported or exported pharmaceutical products

Apart from national identification codesillustrated in Table 2.6, number of literatures regarding toidentification codes used in other countries are analyzed. In worldwide, the ISBT 128 is a unique 13 digits identification code used for identifying, labeling, and transferring information regarding to human blood, cell, tissue, and

organ products across international borders and disparate healthcare systems (Wray, 2007).The information contains in ISBT 128 code included collection organization, collection year and sequence number assigned by the collectors. The FDA issued theNDC code to identify pharmaceutical productstrial use and market in United States. This identification code composed of 10 digits identifying the labelers, product, and package sizes for the specific drug (Levinson, 2006).

The Health Industry Business Communications Council issued a HIBCC codeto identify blood and blood products. The HIBCC code consisted ofunique 25 alpha-numeric digits identified serial, batch number and expiry date (ANS, 2013). While the Health Canada issued a DIN. This identification code is a computer-generated 8 digits to pharmaceutical products prior to being marketed in Canada. TheDIN code consisted ofmanufacturer, product name, active ingredientand strength of active ingredients, dosage form, and route of administration (CBSA, 2014).The Anatomical Therapeutic Chemical issued the ATC classification code used to classify pharmaceutical products into different groups according to the organ or system on which they act and/or their therapeutic and chemical characteristics (Chen, 2014). In addition, the SNOMED-CT is another classification code designed based on clinical terminology that provides clinical content and expressivity used for clinical documentation and reporting (IHTSDO, 2014).

Furthermore, apart from healthcare sector, the GTIN series are the globally unique identification codes used for products sold, delivered, storage, and billed throughout the retail and commercial distribution channels. The GTIN is a numeric data structure contains of 8 digits, 12 digits, 13 digits, or 14-digits respectively (GS1, 2013).

From the literature above, numerousglobalized identification codes are existed as well. Each identification code is also designed with divergent objectives based on its issuers. Even though, the globalized identification codes aresummarized in Table 2.7.

Table 2.7 Globalidentification Codes

Identification code	Classification	Identification level	Purpose
DIN	Product Identification	Trade name	Use to identify pharmaceutical products trial use and sell in Canada
NDC	Product identification	Trade name	Use to identify pharmaceutical products trial use and sell in U.S.
HIBC	Product Identification	Trade name	Use to identify blood and blood products
AHFS	Product Classification	Classification	Use to classify pharmaceutical products with similar pharmacologic, therapeutic, and/or chemical characteristics
ATC	Product Classification	Classification	Use to provide classification of pharmaceutical products according to their therapeutic, organ and chemical substance
SNOMED CT	Product Classification	Classification	Use to provide the chemical composition of pharmaceutical products
ISBT 128	Serial Identification	Serialization blood, cell, tissue, and organ products	Use to identify blood, cell, tissue, and organ products
GTIN 8	Product Identification	Trade name	Use to identify commercial products

Table 2.7 Globalidentification Codes (cont.)

Identification code	Classification	Identification level	Purpose
GTIN 12	Product Identification	Trade name	Use to identify commercial products
GTIN 13	Product Identification	Trade name	Use to identify commercial products

From Table 2.6 and 2.7, itagreed that each identification code also has its advantages, limitations, useful and valuable information depending on its purposes, setting used, and also user's knowledge. From those analysis, existing identification codesused in healthcare can be categorized into two groups as follows: (1)identification code in nationalsettingssuch as NDC, DIN, FDA's registration code, and so on and, (2)global identification codesuch as HIBC, GTIN, SNOMED-CT, BNF, and etc.

2.3Healthcare Supply Chain Collaboration

The collaboration among supply chain stakeholders has received much attention due to the growing complexity of supply chains. The term "collaboration" described as two or more supply chain stakeholders dealing their businesses through sharing information, making joint decisions and sharing benefits (Simatupang and Sridharan, 2002). On other hand, collaboration was the need for coordination of operational resources to developing the capabilities for implementingsuccessful collaboration (Thron et al., 2006). In another meaning, Schwägele (2005) stated that collaboration was the ability to track and trace the product movement in the supply chain. While Goh et al. (2009) argued that collaboration was the capability of stakeholders to access or provide the information with the relevant stakeholders for better decision support. Therefore, collaboration was a concept that involved people, processes, technology and information flow at different steps of the supply chain.

Kaipia and Hartiala (2006) argued that collaboration could be derived from information sharing advantages such as reduced lead times, more accurate demand forecast and bullwhip effect reduction, capacity planning and inventory control. Seminiaka and Silina (2012) highlighted the benefits of collaboration in term of reduce supply chain costs, improve operational efficiency and agility, improve customer service, and monitor suppliers' performance.

Based on those literatures, it could concluded that the main enable of collaboration derived from implementing IT systems to capture information flows in particular with physical shipment of products. The IT systems could improve the speed of information exchange and also the quality of information shared. Kim et al. (2011) stated that implementing IT systems could increase buyer-seller's integration and compatibility to collaboration enhancement. However, Johansson and Walker et al. (2013) argued that only implementing IT systems could not yield collaboration among stakeholders, the level of collaboration was depended on the stakeholder's shared information and relationships. In term of information quality, Moberg (2002) highlighted that shared information among stakeholders should be reliable, valid, accurate, timely, and of the proper formatting. This idea supported by Caridi et al. (2010), they argued that collaboration could be achieved when sharing meaningful or useful information resulted on improving supply chain performance. The collaboration could bring benefits to suppliers could be summarized as creating revenue opportunities, efficiencies and customer royalty, in addition, hospitals could improve profitability, reduce waste and contribute to more valuable relationships (Anbanandam, 2011). Min et al. (2005) stated that constructing collaboration among supply chain depended on top management commitment, strengthen information sharing (Lee and Whang, 2000), and trust among stakeholders involved in the supply chain (Agarwal and Shankar, 2002).

Data standards in supply chain collaboration were viewed as a resource and a coordination mechanism on improving information sharingbetween inter-organizational supply chains between stakeholders (Fabbe-Costes et al., 2006). The data standards facilitated electronic transactions by making it easier to exchange information. In another study, Brüggemann and Hübner (2008) indicated that standardized, updated and regularly available information could optimize supply chain

processes.Caridi (2010) defined four types of information collaboration as follow 1) transactions such as purchase order, purchase order modification, advanced shipping notice and invoices, 2) status information such as purchase order status, stock level, storage capacity, machine maintenance plan and production capacity, 3) information about the product features such as product life-cycle, ingredients and stock keeping unit features, and 4) operational plans such as distribution plan, production plan, sales forecast, sales promotions. While Kaipia and Hartiala (2006) classified collaboration into three forms including transactional relationships e.g. orders and invoices, information-sharing relationships e.g. inventory levels or order status, and joint planning and development of business plans.

Based on literatures, it could summarized that level of collaboration composed of three types as follow:

Level 1: Operational collaboration, this collaboration deal with day-to-day information sharing such as exchanging purchase order, advance shipment notice and invoices.

Level 2: Tactical collaboration, this collaboration deal with developing plans for specific projects such as stock level, storage capacity, product life-cycle, ingredients and stock keeping unit features.

Level 3: Strategic collaboration, this involves continuing contact among the top leaders to discuss broad goals or changes in each stakeholder.

Therefore, in the next section, the conceptual framework of this study will be provided.

2.4Developing the Conceptual Framework

In the previous section, list of information needed to enhanceHSC collaborations from the existing pharmaceutical databases are reviewed. Those pharmaceutical databases are developed to provideessential information for their specific users. However, the information that needed to be sharedmust be in standardized format and enabling for the interoperability between IT systems existedamong healthcare stakeholders.

Itnoted that mainly of existing pharmaceutical databases use product name as the primary key to identify its relevant information. Meanwhile, the identification code can be the key to connect all information used in supply chain. The unique identification code could pool fragmented set of data altogether. Then, with the unique identification code, set of data in separated databases can be integrated.

Furthermore, to avoid data duplicationamongproduct databases, the standard data attributes must be set up standardization. Data standardization can be the tool to achieve the integrated set of data from all existing product databases; the data pooling from each database, with the standardized form of data particularly the identification code, an integrated datapool can be achieved. Coding system could come into play especially inidentifying the uniqueness of products. Consequently, to enhance collaborations in the entire HSCwith data consistency can be achieved.

Therefore, the conceptual framework of this study was proposed as follows:

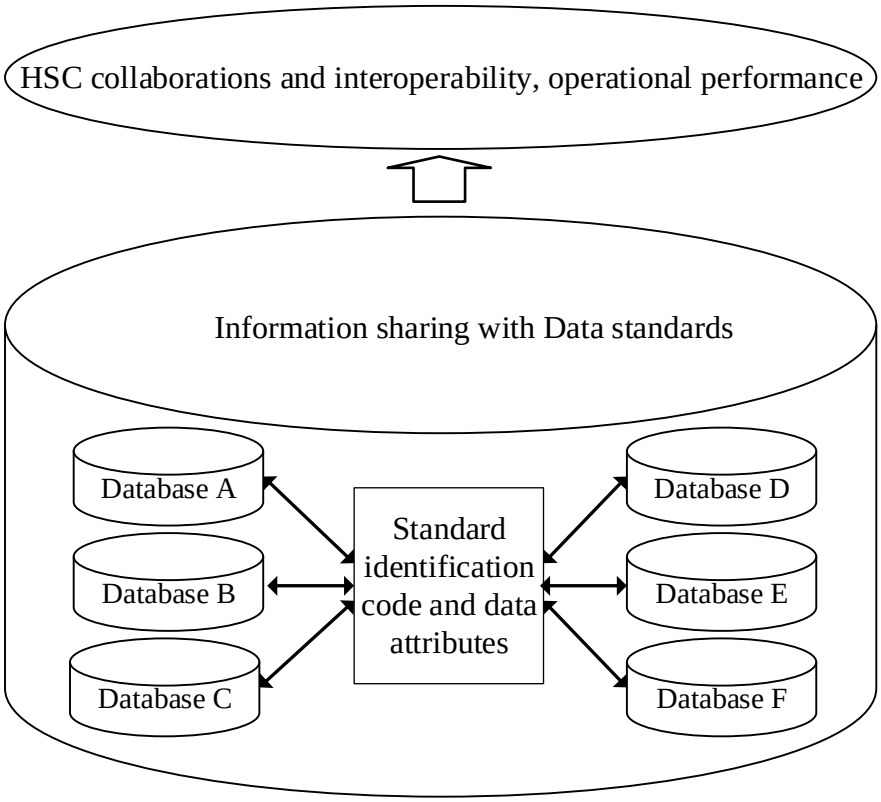

Figure 2.4 An integrated datapool for developing collaborations in HSC

Based on both research assumptions stated in Chapter 1: "*an integrated datapool could lead to enhance HSC collaborations and operation performance improvement*" and "*the data standards could lead to increase HSC collaboration and operation performance improvement"*, in together with this proposed conceptual framework, a proof of concept is needed.

Lastly, research assumptions and proposed conceptual framework come to the research questionas follows:

"Would an integrated datapool and data standards be a mean to operation performance improvement and HSCcollaborations?"

To explore much more in details for this research question, firstly the component in this conceptual framework must be constructed and tested. The data standards must be developed for constructing an integrated datapool. Hence, the consequent of this research question is firstly to develop data standards include product identification code and set of datapool attributes. Now that, the proposed datapool will be tested with the concept of operational performance improvement and HSC collaboration enhancement.

2.5 Research Objectives

The primary objective of this research focusing on proposing the intervention concept to increaseoperational performance and enhance HSC collaborationamong healthcare stakeholders in Thailand. From this, the research can be further derived into two objectives as follows:

1. Developan integrated datapool withdata standards for HSC collaboration enhancement
2. Proof of the concept for operational performance improvement and HSC collaboration enhancement

Next, in Chapter 3, the methodology for constructing an integrated datapool and recommending data standardswill be described. Additionally, the methodology for testing the intervention concept will be further explained.

CHAPTER III
RESEARCH METHODOLOGY

The problem, effect and impact relevant to information sharing and collaboration were derived from literatures as presented in Chapter 1. In particular to the intervention improvement concepts to increase operational performance and collaboration among healthcare stakeholders were derived from existing cases as presented in Chapter 2. The intervention improvements suggested on constructing an integrated datapool with data attributes for HSC collaboration enhancement. Therefore, the main purposes of this chapter are focused on datapool developing methods as follows: 1) constructing an integrated datapool with sets of data attributes and, 2) testing the use of proposed datapool in term of increasing information sharing and collaboration among healthcare stakeholders.

Base on those purposes, the research design and methodology is designed and illustrated in Figure 3.1. The detailed discussion on each research methodology is further explained as follows:

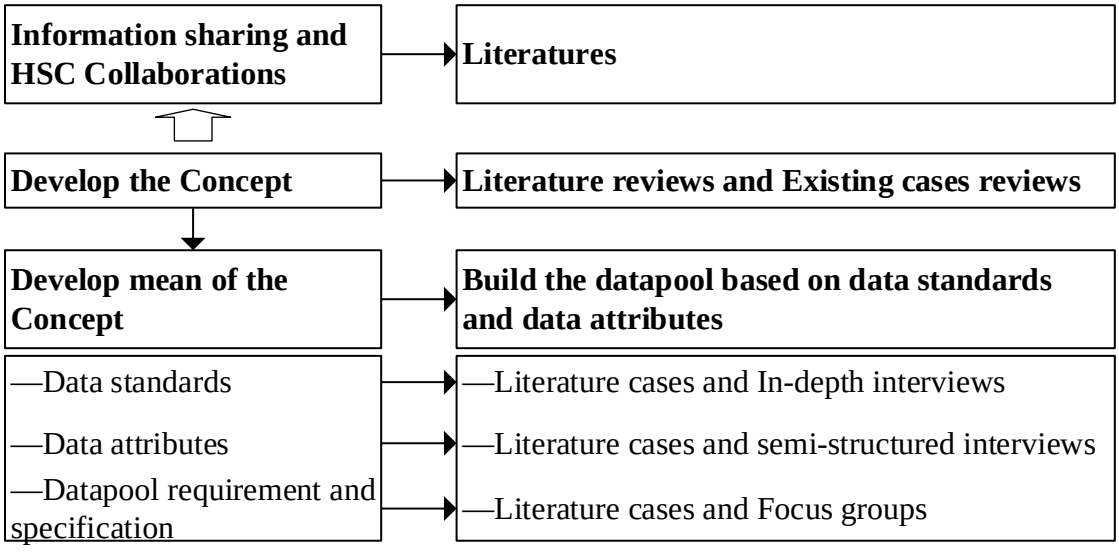

Figure 3.1 Research design and methodology

3.1 Constructing the Datapool

In order to construct an integrated datapool, it composed of 3 components as follows: 1) data standards development, 2) data attributes that should be kept in the proposed datapool and, 3) datapool requirement and specification. Each component will be described in the next section.

3.1.1 Data standards Development

To develop data standards to identify pharmaceuticals in the proposed datapool, lists of data standards and its characteristics reviewed from literatures and existing cases in Chapter 2 are considered as pre-seed inputs. Next, the indepth interview method is applied to recommend for the suitable data standards characteristics in HSC setting in Thailand.

Schensul et al. (1999) described that the indepth interview is an open-ended, discovery-oriented method to obtain detailed information about a topic from an informant. This idea supported by Mack et al. (2005), they stated that the indepth interview is a qualitative research method; its goal is to explore in depth of an informant's point of views, experiences, feelings and perspectives. Babbie (2001) discussed in details of conducting indepth interview, she explained that the indepth interview involved in conducting intensive individual interviews with a small number of informants to explore their perspectives on a particular idea, program or situation. Kvale (1996) has conducted indepth interviews at the National Defense Research Institute (NDRI) and stated that it is most likely to provide the depth of information that might be useful and very complete response. Harrell et al. (2009) argued that indepth interview is the best research method to resolve seemingly conflicting information, because the researcher has the direct opportunity to ask about the apparent conflict. This is agreed by Boyce and Neale (2006), they argued that indepth interview often used to refine questions for a particular group provide much more detailed information than what is available through other data collection methods.

From literatures above, it can summarized that the indepth interview is a collection method introduced for gaining detailed information about a person's thoughts and behaviors, or to explore new issues in depth and used to provide context to outcome data, offering a more complete picture of what happened in the area of

interest and why. In this study, it is by nature that healthcare is a complex, specialty context and little of in depth information. Likewise, the characteristics of data standards. There are numerous identification codes existed and in use among healthcare stakeholders. However, little of information regarding to the best-fit data standards should be deployed in HSC in Thailand. Therefore, the indepth interview has seen to be suitable collection method to gain much more ideas regarding to the characteristics of data standards and the possible solutions on data standards implementation from healthcare stakeholders—key informants.

The main objectives on conducting indepth interview in this study is: (1) to gain key informant's ideas on data standards characteristics that suitable for HSC settings in Thailand and, (2) to gain ideas on possible solutions for data standards implementation. Finally, the indepth interview is conducted against 36 key informants represented to healthcare stakeholders listed on Figure 1.2. To choose a key informant, his or her roles are considered since it has impacts to the final outcomes. To summarize, the role of key informants participated in the indepth interview session are organization directors from hospitals, manufactures, distributors, government agencies both regulators and reimbursement, and IT organizations. To collect ideas regarding to indepth interview method, both one-on-one interview and group discussion are used. The key informants were asked to discuss on best-fit characteristics of data standards that are crucial to improve information sharing and collaboration among healthcare stakeholders based on two expected outcomes as follows: operational performance and patient safety enhancement. Moreover, the possible solutions for data standards implementation in HSC settings. The recommended data standards and its implementation approaches will be presented in Chapter 4.

3.1.2 Datapool Attributes Selection

In the proposed datapool, data attributes are one of crucial information to improve operational performance and collaboration, and quality of care among healthcare stakeholders. To propose data attributes that should be kept in proposed datapool, list of data attributes reviewed from literatures illustrated in Table 2.5 are considered and used to develop a check sheet containing pre-defined attributes. To select necessity datapool attributes, the semi-structure interview method is considered.

Berg (2001) described that semi-structure interview is a research method that combines a pre-defined set of questions and uses to gain informant's ideas during interviewing process. Bhattacherjee (2012) pointed out that semi-structured interview has a set of pre-determined questions and let the informant decide based on pre-determined questions. Gray (2004) and Punch (2005) described the collection process that the researcher has a list of questions or specific topics to be covered and gained informant's ideas through discussion during conducting an interview. Kelly (2007) stated that semi-structure interview use of pre-determined questions provides uniformity. While Mathers et al. (2002) mentioned that semi-structured interview involves a series of questions based on the topic areas that the researcher wants to explore but not limit to, both interviewer and interviewee could discuss some additional topics in more details. Murtonen (2005) pointed out that the main objective of semi-structured interview is used to understand how interventions work and how it could be improved and also allows informants to raise issues that may not have considered in pre-defined questions and it can provides useful information based on participant's experiences.

From literatures above, it can concluded that the semi-structure interview is a collection method used to gain uniform information, ideas and perspectives based on set of pre-defined questions and lets informants decide on a specific pre-defined questions. In the meantime, semi-structure interview method allows informants to add on their specific ideas that may not listed on original pre-defined questions. From those analysis, it aligned to our expected results. We have a set of pre-defined datapool attributes and expected informant's judgments on whether each datapool attribute should be kept in an integrated datapool, as well it is not limit to informants to add up some datapool attributes to an original check sheet. Therefore, it has seen that semi-structure interview method is suitable to select datapool attributes that crucial among healthcare stakeholders and should be kept in proposed datapool.

To conduct a semi-structure interview, the check sheet is developed based on data attributes listed in Table 2.5. This check sheet is used to discuss with informants whether each datapool attribute important to increase operational performance and collaboration, enhance patient safety or both. Furthermore, we leave a box in check sheet for informants to add up data attributes that are not listed in pre-

defined data attributes. To examine a pre-test, group of informants including doctors, nurses, pharmacists and supply chain practitioners are invited to do a pre-test examination, estimate time dedicates to complete, and all pre-defined datapool attributes are clear enough and likely to result in equally clear responses.

The main objectives on conducting semi-interview in this study is to select datapool attributes that should be kept in an integrated datapool. Finally, the semi-interview is conducted against 22 informants represented to logistics activities presented in Table 1.2. To choose an informant, his or her domain of expertise are considered since it has impacts to the final outcomes. To summarize, informants participated in the semi-interview are pharmacists dealing on purchasing and material management, doctors and nurses dealing with order management and administration, and supply chain practitioners dealing with logistics and transportation. To verify datapool attributes suggested from informants, the group of informants that worked on pre-test examination are invited to weed out datapool attributes that do not contributed to the research setting or misleading. Finally, we can concluded for the minimum datapool attributes. The list of datapool attributes that should be kept in the proposed datapool will be presented in Chapter 4.

3.1.3 Datapool Specification Design

Due to the information sharing and collaboration concept has significant impacted on constructing an integrated datapool. To design the proposed datapool, the database's functionalities presented in Table 1.3 and 2.4, in particular with the conceptual framework proposed in Chapter 2 are roughly sketched. To gain datapool's components, the focus group method is considered.

Mack et al. (2005) explained that the focus group is valuable to elicit information on a wide range of opinions in short time. This idea is agreed by Kumar (1987), he stated that the focus group is a rapid assessment tool to gain knowledge about a particular topic from a directly affected by the issue. While Grudens-Schuck et al. (2004) presented the focus group's objective are: 1) to explore the in-depth opinions regarding to issues or development ideas, 2) to understand differences in perspectives, 3) to test the proposed results and, 4) to capture opinions of target audiences. Ping (2008) indicated that the focus group is used to obtain perspective

attitudes of people about issues and seek for explanations. Owens (2002) compared that focus group provide depth insights while survey try to capture breadth insights Harrell et al., (2009).

The datapool's requirement and specification must be easy to use and contain useful and valuable functionalities. From literatures above, it could concluded that conducting number of focus groups with medical professionals, supply chain practitioners and IT experts are seen beneficial to capture in depth opinions on the component of an integrated datapool in short time. To conduct a focus group, the roughly sketched of datapool's conceptual design mentioned earlier is used as pre-seed information. The conceptual design of proposed datapool composed of identification code and datapool attributes. Due to the proposed datapool is a building block to improve operational performance and enhance collaboration among healthcare stakeholders, number of focus groups have been organized with both individual person and healthcare organizations including hospitals, manufacturers, distributors, regulator, payers and non-profit organizations. To gain datapool's requirement and specification, the participants who mostly work related to HSC are analyzed. The individual person that are invited to participate in focus group discussion is chosen based on their roles and domain of expertise regarding to datapool involvement. Nevertheless, constructing an integrated datapool, it needed IT technical knowledge. Hence, we invited IT experts to participate in focus group discussion as well. Finally, participants involved in focus groups are doctors, pharmacists, IT expert, patients or end consumers, and supply chain practitioners. The agenda, presentation and discussion's topics are presented to participants in advance. The core topic discussed in the focus group is covered:

> *"the components and functionality of datapool that lead to improve operational performance and enhance HSC collaborations in term of efficiency and patient safety"*

In order to gain in depth opinions, the participants who have same domain of expertise are grouped together. Lastly, three focus group discussion are organized. Firstly, it conducted with IT experts to gain opinions regarding to IT technical

infrastructure and specification. Secondly, it held with manufacturers, distributors, payers, regulator and hospitals to gain specific user requirements. Thirdly, it organized with doctors, IT experts, pharmacists and nurses at a leading hospital to gain requirement and specification related to proposed datapool implementation.

3.2 Testing the Use of Datapool

From section 3.1, the research methodology used to construct an integrated datapool are clarified. After the proposed datapool has been developed, it needed to test for its impacts on operational performance improvement and collaboration enhancement focusing on information sharing between healthcare stakeholders. Therefore, in this section, the research methodology for testing the use of an integrated datapool will be presented.

The case study is systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest Marshall and Rossman, 1989 and Bromley, 1990). In a case study, Yin (1994) stated that unit of analysis can be varied from an individual to a corporation and sourced data come largely from documentation, archival records, interviews, direct observations, participant observation and physical artifacts. Case studies in healthcare researches often involve in-depth interviews with participants and informants, observation, and excerpts from patients' personal writings. Here after, we will explain the step-by-step method for testing the use of datapool.

To decide number of case studies for datapool testing, Ellram (1996) argued that a single case, like one experiment, is suitable when that case represents a critical case to test a well-formulated theory, an extreme or unique case or a case which reveals to an inaccessible phenomenon. While Rowley (2002) indicated that a single case design is appropriate when the case examined is special for some reasons and cover to experiment settings. Both ideas supported by Voss et al. (2002), they stated that number of cases can differ from the number of organizations studied and a single case involves the opportunity to study several contexts within a case.

From literatures above, it explained that a single and multiple cases are applicable to setting an experiment. However, a single case is acceptable if that case

can study several contexts within a case. Due to our testing is focusing on information sharing in HSC by using an integrated datapool. It classified as the special and cover to experiment settings. Hence, we decided to use a single case in a leading public hospital in Thailand and its four major suppliers. According to Yin (1994), we adopted two research methodologies for testing the use of our proposed datapool as follows: direct observation and experiment. The direct observation method is used to examine the current state of business transaction processes between hospital and suppliers. In the meantime, the experiment method is used to implement EDI systems using an integrated datapool in real-life context and evaluate experiment results. Next, both research methodologies are further discussion more details.

3.2.1 Direct Observations

Due to the experiment results are comparing information sharing outcomes between before and after using an integrated datapool. It noticed that the current practice regarding to information sharing between hospital and suppliers must be initially understood. After that, the proposed datapool is adopted to current information sharing and compared for experiment results. Hence, first of all, the direct observation method is adopted to examine current information sharing processes.

Salvia and Ysseldyke (2001) described that direct observation refers to observation of behavior that has been explicitly elicited by a predetermined and standardized set of stimuli. Kumar (1996) stated that direct observation is a structural process to observe an event, institution, system, or process in its natural setting, thereby providing a richer understanding on their nature, problems and successes. Yin (2003) argued that direct observation can identify whether the process is poorly implemented or required inputs are absent. Seuring (2008) stated that direct observation is often used in operational performance improvement. This is supported by Dubois and Gadde (2002) and Piekkari et al. (2009), they argued that direct observation is widespread used and acceptable in logistics, operations and material management to identify opportunity for improvement. While Rury (1992) stated that direct observation is a tool to gain in depth insights and provide valuable details on how and why process unfold and outcomes occur. Eisenhardt (1989) described that direct observation often been viewed as a useful tool for the preliminary, exploratory

stages of participant's jobs in real-life context. Salvia and Ysseldyke (2001) pointed out that direct observation used to observe participant's behavioral with 4 specific objectives as follows: 1) to measure specific behaviors, 2) the behaviors being observed have been operated whether in a precise manner, and 3) participant conducted their jobs under standardized procedures and, (4) use for scoring and summarizing of data are standardized. Furthermore, Levin-Rozalis (2004) indicated that direct observation is often chosen because the researcher wants to know how the context of the phenomenon works. Kawulich (2005) argued that data should be collected from two or more stages of the supply chain, such as at the minimum a dyadic perspective should be taken during direct observations,. Yin (1984) indicated that typically direct observation uses multiple data sources to formulate the finding results. Kohlbacher (2006) argued for collected data regarding to direct observation needs analyzing documents, process and publications.

From literatures above, it noticed that direct observation is a data collection technique use to observe participants in the context, documentation, and implementation and operational performance evaluation. Furthermore, its evidences is aligned with the setting—testing the use of proposed datapool in order to improve operational performance and enhance collaboration through discovering it in unfold environmental contexts. Hence, in this study, the direct observation is adopted as attempted to observe participants in information sharing process between hospital and suppliers.

Due to some outputs of this study is to investigate the operational performance and collaboration between healthcare stakeholders. Therefore, the direct observation is used to understand current and future state of an integrated datapool implementation. Finally, the experiment results will be compared based on number of performance indicators.

3.2.2 Experiment

In section 3.2.1, we described the use of direct observation method to examine current state of information sharing in our hospital case study. The experiment method, which can acquire the knowledge of information sharing

operation rules and features on the real environment. Therefore, testing the use of proposed datapool, an experiment method is considered.

Experiment is often conducted in natural settings or where the variables naturally occur and involved collecting data outside of an experimental setting. This type of data collection is most often collected in natural environments and can be gathered in a variety of ways for various disciplines (Alston, 2015). Boyd and Westfall (1972) indicated that an experiment is conducted under actual use conditions, instead of under controlled conditions. This idea is supported by Levitt and List, 2006; List, 2008; and Andreoni et al., (2005), they indicated that experiment occurs in the natural environment of the agent being observed. Experiment collects unconventional data via face-to-face interviews, surveys, or direct observation. The Department of Health and Human Services explored that the experiment or field study is a study in which a treatment, procedure, or program is intentionally introduced and a result or outcome is observed. Brown (1992) stated that the experiment is a study in which a treatment and procedure is introduced and a result is observed. Gay (1992) explained that the experimental method is the only method of research that can truly test hypotheses concerning cause-and-effect relationships. Furthermore, Croson and Shang (2005) stated that the experimental method is a systematic and scientific approach to manipulate one or more variables, and controls and measures any changes in other variables. Harrison and List (2004) explained steps in conducting an experiment as follows: define the problem, formulate hypothesis and deduce their consequences, construct experiment design, conduct the experiment, compile data to usable forms and present findings.

To evaluate collaboration impacts on using of an integrated datapool in the real-life context, an experiment is implemented. The experiment took over 8 weeks at a leading public hospital in Thailand. From December 2014 - January 2015, we set up a working group, collaborated operators altogether and conducted experiment focusing on information sharing and collaboration. The steps to conduct experiment suggested by Harrison and List are used as a guideline. Therefore, experiment detailed on exploring problems related to sharing trading documents between hospital and its suppliers. The hypothesis is organized into 3 different settings as follows: 1) exchange trading documents based on paper-based system, 2) share trading documents via EDI

system and, 3) share trading documents via EDI system using an integrated datapool. Finally, the settings outcomes will be compared among those settings based on its impacts to operational performance and collaboration between healthcare stakeholders.

Next, in Chapter 4, the data collection process for constructing an integrated datapool will be presented to explore the step-by-step on formulating data standards, selecting datapool attributes and gathering datapool requirement and specification.

Furthermore, in Chapter 5, the proposed data standards, minimum datapool attributes and recommended datapool functionalities will be presented for constructing an integrated datapool.

Moreover, in Chapter 6, the experiment's process and results on the use of proposed datapool will be discussed.

CHAPTER IV
DATA COLLECTIONS FOR THE DATAPOOL

In Chapter 3, we presented research methodology used for constructing datapool including data standards development, datapool attributes selection, and datapool requirement and specification formulation. In particular with the research methodologies used in regard to test the use of an integrated datapool in term of operational performance improvement and HSC collaboration enhancement. Here, in this chapter, the data from several collection methods are presented as follows:

4.1 Data Standards

To develop the suitable data standards for HSC context in Thailand, the characteristics of data standards reviewed from literatures were considered to formulate initial discussion topics. Then, number of indepth interviews are organized during 2011 to 2012. The key informants were invited from each healthcare stakeholder depicted in Figure 1.1. Before conducting an indepth interview, the list of discussion topics was conveyed to key informants in advance. In each indepth interview, it took 2-3 hours in discussion and key informants were asked to share their ideas, perspectives and also opinions regarding to the suitable data standards characteristics that fit to HSC context in Thailand. The topics under indepth interview are included: the characteristics of data standards that suitable for HSC context in Thailand and;

The indepth interview was discussed with number of individual and healthcare organizations. The interview was conducted on one-by-one manner until there are no additional ideas contributed to new data standards characteristics. The finalized data standards characteristics was analyzed and distributed to key informants for their final verification before documentation. There were 18 healthcare organizations involved in indepth interview: 6(33%) were manufacturers, 3(17%) were

distributors, 5(28%) were healthcare providers and 4(22%) were regulators. Figure 4.1 illustrated the healthcare organizations involved in the indepth interview.

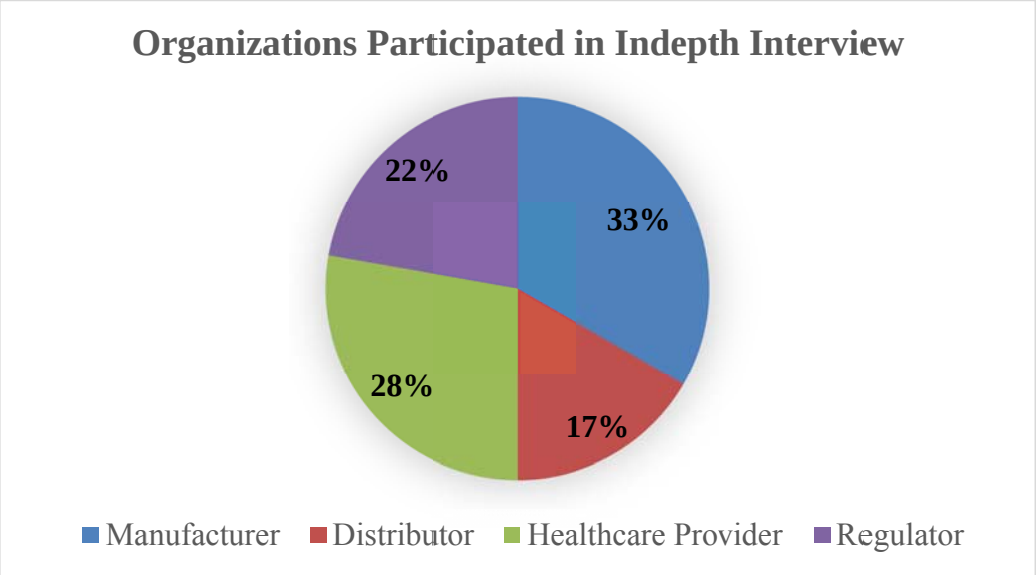

Figure 4.1 Organizations involved in indepth interview

The role of participants involved in indepth interview including 36 informants; 9(25%) were doctors, 13(36%) were pharmacists, 1(3%) was nurse, and 13(36%) were logistics practitioners. Figure 4.2 illustrated the roles of key informants involved in the indepth interview.

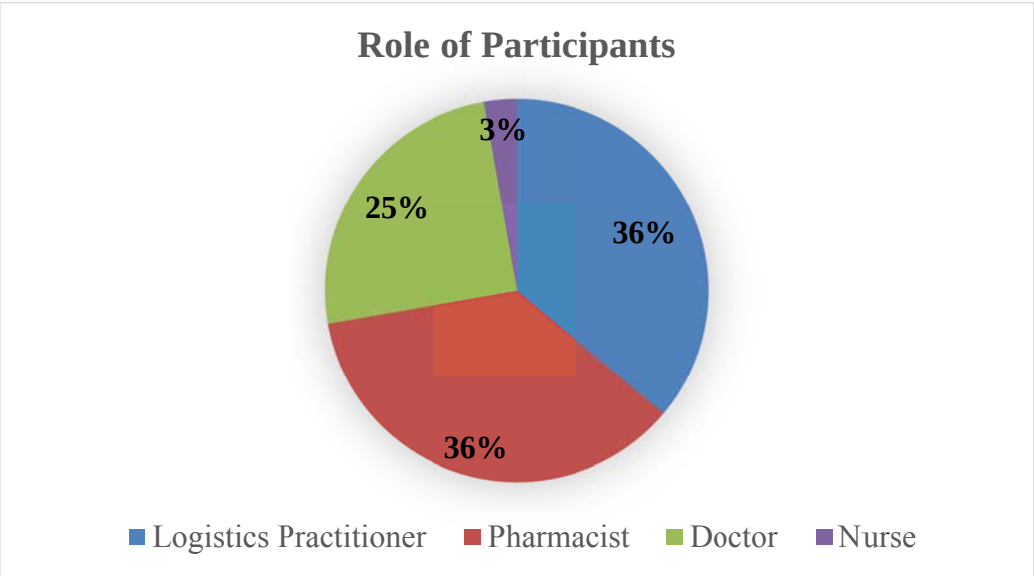

Figure 4.2 Roles of participants involved in indepth interview

There have 18 healthcare organizations involved in the indepth interview included 6 manufacturers, 3 distributors, 5 healthcare providers and 4 regulators. Base on this, 36 key informants were interviewed including 9 doctors, 13 pharmacists, 13 logistics practitioners and 1 nurse. The number of healthcare organizations and persons involved in indepth interview were summarized in Table 4.1.

Table 4.1 Indepth interview Participant

Stakeholder	Key informant	# of organizations	# of persons
Manufacturer	Logistics practitioner	6 (33%)	6 (17%)
Distributor	Logistics practitioner	3 (17%)	8 (22%)
Healthcare provider	Doctor	5 (28%)	6 (17%)
	Pharmacist	-	10 (28%)
	Nurse	-	1 (3%)
Regulator	Doctor	2 (11%)	3 (8%)
	Pharmacist	2 (11%)	2 (6%)
	Total	**18**	**36**

Three characteristics mentioned in literatures including uniqueness identification across HSC, globalization and machine readable format were used as a pre-seeded information. Here after, the ideas, opinions and perspectives related to the characteristics of data standards gathered from the indepth interviews are presented.

"Indicate which are the characteristics of data standards that suitable for HSC context in Thailand?"

Healthcare Provider

Three are 5 doctors, 10 pharmacists and a nurse participated in the indepth interview to discuss on the characteristic of data standards that suitable for HSC context in Thailand. The participants were asked to explore their opinions regarding to pre-seed characteristics or suggest additional characteristics which impacted to

increasing efficiency and patient safety in HSC context in Thailand. Based on individual and group discussion, most of informants (100%) indicated that the uniqueness of pharmaceutical codes at prescription unit was the mandatory characteristics to reach an acceptable level of HSC collaboration among healthcare stakeholders in Thailand. The argued that unique identification code could identify pharmaceuticals and be able to track and trace pharmaceuticals from point-of-origin through point-of-consumption through the entire HSC in Thailand. Furthermore, they supported that each pharmaceutical has specific pharmacological proprietaries. In term of globalization, some informants (80%) agreed on this characteristics. However, the 20% of informants supposed that globalization is optional characteristics. They supposed that only manage pharmaceuticals within Thailand was sufficient. They explained that only track and trace within the border of Thailand is enough for country-level HSC efficiency and patient safety to increase operation performance in receiving, stock management and dispensing of pharmaceuticals. To discuss on ability to integrate with barcode scanner, most of informants (100%) agreed that it was important for healthcare personals to manage HSC efficiency. Hence, the data standards that supported for machine readable format is mandatory to increase operational in issuing and receiving of pharmaceuticals.

Manufacturer

It had 6 personals from 2 manufacturers involved in indepth interview. They were asked to explore their opinions on the data standards characteristics as well. Most of informants (100%) recommended that unique pharmaceutical code is a mandatory characteristics for HSC in Thailand. They argued for the important on track and trace, and identify for price and specification of pharmaceuticals. In addition, they supported by the difficulty of current recall of pharmaceuticals in term of difficulties and costs. In term of globalization, mainly of manufacturers (83%) agreed to globalization characteristics but the rest stated that globalization was an optional characteristics for import or export pharmaceuticals. They stated that only import or export pharmaceuticals required globalization identification for patient safety. Discussion on machine readable format, mainly of them (100%) agreed on barcode on packaging. However, they concerned on cost of affixing labels on pharmaceutical

packages due to some of pharmaceutical packages have not affixed labels. To handle this situation, they recommended the government to issue regulations to enforce manufacturers for preparing barcode labels on pharmaceutical packages.

Distributor

There were 8 personals from 3 distributors involved in indepth interview. They were asked to explore their opinions on the data standards characteristics. Most of informants (100%) recommended that unique pharmaceutical code is a mandatory characteristics for HSC in Thailand. Similarity to manufacturers, they stated for the important on track and trace, and identify for the pharmaceutical movement across the entire chain. The recalls was another main concerns, the distributors needed to handle for pharmaceutical recalls. This issue has significant impacts on current recall of pharmaceuticals in term of difficulties and costs. Discussing on globalization characteristics, mostly of distributors (100%) stated the important of globalization. The reason behind was distributors pay more attention on import lot of pharmaceuticals from other countries. They stated that only import or export pharmaceuticals required globalization identification for patient safety. Discussion on machine readable format, mainly of distributors (100%) agreed on barcode on packaging. This was important for their operational performance. They recommended that to affixing barcodes on pharmaceuticals should be affixed at the point-of-origin or production of products.

Regulators

It had 5 personals from regulators involved in indepth interview. They were asked to explore their opinions on the data standards characteristics. Most of informants (100%) stated that unique pharmaceutical code is a mandatory characteristics for HSC in Thailand. They stated for the important on track and trace, and identify for the pharmaceutical movement across the entire chain. They highlighted for managing pharmaceuticals in broader scale and patient safety enhancement. Discussing on globalization characteristics, mostly of distributors (80%) stated that globalization was not significant in Thailand HSC context. Similarity to healthcare providers, they believed that only track and trace within the border of

Thailand is enough for country-level HSC efficiency and patient safety. This was similar to machine readable format characteristics, mostly of them (80%) accepted for its requirement on operational performance improvement in hospitals.

Based on those discussion, it could conclude that three characteristics were important in operational performance improvement and HSC collaboration enhancement as follow:

Uniqueness identification code

This characteristics stated in literatures and also strongly agreed during indepth interview discussion. All informants widely accepted for its mandatory across HSC from point-of-origin to point-of-consumption. Additionally, this uniqueness might detailed at dispensing unit to a specific pharmaceutical.

Globalization

Pharmaceutical products by nature is a global supply chain. Therefore, manufacturers and distributors are recommended this characteristics. Due to a global supply chain, the pharmaceutical products move in and out cross the border of Thailand. By this, the product visibility and traceability is not narrative to Thailand border anymore, consequently lighting the importance of globalization characteristics.

Machine readable format

Data standards could be translated and affixed into barcode symbology. If the label affixed to a package of pharmaceutical products, healthcare stakeholders can capture its relevant product information starting from point-of-manufacture to point-of-use along the entire HSC.

To implement data standards across entire HSC in Thailand, the possible approach is harmonization data standards. This idea is supported by Halamka, 2006; Redford et al., 2007, Hughes et al., 2014 and Hoyt and Yoshihashi, (2014). These researcher pointed out the need for harmonization of data standards across the entire HSC with the best available data standards, optimal and cost effective. Hence, in this proposed datapool, a data standards is set up as the primary key and referred to some existing and in use national data standards mentioned in Table 2.6.

4.2 Datapool Attributes Selection

To select datapool attributes that should be kept in an integrated datapool, a check sheet is developed based on list of data attributes in Table 2.5. This check sheet contains information as follows:

1. list of data attributes and categorized into pharmacological, clinical indications and logistics information and;

2. suggestion for additional data attributes that are not listed in check sheet and informants decided to add to original check sheet

Then, the check sheet included list of datapool attributes is launched to informants. The informants were asked to decide on pre-defined datapool attributes as well as recommend additional datapool attributes that might not listed in check sheet but impacts to supply chain efficiency and patient safety enhancement. The responses in together with additional data attributes recommended during the interview are then analyzed with statistical method and summarized. The data collection is made during 2011 to 2012. The informants are classified into 2 groups as follows:

Firstly, the informants representing hospitals are interviewed. Doctors, the key actors in prescription process were asked to select datapool attributes that important in their patient care provision. They highlighted some datapool attributes related to pharmaceutical information such as trade name, generic name, dosage form, strength and etc. To select datapool attributes regarding to clinical information, most of datapool attributes were treated as the most important information. To select datapool attributes related to logistics information, they choose manufacturer, brand owner, packaging instructions, storage conditions and image or presentations of pharmaceutical products as valuable information. Furthermore, pharmacists and nurses who are participated in purchasing, inventory management and administration were interviewed. They selected datapool attributes related on pharmaceutical, clinical and logistics information for their purchasing and inventory management. Nurses selected some datapool attributes related to clinical information. It is important in their administration process.

Secondly, informant representatives for manufacturer and distributors were interviewed. They selected some datapool attributes related to pharmaceutical information such as registration code, trade name, generic name, and etc. In term of

logistics information, they selected all datapool attributes and none of clinical information is selected.

Finally, the informants participated in semi-structure interview including 2(8%) manufacturers, 3(12%) distributors, 18(72%) healthcare providers and 2(8%) regulators. Figure 4.3 illustrated the healthcare organizations involved in the datapool attribute selection.

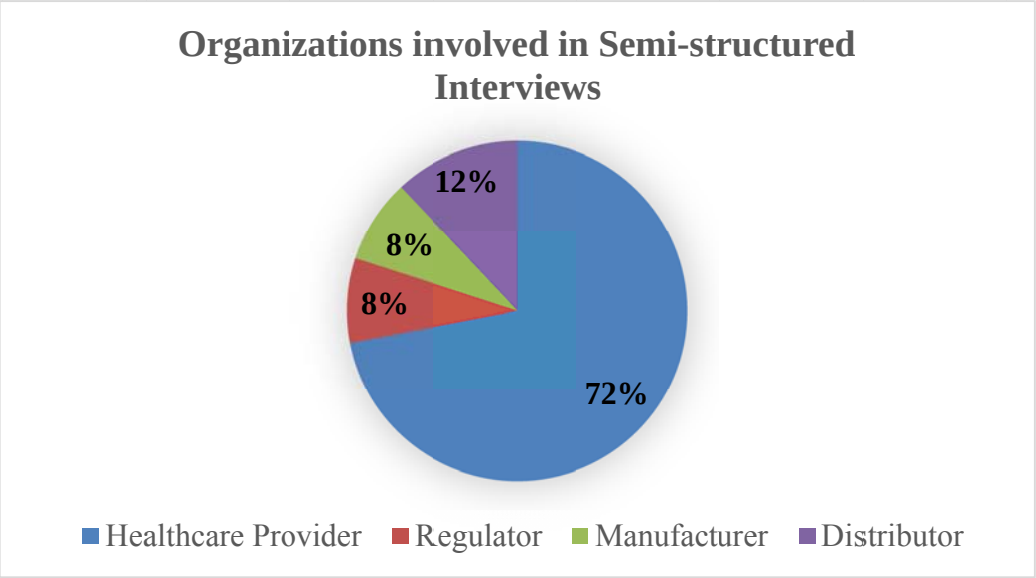

Figure 4.3 Organizations involved in Semi-structured Interview

In term of roles of informants, there were 25 participants involvement. There were 4(17%) doctors, 12(52%) pharmacists, 2(9%) nurses and 5(22%) logistics practitioners. Figure 4.5 illustrated roles of participants in the datapool attribute selection.

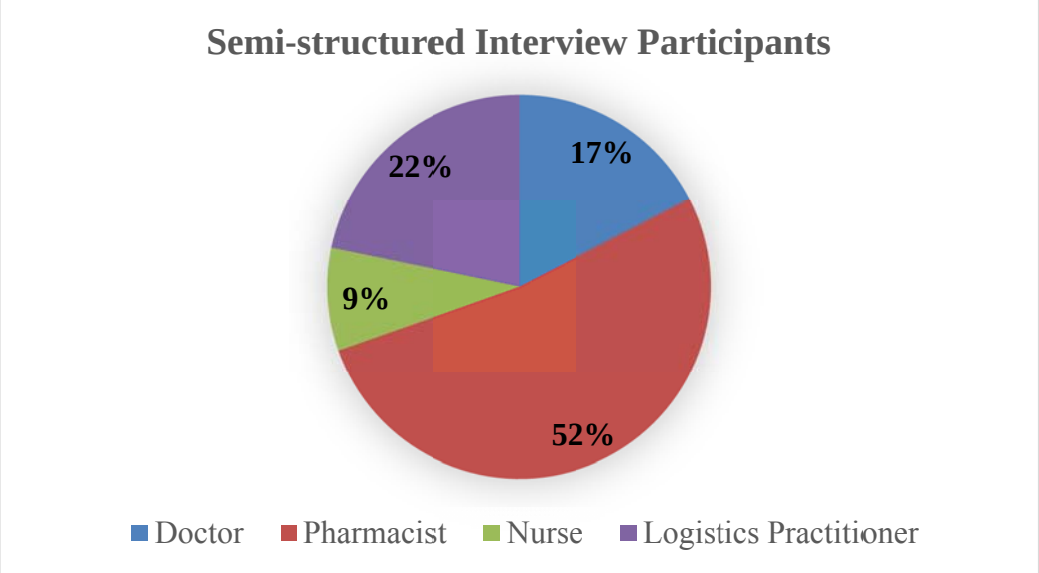

Figure 4.4 Roles of participants in Semi-structured Interview

Finally, the informant participated in selecting datapool attributes that should be kept in an integrated datapool are presented in Table 4.2.

Table 4.2 Datapool attributes selection Participant

Stakeholder	Informant	Logistics activity involvement	# of persons
Manufacturer	Logistics practitioners	Warehouse, inventory management and distribution	2 (8%)
Distributor	Logistics practitioners	Sales, inventory management and transportation	3 (12%)
Healthcare provider	Doctors	Order or prescription management	4 (16%)
	Pharmacists	Sourcing and purchasing, and inventory management	12 (48%)
	Nurses	Inventory management, and administration	2 (8%)
Regulator	Doctors	Policy and strategy	1 (4%)
	Pharmacist	Reimbursement	1 (4%)
		Total	**25**

To conclude, according to 38 data attributes listed in Chapter 2, the 31 datapool attributes are selected and should be kept in the datapool as follows: 9 datapool attributes related to pharmacological information, add up with 10 datapool attributes related to clinical information and another 12 datapool attributes related to logistics information. Finally, the list of datapool attributes are registration code, trade name or trademarks, generic name, dosage form, chemical structure, actions, dissolution, route of administration, dosage or prescription Unit, active ingredient or substance, strength and strength unit, nomenclature, indications, contraindications, dosage, overdosage, adverse drug reactions, drug interactions, administrations, precautions, special precautions, pregnancy category, presentation unit, unit conversion, barcode number and symbology, storage condition, unit weight, unit volume or content, packaging dimension, image or presentation, brand owner, manufacturer, distributor, start and end marketing date, shelf life from production, and handling instructions.

4.3 Datapool Requirement and Specification

To construct an integrated datapool, it is significant to understand its requirement and specification. The functionality of FDA and Ya&You pharmaceutical databases presented in Table 1.3 in particular with the functionality of worldwide datapool application are reviewed.

The literatures and existing cases regarding to datapool application are presented in Table 4.3.

Table 4.3 Review of data standards application

Country	Characteristics of the application	IT application in healthcare	
		Identification	Database
United States	Provide drug information	NDC	FDA Database
Canada	Provide drug information	DIN	Health Canada
Germany	Drug and Medical Devices Identification	GTIN	-
United States	e-procurement for drug and medical devices identification	GTIN	United States Device Identification Database (UDID)
Australia	eCommerce and supply chain management in the healthcare and pharmaceutical industries	GTIN, AMT	National Product Catalogue (NPC)
Netherlands	Drug and blood Identification	GTIN	-
Switzerland	Drug and medical devices identification with Electronic Health Record	GTIN	SmartLog
Canada	Drug and Medical Devices Identification	DIN, GTIN	CareNET
Hong Kong	Drug and medical devices identification with Electronic Health Record	GTIN	-
New Zealand	Drug Information		-
Spain	Medical device's location Identification		-
Columbia	Tracking system	GTIN	CABASnet
Japan	Medical Devices Guidelines & Traceability System	GTIN	JFDMA

Source: GS1 (2008) and GS1 (2009)

These datapool applications are analyzed and concluded that the functionality of these datapool applications composed of three main functionalities as follows: 1) data entry function available for entering product data or information, 2) search function available for inquiring for product relevant information and, 3) reporting function available for providing adverse drug events (ADEs) and recent safety updates and surveillance of any pharmaceuticals. In term of searching functionality, these datapool composed of 2 searching method; single search and combined search. Single search covered for one criteria while combined covered for multiple search criteria. According to literatures and existing cases analysis, the datapool functionality are sketched in Table 4.4.

Table 4.4 The functionality of existing datapool application

Datapool	**Country**	**Functionality**			**Search and inquiry information method**
		Entry	**Search, Inquiry and Use**	**Provide ADEs, safety update and surveillance**	
NDC	U.S.	√	√	√	Single search
Health Canada	Canada	√	√	√	Single search
MIMS	U.S.	√	√	X	Single search
Ya&You	Thailand	√	√	X	Single search
FDA	Thailand	√	√	X	Single search
SmartLog	Switzerland	√	√	X	Single search
UIDD	U.S.	√	√	X	Single search
NPC	NeTHA, Australia	√	√	X	Single search
CareNET	Canada	√	√	X	Combine search
JFDMA	Japan	√	√	X	Single search

√ Existed functionality

X Not existed functionality

The functionality of datapool documented in Table 1.3 in particular with Table 4.5 were used to roughly sketched for conceptual design and framework, specification, and functionality requirement of an integrated datapool. To finalize datapool conceptual design and framework, number of focus groups were conducted. In this study, three discussion has been held. The informants participated in the first focus group including 1(13%) manufacturers, 2(25%) distributors, 2(25%) healthcare providers, 2(25%) IT organizations and 1(13%) regulators. Figure 4.5 illustrated healthcare organizations involved in the first focus group discussion.

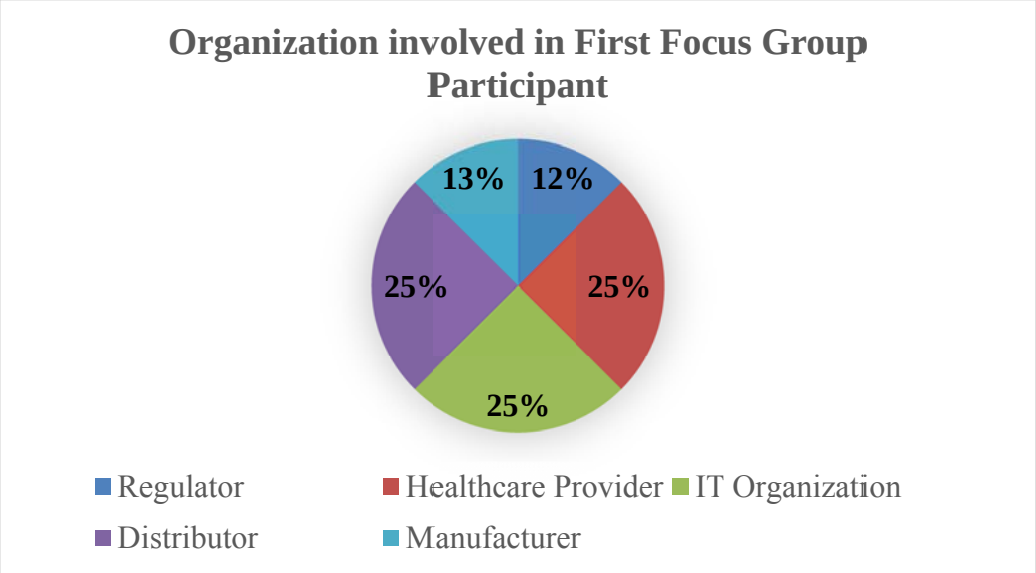

Figure 4.5 Organizations involved in First Focus Group Discussion

In term of roles of informants, there were 9 participants involvement including 3(33%) doctors, 3(33%) IT experts and 3(33%) logistics practitioners. Figure 4.6 illustrated roles of participants in the first focus group discussion.

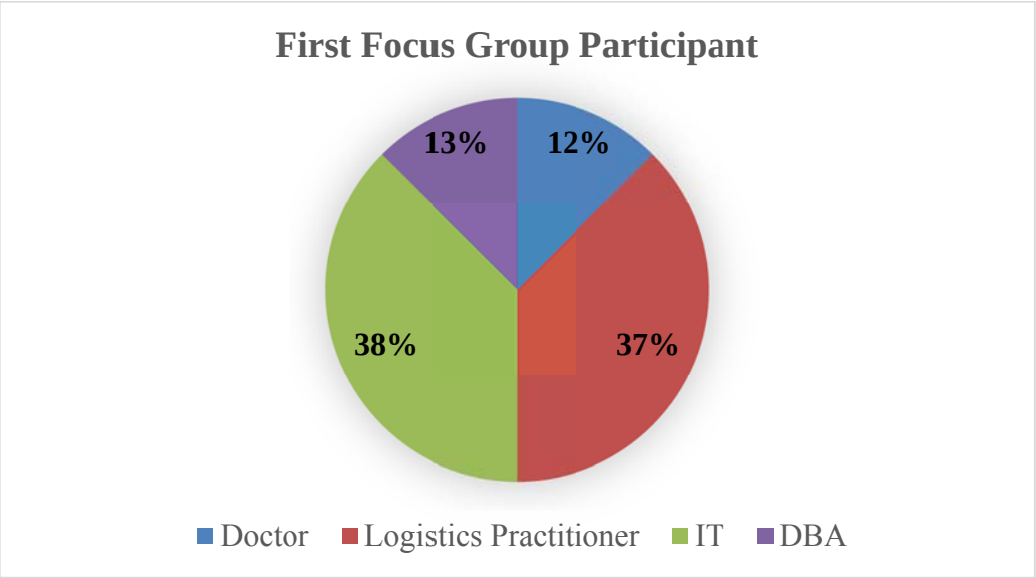

Figure 4.6 First Focus Group Participant

Finally, the participants involved in the first focus group discussion were presented in Table 4.5.

Table 4.5 First Focus Group Participant

Stakeholder	Key informant	# of organizations	# of persons
Manufacturer	Logistics practitioner	1 (13%)	1 (11%)
Distributor	Logistics practitioner	2 (25%)	2 (22%)
Healthcare provider	Doctor	2 (25%)	1 (11%)
	IT Expert	-	2 (22%)
Regulator	Doctor	1 (13%)	1 (11%)
IT Organization	IT Expert	2 (25%)	2 (22%)
	Total	**8**	**9**

The informants participated in the second focus group including 22(38%) manufacturers, 1(2%) distributors, 34(59%) healthcare providers, and 1(2%) regulators. Figure 4.7 illustrated the healthcare organizations involved in the second focus group discussion.

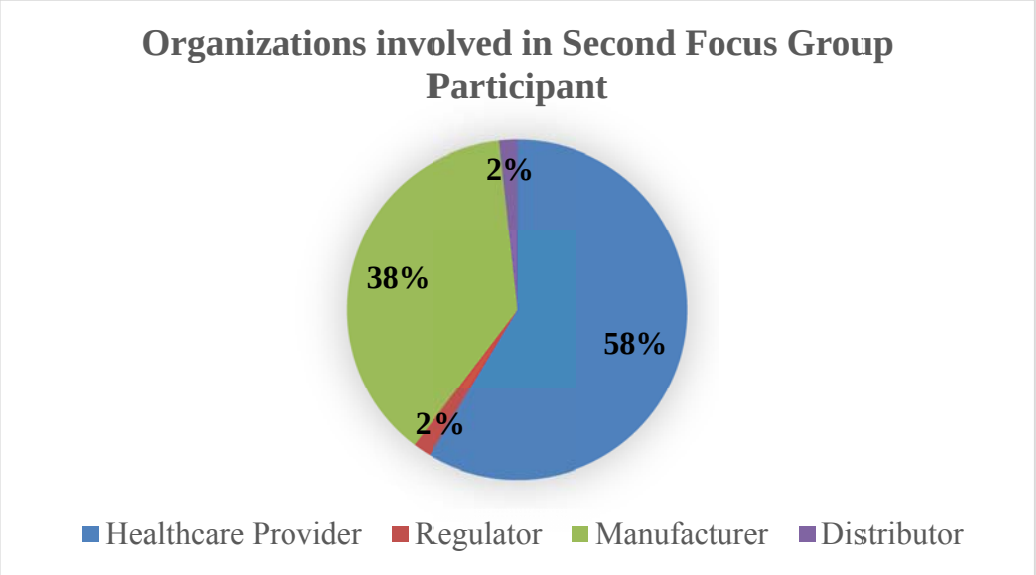

Figure 4.7 Organizations involved in Second Focus Group Discussion

In term of roles of informants, there were 58 participants involvement including 16(28%) doctors, 21(36%) pharmacists, 2(3%) nurses and 18(31%) logistics practitioners. Figure 4.8 illustrated roles of participants in the second focus group discussion.

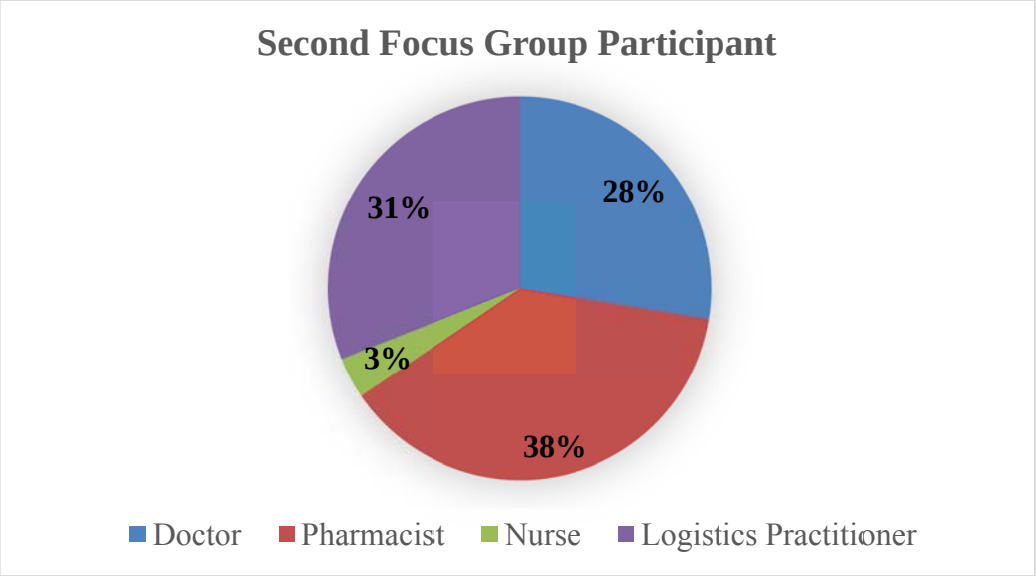

Figure 4.8 Second Focus Group Participant

Finally, the participants involved in the second focus group discussion were presented in Table 4.6.

Table 4.6 Second Focus Group Participant

Stakeholder	Key informant	# of organizations	# of persons
Manufacturer	Logistics practitioner	22 (38%)	17 (29%)
Distributor	Logistics practitioner	1 (2%)	1 (2%)
Healthcare provider	Doctor	34 (59%)	16 (28%)
	Pharmacist	-	21 (36%)
	Nurse		2 (3%)
Regulator	Pharmacist	1 (2%)	1 (2%)
	Total	**58**	**58**

The third focus group was held on 9 March 2012. There were 9 participants involvement including 2(22%) doctors, 4(44%) pharmacists and 3(33%) IT experts. Figure 4.9 illustrated roles of participants in the third focus group discussion.

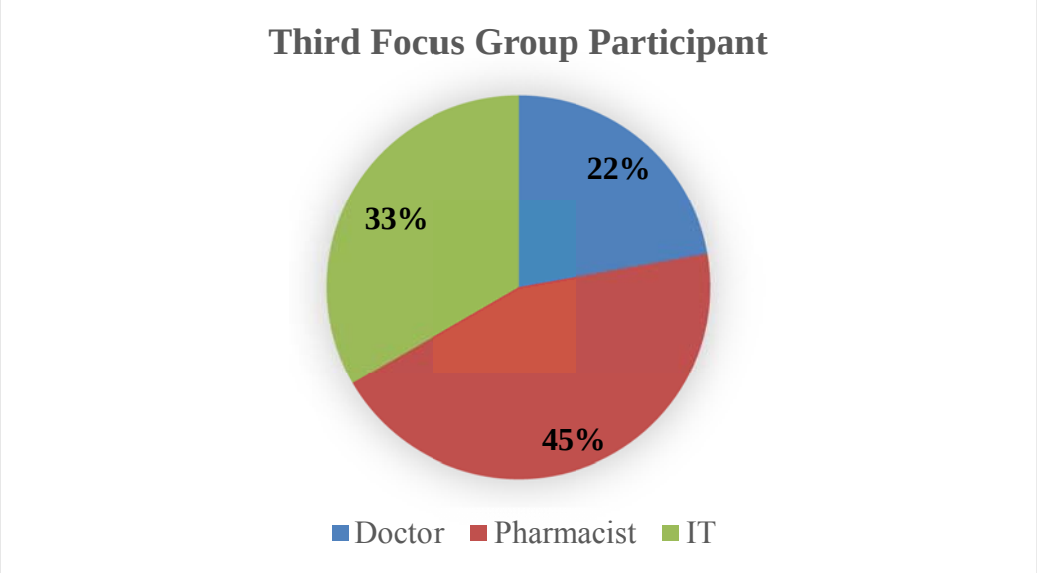

Figure 4.9 Third Focus Group Participant

Finally, the participants involved in the third focus group discussion were presented in Table 4.7.

Table 4.7 Third Focus Group Participant

Stakeholder	Key informant	# of organizations	# of persons
Healthcare provider	Doctor	1 (100%)	2 (22%)
	Pharmacist	-	4 (44%)
	IT Expert		3 (33%)
	Total	**1**	**9**

To conclude requirement and specification, three focus group discussion are organized into three round. Firstly, we invited 3(33%) doctor that has IT background, 3(33%) IT experts, 3(38%) logistics practitioners that involved in IT systems and 1(13%) DBA. In the second focus group, we also invited 16(28%) doctors, 2(2%) nurses, 21(36%) pharmacists and 18(31%) logistics practitioner. In the last focus group, there are 2(22%) doctors, 3(33%) IT experts and 4(44%) pharmacists from a leading hospital participated in this round. Finally, 76 participants are participated. The participants in focus group discussion were illustrated in Table 4.8.

Table 4.8 Focus Group Participant

Focus group	Participant involvement	Date
1	Doctor 3(33%), IT expert 3(33%), Logistics practitioner 2(27%) and DBA 1(13%)	10 February 2012
2	Doctor 16(28%), Nurse 2(3%), Pharmacist 21(36%) and Logistics practitioner 18(31%)	2 March 2012
3	Doctor 2(22%), IT expert 3(33%) and Pharmacist 4(44%)	9 March 2012

According to the information gathering from all those focus groups, the minimum datapool requirement and specification were discussed as follow:

First Focus Group Discussion

There had 9 participants involved in the first focus group discussion including 3 doctors 3 IT experts, 2 logistics practitioners and a DBA. Mostly of informants (100%) stated the needs on two functionalities included enter pharmaceutical information and search, inquiry for pharmaceutical related information. However, mostly of them (100%) would not see any benefits on sharing unofficial pharmaceutical information such as doctor-to-doctor information and safety and surveillance information. They argued that these two information was detailed and specific for medical professionals.

Second Focus Group Discussion

There had 58 participants involved in the first focus group discussion including 16(28%) doctors, 21(36%) pharmacists, 2(3%) nurses and 18(31%) logistics practitioners. Similarity to the first focus group discussion, enter pharmaceutical information and search, inquiry for pharmaceutical related information were accepted in the second focus group discussion. However, mainly of doctors (88%) stated the needs on sharing doctor-to-doctor information. They provided reason that this information could help on better patient care provision. Even though, some of them (12%) argued that this information was sensitive and might lead to confusing during provision of care. Mainly of pharmacists and nurses (85%) mentioned on the needs for safety and surveillance information. They argued that this information was significant for pharmacists to provide better pharmaceutical administration.

Third Focus Group Discussion

There had 58 participants involved in the first focus group discussion including 2(22%) doctors, 4(44%) pharmacists and 3(33%) IT experts. Similarity to first and second focus group discussion, mainly of participants agreed to the benefits on enter pharmaceutical information and search, inquiry for pharmaceutical related information. However, there were little discussion on exchange information.

Based on those three focus group discussions, it could finalize that datapool functionalities and sufficient on operational performance improvement and HSC collaboration enhancement as follow:

Enter Pharmaceutical Information

This function involved on entering product name and its relevant information such as description, substance, or composition into datapool application. The manufacturer and distributor would be responsible for entering pharmaceutical related information.

Search, Inquiry Pharmaceutical Information

This function used for inquiry list of pharmaceuticals, and searching for specific pharmaceutical specific information. This form would be available for all healthcare stakeholders.

Doctor-to-Doctor Information

This function used for sharing unofficial pharmaceutical information among doctors in order to enhance patient care provision.

Safety and Surveillance Information

This function used for sharing safety and surveillance information among medical professionals and used for reporting ADEs information associated to a specific pharmaceutical.

The minimum datapool requirement and specification were concluded and summarized in Table 4.9.

Table 4.9 Datapool requirement and specification

Source	Information Entry	Information Search	Doctor-to-doctor information	Safety update and surveillance information
Literature	√	√	X	X
Focus group#1	√	√	X	X
Focus group#2	√	√	√	√
Focus group#3	√	√	√	√

√ Mandatory functionality

X Preferable functionality

Next, in Chapter 5, the design of a datapool including recommended data standards, list of datapool attributes and detailed functionality will be presented.

CHAPTER V
THE DESIGN OF DATAPOOL

From literatures and existing cases analyzed in Chapter 2 in particular with the data collection process illustrated in Chapter 4, it noted that data standards, datapool attributes and datapool's requirement and specification are ready for constructing. Therefore, the main objective of this chapter is to present the design of an integrated datapool. The components of this datapool can be designed as follows:

5.1 Data Standards

To recommend data standards for this proposed datapool. It used list of data standards summarized in Table 2.3 and 2.4, then matched to data standards characteristics gained from indepth interview summarized in Chapter 4.

The matching result between recommended characteristics and existing data standards are illustrated in Table 5.1.

Table 5.1 The comparison of the characteristics and existing data standards

Data standards	Recommended characteristics			Matching results
	Uniqueness	Globalization	Machine readable	
NHSO'24 digit	X	X	X	This data standards is not unique. It granted at generic name; means different trade products has the same data standards even it has different cost.
FDA's Registration code	√	X	X	This data standards is unique at trade name. However, it is not capable to globalization and machine readable format.
GPSC's Code	X	X	X	This data standards is purposely defined as product classification.
CDG Code	√	X	X	This data standards is unique at trade name. However, it is not capable to globalization and machine readable format.
DMS Code	√	X	X	This data standards is unique at trade name. However, it is not capable to globalization and machine readable format.
TCD's Code	X	X	X	This data standards is purposely defined as product classification.
GTIN	√	√	√	This data standards is fully matched to uniqueness, globalization and machine readable format characteristics.

√ = Matched to data standards characteristics

X = Do not matched to data standards characteristics

Table 5.1 The comparison of the characteristics and existing data standards (cont.)

Data standards	Recommended characteristics			Matching results
	Uniqueness	Globalization	Machine readable	
DIN	√	X	X	This data standards is unique at trade name. However, it is not capable to globalization and machine readable format.
NDC	√	X	√	The identifier is defined as identification of pharmaceutical products
SNOMED-CT	X	√	X	This data standards is purposely defined as product classification.
HIBC	√	√	√	This data standards is fully matched to uniqueness, globalization and machine readable format characteristics.
ATC	X	√	X	This data standards is purposely defined as product classification.
AFHS	X	√	X	This data standards is purposely defined as product classification.

√ = Matched to data standards characteristics

X = Do not matched to data standards characteristics

In Section 4.1, the conclusion from number of indepth interview method pointed out that the uniqueness at dispensing unit of any pharmaceuticals, globalization and machine readable format are the recommended data standards characteristics across HSC in Thailand. After matched these characteristics to existing data standards, Table 5.1 indicated that lastly only HIBC and GTIN aligned with recommended

characteristics. Therefore, the NHSO'24 digit, GPSC, TCD, SNOMED-CT, ATC and AFHS data standard are weed out.

To decide between HIBC and GTIN, number of case studies are analyzed to support justification.

The FDA United States has audited the use of data standards in 2004 and they mentioned that the use of HIBC is decreased from 77% to 56% with a corresponding adoption of GTIN data standards is increasing from 23% to 44% over the same period and they predicted that the HIBC data standards will disappear due to its limitation (Dennis O-Keefe, 2012). The Canadian Institute for Health Information has surveyed the use of data standards in hospitals and suppliers in Canada in 2010 and found that 89% of hospitals and 75% of suppliers agreed that GTIN will benefit their HSC system, and they indicated the top four benefits are: patient safety, enhanced product traceability, cost savings and error reduction (ISMP, 2013). Gerle Ziekenhuizen Maastricht hospital in Netherlands stated that implementing GTIN data standards at point-of-care reduced their administration errors from 3.10% to 0.84% or 74% reduction (Wesselink and Ziekenhuizen, 2006). While Chelsea and Westminster Healthcare NHS Trust in United Kingdom deployed the robotic dispensing system by adopting GTIN data standards resulted in a reduction of dispensing errors from 2.7% to 0.9% of prescriptions or 67% reduction (Robertson, 2007 and Mohan et al., 2014). Bad Krozingen Hospital in Germany, they introduced the use of GTIN barcoding system in their hospital resulted in saving a significant 78% in consumable supplies (Klein, 2006). The Moorfields Eye Hospital in United Kingdom implemented GTIN data standards to improve efficiency in their operations (Kotecha et al., 2014). In United Kingdom, Airedale NHS Trust implemented GTIN on patient wristbands to deliver the right treatment to the right patient as well as Wythenshawe Hospital, they implemented GTIN data standards to uniquely identify, track and trace surgical instrument trays (Lynch, 2009). The University Hospital CHU Dijon in France has deployed the traceability platform based on GTIN data standards to track product data from receiving the products until their administration or usage (Marechal and Jost, 2015). In 2007, the UK Department of Health issued a policy guidance document recommending that the GS1 System should be adopted throughout the Healthcare system in England (ABHI and GS1, 2013).

From existing cases above, it seen that HIBC data standards is decreased and will be disappeared soon while the use of GTIN is increasing. The GTIN benefits are widely accepted in many hospitals and suppliers. It noted that global data standards is needed to enable the efficient and effective roll-out of data standards throughout the entire HSC. HSC is by nature a global supply chain, with supply chain that often cross borders. Local needs are incorporated into global data standards, but local data standards hinder interoperability and compatibility. From this analysis, it can concluded that the GTIN data standards is seen to be the most effective and technologically sound system to implement as data standards across HSC in Thailand. Therefore, in our proposed datapool, the GTIN will be deployed as a primary key and reference to existing national data standards including the FDA's registration code, NHSO's 24 digit and the TMT code.

The coding structure of GTIN data standards described in Table 5.2.

Table 5.2 The coding structure of GTIN data standards

Segment	Description	# of digits
Holder or manufacturing identification	The number assigned to brand holders or manufacturing companies by the GS1. The inclusion of the GS1 company prefix ensures uniqueness throughout the world.	7
Product identification	The number assigned by the brand holders or manufacturers of the GS1 company prefix to uniquely identify a trade item within the organization.	5
Check digit	The calculated one-digit number used to ensure data integrity.	1

Source: GS1 organization

5.2 Datapool Attributes

To recommend datapool attributes that should be kept in an integrated datapool, the list of 38 data attributes in Section 4.2 is used to develop a check sheet and used semi-structure interview method to gain ideas from medical professionals and supply chain practitioners. Finally, the informant highlighted 33 datapool attributes effecting to supply chain efficiencies and patient safety. These datapool attributes classified into 4 categories as follows: identification code, pharmacological information, clinical information and logistics information. The data attributes that should be kept in proposed datapool are illustrated in Table 5.3.

Table 5.3 Datapool attributes

No	Name of attributes	Description
Identification code		
1	Identification code	GTIN
2	Reference codes	Registration code, Drug24, GIIN and TMT
Pharmacological information		
3	Trade name (Trademarks)	Indicates the trade or brand name under a proprietary, trademark-protected which the pharmaceutical product is marketed
4	Generic name	Indicates the generic name or active ingredients of pharmaceutical products
5	Dosage form	Indicates the physical form in which a drug is produced and dispensed e.g. tablet, capsule, powder, etc.
6	Route of administration	Indicates the way of administering a drug to a site in a patient e.g. oral, topical, intramuscular, rectal, etc.
7	Dosage or Prescription Unit	Indicate the unit of measurement of the lowest level of drug formulation hierarchy intended or labeled for individual presentation forms e.g. tablet, capsule, bottle, etc.

Table 5.3 Datapool attributes (cont.)

No	Name of attributes	Description
8	Active ingredient or Substance	Indicates the component that provides pharmacological activity in the diagnosis, cure, mitigation, treatment, or prevention of disease, or to affect the structure or any function of the body of man.
9	Strength	Indicates how much of the active pharmaceutical ingredient is presented in a dosage unit e.g.: 5 millilitre [mL] or 15 mL.
10	Registration or Application number	Indicates the registration code assigned by the Thai FDA to a drug product prior to being market in Thailand.
11	Product nomenclature	Nomenclature is the classification of pharmaceutical products regarding to ATC and AHFS schema
Clinical information		
12	Indications	Indicates those diseases, signs and symptoms that may be treated by using a specific drug.
13	Contraindications	Indicates those conditions, physical, mental or emotional state as well as other signs and symptoms which may be present where a specific drug should not be used.
14	Dosage	Guideline the amount of drug taken at any one time. This can be expressed as the weight of drug (e.g. 250 mg), volume of drug solution (e.g. 10 mL, 2 drops), the number of dosage forms (e.g. 1 capsule, 1 suppository) or some other quantity (e.g. 2 puffs)

Table 5.3 Datapool attributes (cont.)

No	Name of attributes	Description
15	Overdose	Describes the ingestion or application of a drug or other substance in quantities greater than are recommended or generally practiced
16	Adverse drug reactions	Guidance an expression that describes harm associated with the use of given medications at a normal dosage during normal use
17	Drug Interactions	Guidance the effects, either beneficial or harmful, that may arise from the mix of chemicals from different substances.
18	Administrations	Indicates the way the dosage form is given. Common routes of administration include oral, rectal, inhalation, nasal and topical.
19	Precautions	Describes related to a specific drug serves as notice to inform the patient that there may be risk in using the drug in certain diseases or medical states.
20	Special precautions	Guidance for professionals in making appropriate decisions about drug therapy in pediatric, geriatric, pregnant, or lactating patients.
21	Pregnancy category	Recognize drug therapy that may not be appropriate for pregnant women
Logistics information		
22	Presentation or Packaging Unit	The form of presentation in which the drug product is formulated and supplied e.g. tablet, box, bottle, and etc.
23	Barcode number	A numeric barcodes used to uniquely identify presentation form of drug trade products.

Table 5.3 Datapool attributes (cont.)

No	Name of attributes	Description
24	Barcode symbology	Identify the symbology of barcode marked on package e.g. 1D, 2D
25	Conversion factor	The numerical factors that enable to perform transactions in units other than the prescription unit of the drug being transacted e.g. a box contains of 100 tablets.
26	Storage condition	Guidelines for temperature control of pharmaceutical products during storage and transportation.
27	Weight	A weight unit of measurement e.g. gram, kilogram and etc.
28	Volume or Content	The volume for one presentation unit of the pharmaceutical products e.g. 60mL, 120mL and etc.
29	Packaging dimension	A dimension unit of measurement e.g. millimeter, meter and etc.
30	Image or Presentation	Attach the images of product packages.
31	Brand owner	Indicates the name and address of brand owner of pharmaceutical products
32	Manufacturer	Indicates the name and address of manufacturer of pharmaceutical products
33	Distributor	Indicates the name and address of distributor of pharmaceutical products

Compare the list of datapool attributes to existing databases illustrated Table 2.4, the recommended datapool attributes introduced originally on 11 datapool attributes as follows: identification code, reference national identification code to other healthcare authority's coding systems in Thailand, brand owner of a pharmaceutical product, dosage and presentation unit of measurement and its unit conversion, barcode number and symbology, unit weight, unit volume, packaging dimension, and image of pharmaceutical products.

The comparison of datapool attributes among pharmaceutical databases is presented in Table 5.4.

Table 5.4 Recommended data attributes against existing databases

	Existing databases						
Needed datapool attributes	**FDA**	**Ya&You**	**MIMS**	**CareNET**	**Health**	**NDC**	**Originality in proposed datapool**
Identification code	X	X	X	X	X	X	Originality
Reference codes	X	X	X	X	X	√	Originality
Trade name	√	√	√	X	X	X	-
Generic name	√	X	√	X	X	X	-
Dosage form	√	√	√	X	X	X	-
Route of administration	√	√	√	X	√	√	-
Dosage or Prescription Unit	√	√	√	X	√	√	-
Active ingredient or Substance	√	√	√	X	X	X	-
Strength	√	√	√	X	X	X	-
Registration or Application number	√	√	√	X	X	X	-
Product nomenclature	√	√	√	X	X	X	-
Indications	√	√	√	X	X	X	-
Contraindications	√	X	√	X	X	X	-
Dosage	√	√	√	X	X	X	-

Table 5.4 Recommended data attributes against existing databases

Needed datapool attributes	Existing databases						Originality in proposed datapool
	FDA	Ya&You	MIMS	CareNET	Health	NDC	
Overdose	√	√	√	X	√	√	-
Adverse drug reactions	√	√	√	X	√	√	-
Drug interactions	√	√	√	X	X	X	-
Administrations	√	√	√	X	X	X	-
Precautions	√	√	√	X	X	X	-
Special precautions	√	√	√	X	X	X	-
Pregnancy category	√	X	√	X	X	X	-
Presentation or Packaging unit	X	X	X	X	X	X	Originality
Barcode number	X	X	X	X	X	X	Originality
Barcode symbology	X	X	X	X	X	X	Originality
Conversion factor	X	X	X	X	X	X	Originality
Storage condition	X	√	X	X	X	X	Originality
Weight	X	X	X	X	X	X	Originality
Volume or Content	X	X	X	X	X	X	Originality
Packaging dimension	X	X	X	X	X	X	Originality
Image or Presentation	X	X	X	X	X	X	Originality
Brand owner	√	√	√	X	X	X	-
Manufacturer	√	√	√	X	X	X	-
Distributor	√	√	X	X	X	X	-

√ = Available in reviewed databases

X = Not available in reviewed databases

Table 5.4 illustrated recommended datapool attributes that have significant impacts to operational efficiency and patient safety. Compared to existing datapool application, it pointed out that no such datapool applications can fulfilled the completely information needed among healthcare stakeholders. Only the NDC and CareNET datapool applications contain some logistics information while Health Canada and MIMS aimed to present pharmacological and clinical information of a pharmaceutical product. Hence, this proposed datapool contains mostly of datapool attributes needed among healthcare stakeholders subjected to operational performance improvement and collaboration enhancement.

5.3 Datapool Requirement and Specification

Regarding to literatures and existing cases reviewed in Chapter 2 in particular with data standards and datapool attributes collection in Chapter 4, it can identify the structure and functionality for an integrated datapool. The results from the focus group discussion suggested for 4 main functionalities should had in proposed datapool application as follows: 1) entering of product information, 2) searching for product information, 3) doctor-to-doctor information sharing for ADEs and safety information updates and, 4) reporting safety updates and surveillance information. From this analysis, it analyzed that the proposed datapool must be designed into 3 different layers as follows:

Database Layer, this layer contains tables and tables relationships for storing datapool attributes mentioned in Section 5.2;

Application Layer, this layer contains programs and application for entering, inquiry and searching for datapool attributes, and also integrating datapool attributes with other datapool systems and;

Graphic User Interface or GUI Layer, this layer contains forms and layouts for users to access to the specific datapool attributes and other relevant information in the database's tables.

In the proposed datapool, the sensitive pharmacological and clinical information relevant to a pharmaceutical product are limited accessibility to medical professionals. Importantly, the adverse drug events (ADEs) information is managed in 3

different perspectives as follows: 1) pharmaceutical management and reporting used for manage the overall pharmaceutical product movement, 2) information notification used for reporting the severity and the type of adverse events of any pharmaceutical products and, 3) professional information sharing used for sharing information on which medical professionals should know to support their provision of patient care.

The functionality of this proposed datapool is illustrated in Figure 5.1.

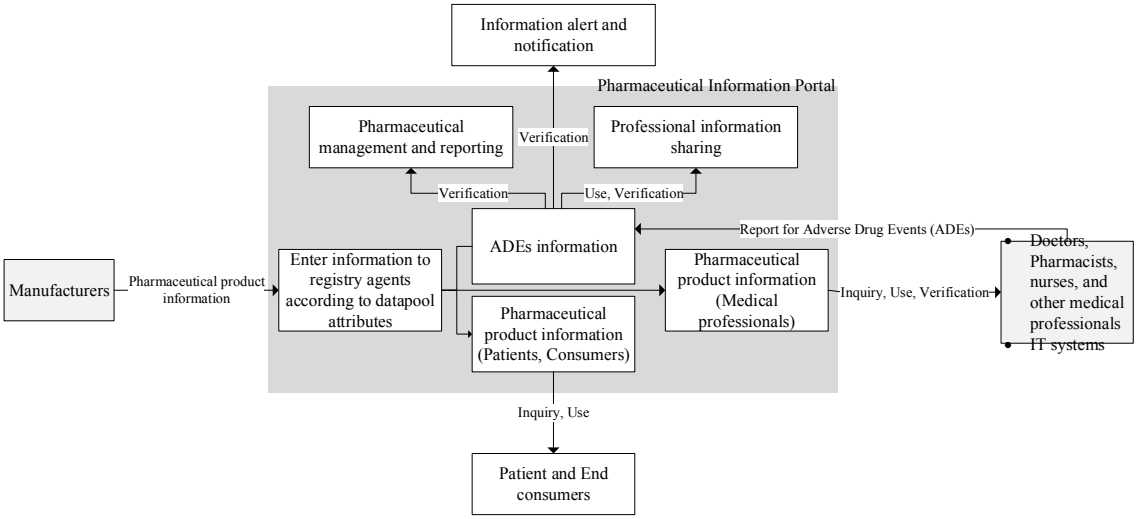

Figure 5.1 The functionality of datapool

This conceptual design and also its functionalities are discussed among doctors, nurses, pharmacists, supply chain practitioners, IT experts and end consumers during focus group discussion and it widely accepted.

To work with this proposed datapool, the manufacturer is responsible to enter recommended datapool attributes into the proposed datapool. After that, the registry agents verify and authorize for product name, description and its relevant information. Only authorized datapool attributes are shared to healthcare stakeholders. In term of informal safety updates and surveillance information, medical professionals can share this information within their groups for better patient care provision. However, the formal safety updates and surveillance information that are validated by the Department of Medical Sciences are published for safety awareness on specific pharmaceutical products.

Therefore, it can concluded that the datapool's Graphic User Interface (GUI) should composed of at least 4 user interface portals as follows:

1.	Enter information	This portion is allowed for manufacturers to enter and edit data attributes related to their pharmaceutical products.
2.	Searching information	This portion is used for searching data attributes related to a pharmaceutical product. Mainly information can be explored in local language for self-awareness of product consumed.
3.	Doctor-to-doctor sharing	The information in this section is required authorization and authentication before accessing to safety and surveillance information of a pharmaceutical product. This section limits use for only medical professionals.
4.	Safety updates and surveillance	This section is similar to professional information required authorization and authentication. The ADEs information will be exchanged among healthcare stakeholders for product recalls, provision of care and surveillance awareness.

To construct conceptual design of an integrated datapool, the data standards and datapool attributes presented in section 5.1 and 5.2 are mapped to the datapool contents described in section 5.3.

The mapping of data standards and its datapool attributes to proposed datapool specification is illustrated in Figure 5.2.

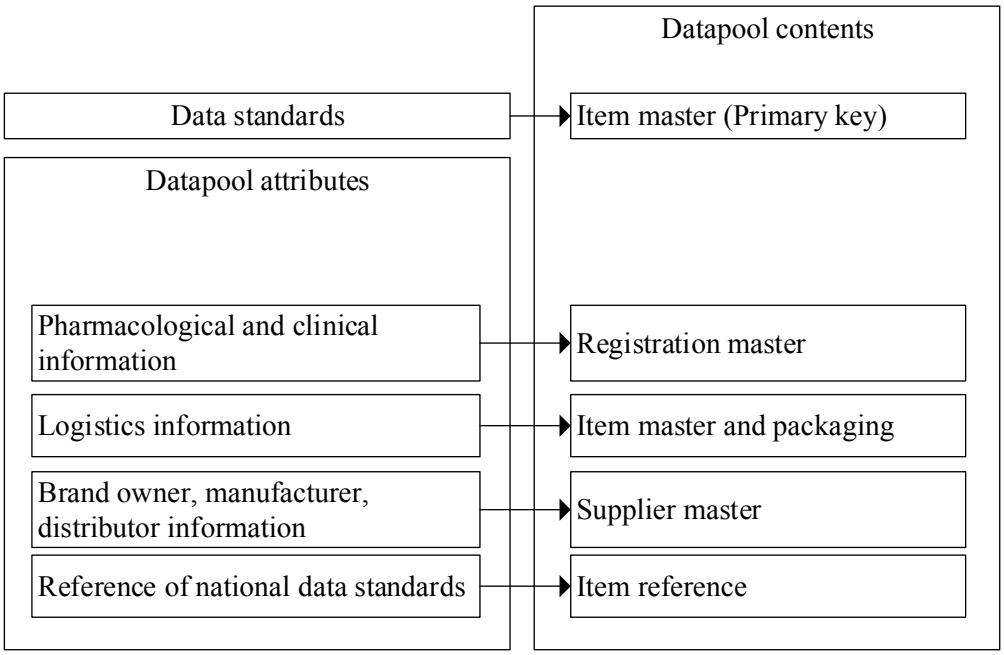

Figure 5.2: Mapping of data standards, datapool attributes and datapool content

After several focus group discussions, the application design and architecture of an integrated datapool are fully designed and illustrated in Figure 5.3.

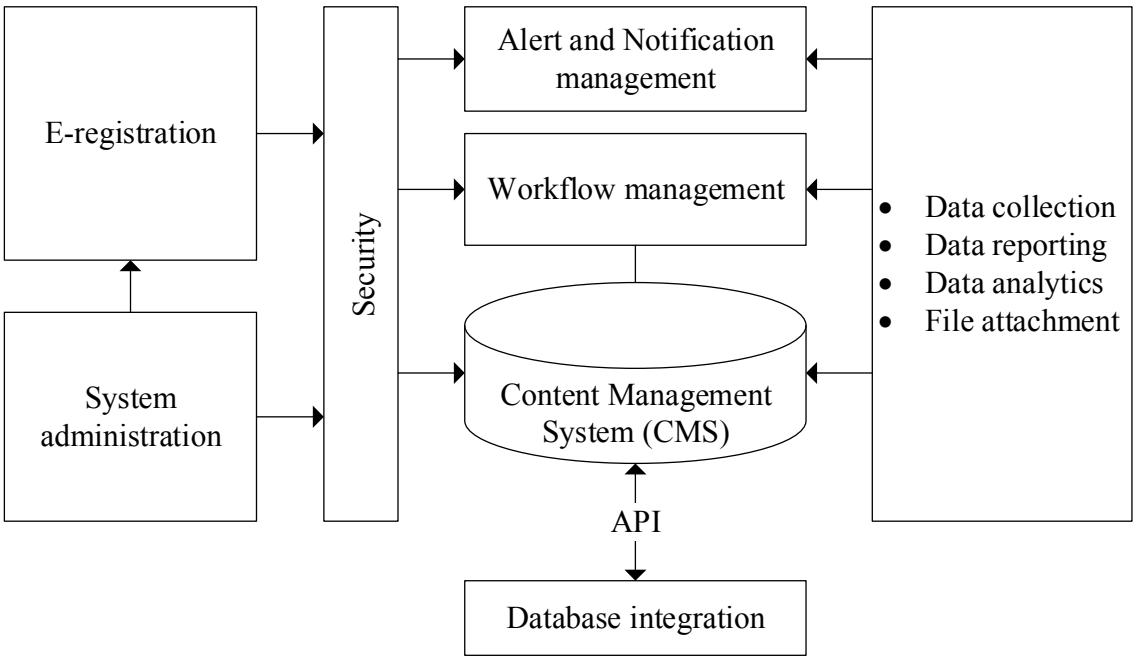

Figure 5.3 Application architecture of datapool

From Figure 5.3, the application GUI and functionality are defined. The functionality of proposed datapool consists of 6 sections as follows;

Registration, this GUI includes the functionality of enter new product information, update and delete existing production information.

Search product information, this GUIection includes the functionality of searching product information. The search criteria can be searched by single and multiple conditions.

Master data configuration, this GUI involves with content management or master data configuration such as list of unit of measure, dosage form, strength unit and etc.

User administration, this GUI includes user name and password maintenance.

Inquiry and reports, this GUI includes online inquiry for product information and print out product information reports and;

Application Interface, this interfacing section includes the database integration regarding to information via application interface tables.

From Figure 5.3, the detailed design and GUI forms of an integrated datapool are illustrated in Appendix I and Appendix II respectively. Here after, an integrated datapool has been developed and ready for experiment.

Next, in Chapter 6, the pilot case study will be implemented in real-life context focusing on information sharing to evaluate the power of proposed datapool in term operational performance improvement and collaboration enhancement among healthcare stakeholders.

CHAPTER VI
THE USE OF DATAPOOL FOR HSC COLLABORATIONS

In Chapter 5, the design of an integrated datapool has been finalized and also constructed. Then, the use of this proposed datapool to increase operational performance and enhance HSC collaboration must be tested. Therefore, in this chapter, the experiment of the proposed datapool in real-life context is illustrated. The HSC is facing spiraling cost burden and hospitals are finding tough time to provide patient care provision at affordable cost, then their focus has shifted from managing procurement to manage supplier relationships (Chakraborty et al., 2014). Wöß and Dunzendorfer (2002) presented that the concept of centralized datapool is introduced in tourism which allows to uniform and homogenous data interchange between a web-based EDI application and distributed heterogeneous IT systems. They indicated for the advantage of this concept is that both the stakeholders' adapters and EDI server adapter are designed as add-on modules and therefore their installation causes only low adaptation effort concerning existing IT systems. Regarding to Wöß and Dunzendorfer in particular with our study looks specifically at Electronic Data Interchange (EDI) and its relationship to supply chain collaboration. Then, testing the use of an integrated datapool through web-based EDI system model is considered.

EDI has multiple definitions. The USDA (2011) defined EDI as the electronic exchange of business documents such as purchase orders, invoices, application forms, etc. from one organization's IT systems to another organization's IT systems in standard data formats. Ngai and Gunasekaran (2004) also described EDI as the technology by which business documents such as purchase orders, invoices, shipping advises are transmitted electronically via Internet. This is supported by O'Leary (2000), they defined EDI as the electronic transmission of documents such as purchase orders or invoices between IT systems in different organizations based on a standard, structure and machine-retrievable format. Banerjee and Golhar (1994) defined EDI as information exchange between a firm and its customers and suppliers

and recognized as the new frontier of communication technology that facilitates information exchange.

From those literatures, it can concluded as EDI is the transfer of business documents, such as purchase orders electronically between organizations in a structured, computer- retrievable format that permits data to be transferred without rekeying from an IT system in one stakeholder to an IT system in another stakeholder. It formatted these documents according to an agreed-upon structure. Discussed on implementation, an EDI implementation is a process in which two or more organizations determine how to work together more effectively through the use of EDI systems. Hence, it can describes that EDI serves as a catalyst and a stimulus to improve the business process that flow between organizations. It reduced costs, delays, and errors inherent in a manual document-delivery system.

Successful implementation and application of EDI offers numerous benefits in regard to supply chain collaboration. Hill and Scudder (2002) stated that EDI helps on information sharing and collaboration enhancement. Nanjira (2009) argued that EDI improves operational efficiency, enhance information quality, and achieve reductions in processing time of critically important documents.

Bergeron and Raymond (1992) indicated that the benefits of implementing EDI systems are improvements in terms of information quality, transaction speed, administrative costs, strategic advantage and operations management. In other researches, Magutu et al. (2010) highlighted for ability to access to rigid information, enhance competitive advantage and improve trading relationship. (Hill and Scudder, 2002) indicated for EDI benefits in term of increasing inter organizational co-ordination of activities and of increasing the integration that occurs between supply chain members. While Sokol (1995) indicated the ability to improve certain business services significantly, increase in productivity and enabling faster and more efficient information exchange with trading partners. Furthermore, Greenstein et al. (2000) stated for reducing lead-time from placing the order to receiving the goods form suppliers, reducing errors associated with manual interations and data entry, and greater sharing of information and greater tracking of data. In addition, Walton and Gupta (1999) also argued for cost savings by reducing paperwork and minimizing costs for both coordinating and processing transactions. Droge and Germain (2000)

pointed out for increasing of coordination between trading partners' IT systems, which allows shorter order cycles and higher inventory turnovers. Lee and Han (2000) argued for reducing transaction-related costs of co-ordination between firms via a standardization of tasks and communication between chain members. This is similar to Sohal et al. (2002), they stated that EDI reduces data entry costs and purchase order costs.

EDI application as well enables timely response. This is because of the speed in which the trading partners receive and incorporate the information into their IT systems as a result greatly reducing cycle time (Gottardi and Bolisani, 1996). Langbeer and Helton (2015) also found that EDI system helps to manage better flow of products, information, fund, and service for healthcare stakeholders in the HSC, from manufacturers to distributors to hospitals to the point of care and patients.

From literatures, with EDI system, these organizations also benefit for raising the bar for information sharing and collaboration among supply chain members, enhancing information quality, and achieve reduction in processing time. To exchange information, the structure, standard format and content of EDI documents including the data fields that may be included in a document, the sequencing and format of fields, and etc must be clearly structured. These information, known as transaction sets or messages, are used to exchange business documents between organizations.

For the use of EDI in HSC, literatures argued for the necessary to define and use standardized format including pharmaceutical code, standard data attributes, and standard message to exchange business documents. Hence, the standard data attributes must occur, clear, common, acceptable, comprehensive and well-defined information structure in order to facilitate efficient information sharing and collaboration among healthcare stakeholders and minimize misunderstandings (ATC, 1991; Lubitz and Wickramasinghe, 2006). Although some data standards have already been used in other industries, but it still needs to develop a specific standard data attributes for information exchange process based on the proposed datapool presented in Chapter 5. Of that EDI benefits altogether with testing the use of datapool, the EDI application is suitable to increase operational performance and enhance collaboration among healthcare stakeholders.

From literatures mentioned above, there are numerous benefits are discussed. In a paper-based transaction system, number of delays occur along the timeline caused primarily by delivery delays regarding to mail system or by any other system required to physically move paper documents between hospital and supplier, as well as the manual processing delay caused by the need to key and re-key information. Furthermore, operating costs, manual processing is required for data keying, document storage and retrieval, document matching, envelope stuffing, etc. Speed of processing is another time-sensitive kinds of quality concern. Thus, the process time, operating costs, and information visibility and quality are evaluated in the test of proposed datapool adoption.

Hence, in this chapter, the use of web-based EDI system model using an integrated datapool in together with its evaluation will be presented.

6.1 Case Study Environment

To setting up case-based environment, number of hospital and suppliers were invited to participate. In our case study, a leading hospital and four major suppliers were organized. The participant of case study would be described as follow:

Ramathibodi Hospital was one of Thailand's leading university hospitals. It had 960 in-patient beds and served for average daily 5,000 out-patient visits. In term of inventory, there are 2,100 SKUs of pharmaceuticals supplying from ninety-four suppliers. To identify pharmaceuticals, it created internal unique identification code defining at level of generic name instead of trade name of pharmaceuticals. The main logistics and supply chain process are composed of purchasing, receiving into stores, storage, refilling for sub-storage warehouses and dispensing to patients. The inventory management described as a multi-echelon inventory system, the receiving process in performed against central warehouse and later distributed to sub-storage warehouses and dispensing points e.g. operation rooms, recovery wards, medical dispensing units and etc. The demand of pharmaceuticals was drawn from prescription orders prescribed by doctors. There is some small in-house production such as chemo and in-house of pharmaceuticals. In term of IT systems, they also deployed various kinds of IT systems vary from Enterprise Resource Planning (ERP) to health IT systems such

as HIS, CPOE, CDSS. The ERP handle for material transactions including procurement, inventory management, planning and forecasting, production, billing and financial management of pharmaceutical products while health IT systems handle for diagnosis, clinical care treatment and dispensing pharmaceuticals.

The General Hospital Product (GHP) was a state-owned manufacturer. They produced 240 pharmaceuticals supplying to hospital. Mainly of pharmaceuticals produced in their production lines, however there are some outside processing. In term of IT systems, they implemented ERP system for their order processing, inventory management and billing. The main logistics process were composed of sales order processing, storage, pick & pack and shipment to hospital. The current process relied on manual interventions such as sales representative re-key sales orders onto the screen of ERP systems and mainly of logistics communication relied on telephone, fax or email. To transport pharmaceuticals, they use third-party logistics to manage and ship their pharmaceuticals to hospital.

The DKSH was an international distributor recognized as the leader of pharmaceuticals supplied in Thailand. They supplied nearly 2,400 pharmaceuticals to hospital. In term of business, they imported or bought pharmaceuticals from manufacturers and then shipped to hospital. In term of IT systems, they implemented state-of-art ERP system for their order processing, inventory management and invoicing. The main logistics process involved sales order processing, storage, pick & pack and shipment to hospital. The current process relied on manual interventions such as sales representative key-in sales orders onto the screen of ERP systems and mainly of logistics communication relied on telephone, fax or email. To transport pharmaceuticals, the company used third-party logistics to manage and ship their pharmaceuticals to hospital.

F.E. Zuellig was the biggest local distributor for pharmaceuticals supplied in Thailand. They supplied nearly 1,800 pharmaceuticals to hospital. Their business was similar to D1, mainly of their pharmaceuticals bought from manufacturers and later supplied to hospital. The main logistics process involved sales order processing, storage, pick & pack and shipment to hospital. The current process relied on manual interventions such as sales representative key-in sales orders onto the screen of ERP systems and mainly of logistics communication relied on telephone, fax or email. To

transport pharmaceuticals, the company used third-party logistics to manage and ship their pharmaceuticals to hospital.

6.2 Business Transaction Process

To understand current situation of information exchange between hospital and its suppliers, the direct observation is conducted. Due to our study is performed on the real case and some outputs related to convey interventions into implementation. Thus, a framework that guidance us to build a knowledge base is needed. The value and value creation method introduced by Porter on 1985 is used as a guidance to model our understanding in term of procedures of information sharing and collaboration; identify critical activities, defining the performance indicators to access to information sources based on metrics in accordance with the value definition. The hospital in our study is concerning to the value of information sharing in the case supply chain. The systematic analysis approach is the original method performed in the case study. Therefore, the process model that has been developed by the ICAM (Integrated Computer-Aided Manufacturing) is used to model the process of information flow. The process model represents the activities in the point of view that how the process interrelated, resource used to perform the activity, and the result of each activity. In addition, organization documents received during the observations and interviews are used to underpin the data collection. The main data collection method in case study is observation and semi-structured interviews conducted in the hospital. The aim of the interviews is to gain more detailed information on the current level and context of information sharing and collaboration in the supply chain dyads between hospital and their suppliers. Another objective was to acquire information on the performance measurement and performance goals in the dyads. During the interviews, supporting documents, such as minutes of meetings, purchase orders, stock plan and schedules, organization charts, etc. are collected and used as supporting research material whenever justified. Based on the interviews a detailed description of the activities and information flows in the supply chain dyads is formed. Information on the services provided and the relationship between hospital and their suppliers is gained for the analysis of the contextual setting.

During the conducting case study, a number of rechecked workshops are conducted to confirm the outputs in regular basis that are:

In the first workshop, detailed of processes related to pharmaceuticals movement and its associated information flow are clarified based on the closeness of the supplier-hospital relationship. In this workshop, the topics under discussion included:

- key activities or processes,
- key actors regarding the information flow,
- procedures and IT systems used for information sharing and collaboration
- critical information attributes sharing, and
- methods used in information sharing between the supply chain participants.

This workshop was aimed at understanding the current business process of information sharing and collaboration in the case supply chain environment. The supplier-hospital relationship was illustrated in Figure 6.1.

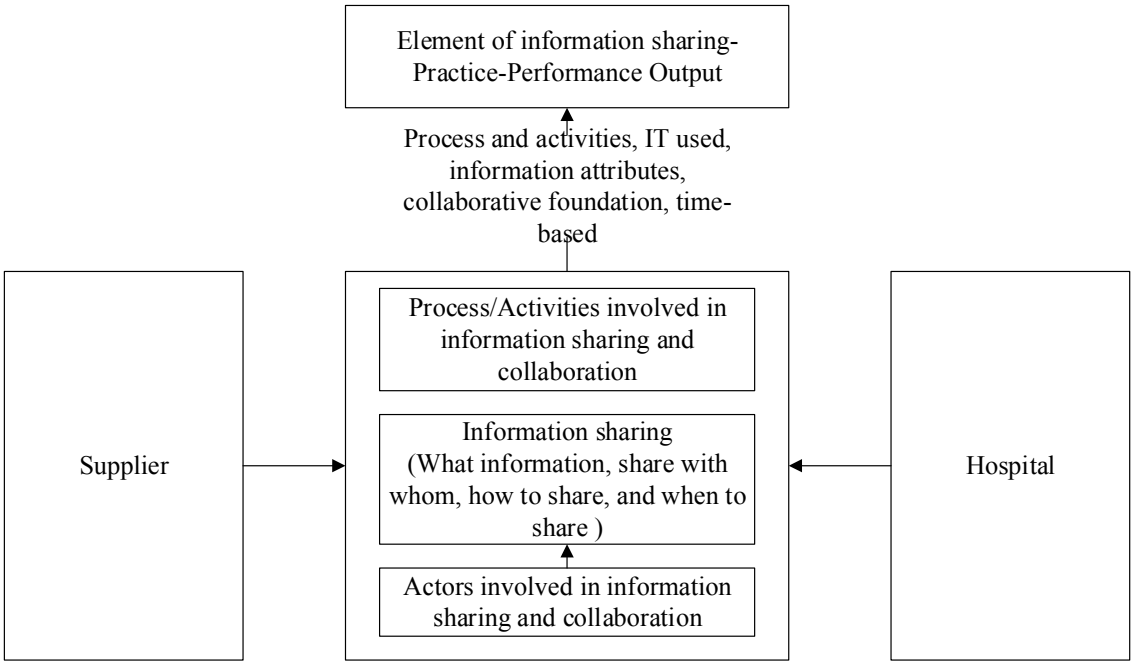

Figure 6.1 The Analysis Process in Hospital Case Study

In the second workshop, the experiment results collecting from experiment were discussed and categorized. This second workshop discussion involved the benefits resulting from experiment, difficulties to implement the proposed model, and also limitations.

The buying-selling process in our case study starts with the buyer issues a draft purchase order or unapproved status of purchase orders based on requestor's requirement using ERP system. Each purchase order is referred to by the PO number, which is automatically generated by the ERP system. After that the draft purchase order has been sent to a selected supplier by postal mail, fax and email. The following process at supplier, the order details is checked for pharmaceutical availability and schedule ship dates. If the availability of pharmaceutical is outstanding, contact is made with the buyer to identify its status by fax or email. In this step, buyer may revises the order details based on supplier's acknowledgement. The revised draft purchase order is then printed out and submit for approval by the purchasing manager. After that, the PO status will be updated in ERP system by the buyer and notified the PO status to supplier to arrange pick up of original purchase order.

In this step, the supplier arranged their messengers to pick up purchase order at hospital's purchasing department and presented it to sales representatives. Then, a sales order is created against PO in supplier's ERP systems. The next process is the picking, packaging and generating shipping labels based on hospital's requirement. All pharmaceuticals delivered to the hospital are listed on the Delivery Order (DO), each of which has a unique number. In this step, the store picker updated the inventory onhand in ERP systems according to the information in the DO to ensure the inventory onhand is up-to-date and an invoice is made based on the shipped quantity. Deliveries are made based on a schedule. Usually, deliveries will be made once or twice a week, with vehicles adopting a milk-run approach and delivering to a number of hospitals. Before the delivery is made, the sales representative notifies the delivery schedule to the buyer in hospitals.

When the pharmaceutical arrives at the hospital's warehouses, the store keeper, buyer and authorized inspector check whether the pharmaceuticals delivered to the hospital are the same as those on the DO, PO and invoice documents, and the packages are on the right conditions. If satisfied, the products are delivered to the store

or fridge, depending upon whether the pharmaceutical needs to be kept chilled. The DO need to be signed as a proof of pharmaceutical receipts, with a copy being returned back to the supplier through the shipper.

During the observation, the process, the operator and process time consumed are recorded. To measure the cost of EDI adoption, it was collected through the description of hospital processes and activity-based costing by considering the PO and ASN as the product examined. The aforementioned data collection and data analysis approach can be summarized in the following steps (E. Kioses, 2007):

Step 1: Map the process

Step 2: Identify sources of cost in the process

Step 3: Measure the sources of cost

Step 4: Validate measurements for the case

Step 5: Cost model development

Step 6: Experiment with different scenarios

Data analysis followed, including detailed write-ups, transformation of this information to a more structure registry, cost model development, scenarios development and recollection of data. The different scenarios were presented in the following section. The final steps of this case study include the shaping of hypotheses, generalization, enfolding of literature and reaching a closure. The following section presents the results of the research. Before presenting the results of this study, the document flow in buying-selling process was presented, as it was recorded during the in-depth interviews. Then, the different scenarios developed are presented. The buying-selling process of hospital case study was illustrated in Figure 6.1.

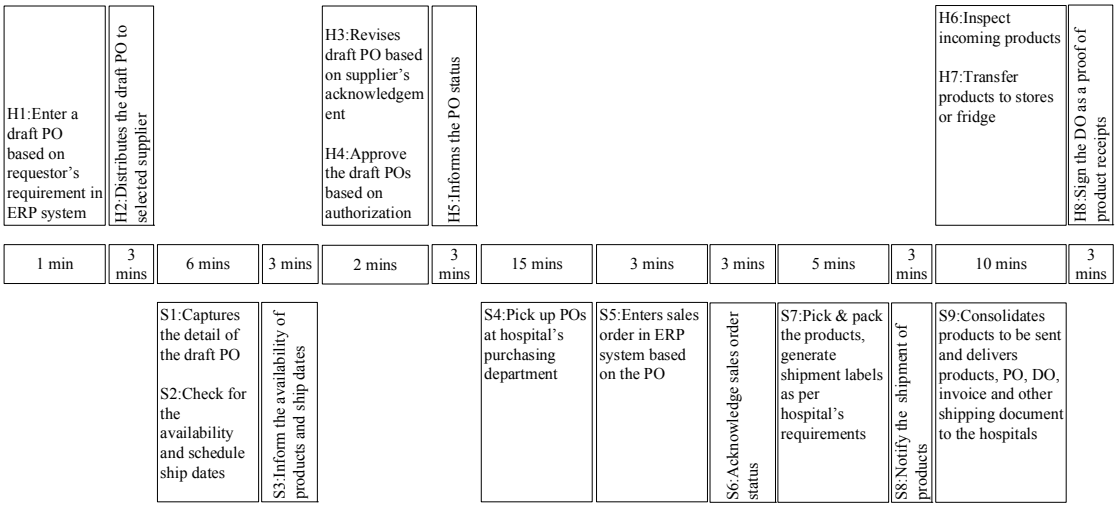

Figure 6.2: Process and time spending for current information sharing process between hospital and supplier

The overall step was 17 steps start at issuing a purchase order and end with receiving pharmaceutical shipment into stores. These steps accounted for 8 steps in hospital side and 9 steps in suppliers' side. Table 6.1 summarized the process steps and process time in exchanging documents.

Table 6.1 The EDI process time in hospital case study

ID	Activity	Actor	Time (min)	Document	Communication
H1	Enter a draft PO based on requestor's requirement in ERP system	Buyer	1		
H2	Distributes the draft PO to selected supplier	Buyer	3		Fax, Email
S1	Captures the detail of the draft PO	Seller	3		
S2	Check for the availability and schedule ship dates	Store picker	3		
S3	Inform the availability of products and ship dates	Seller, Buyer	3		Fax, Email

Table 6.1 The EDI process time in hospital case study (cont.)

ID	Activity	Actor	Time (min)	Document	Communication
H3	Revise draft PO based on supplier's acknowledgement	Buyer	1		
H4	Approve the draft POs based on authorization	Manager	1		
H5	Inform the PO status	Buyer, Seller	3		
S4	Pick up POs at hospital's purchasing department	Messenger	15	PO	Man
S5	Enters sales order in ERP system based on the PO	Seller	3		
S6	Acknowledge sales order status	Seller, Buyer	3		Phone
S7	Pick & pack the products, generate shipment labels as per hospital's requirements	Store picker	5	DO	
S8	Notify the shipment of products	Seller, Buyer	3		Phone
S9	Consolidates products to be sent and delivers products, PO, DO, invoice and other shipping document to the hospitals	Shipper	5		
H6	Inspect incoming products	Authorized inspector	1		

Table 6.1 The EDI process time in hospital case study (cont.)

ID	Activity	Actor	Time (min)	Document	Communication
H7	Transfer products to stores or fridge	Warehouse operator	4		
H8	Sign the DO as a proof of product receipts	Warehouse operator	3		Man
	Total process time (min)		**60**		

The cost of aforementioned was calculated based on the quantified elements of the process described in Table 6.1. As far as the cost of the process was concerned, there are several cost factors in this process. The main cost factors that influence the total cost of EDI identified as followed:

- Labour costs associated with the processing of PO and ASN
- Documentation cost and;
- Communication cost

The calculation of labour costs for the buying-selling process was based on the process time for each activity related to exchanging PO and ASN documents. The operator provided the number of PO and ASN on monthly per organization and the average process time for the activities. Regarding the process time, different activities occurred, in which the average time was used for calculations. The labour cost was based only on man-hours of full-time personnel employed in the hospital case study. For instance, the PO sent, buyers contributed on entering draft PO based on requestor's requirement in ERP system and sending the draft PO to selected supplier. This activity took 3 minutes per PO process time required. As well as sales representative contributed for capturing details on draft PO, checking for the availability of ordered pharmaceuticals, and scheduling for ship dates. These activities took 3 minutes per PO process time required. In this hospital case study, according to

conservative estimated of the actors, the salary and wages for actor, and labour cost per hours might defined as followed:

$$\frac{\text{salary per month (baht)}}{\text{22 working days per month*8 hours per day}}$$

According to the actor described in Figure 6.1 in particular with process time documented in Table 6.1, hence the labour cost per hour was presented in Table 6.2.

Table 6.2 The labour cost on buying-selling process

Stakeholder	**Actor**	**Salary/Month (baht)**	**Labour cost/Hour (baht)**
Hospital	Buyer	20,000	113.4
	Manager	45,000	255.15
	Warehouse operator	20,000	113.4
	Authorized inspector	20,000	113.4
Supplier	Seller	20,000	113.4
	Messenger	20,000	113.4
	Store picker	20,000	113.4
	Shipper	20,000	113.4

The communication cost was directly calculated for the facilities used e.g. telephone communication charges or the cost of mail. According to conservative estimated of the participants, the communication cost was 5 baht for sending fax or email and 3 baht for telephone communication. In term of documentation, according to conservative discussion, purchase order form was 7 baht per purchase order as well as delivery order forms. Table 6.3 summarized the results for current practice. This table included the average cost per PO and ASN as well as an indication of the cost.

Table 6.3 The information exchange process cost in hospital case study

ID	Activity	Labour cost	Documentation cost	Communication cost
H1	Enter a draft PO based on requestor's requirement in ERP system	1.89	-	-
H2	Distributes the draft PO to selected supplier	5.67	-	5.00
S1	Captures the detail of the draft PO	5.67	-	-
S2	Check for the availability and schedule ship dates	5.67	-	-
S3	Inform the availability of products and ship dates	5.67	-	5.00
H3	Revise draft PO based on supplier's acknowledgement	1.89	-	-
H4	Approve the draft POs based on authorization	2.13	-	-
H5	Inform the PO status	5.67	-	3.00
S4	Pick up POs at hospital's purchasing department	28.35	-	-
S5	Enters sales order in ERP system based on the PO	5.67	-	-
S6	Acknowledge sales order status	5.67	-	3.00
S7	Pick & pack the products, generate shipment labels as per hospital's requirements	9.45	-	-

Table 6.3 The information exchange process cost in hospital case study (cont.)

ID	Activity	Labour cost	Documentation cost	Communication cost
S8	Notify the shipment of products	5.67	-	3.00
S9	Consolidates products to be sent and delivers products, PO, DO, invoice and other shipping document to the hospitals	9.45	7.00	-
H6	Inspect incoming products	1.89	-	-
H7	Transfer products to stores or fridge	7.56	-	-
H8	Sign the DO as a proof of product receipts	5.67	-	-
	Total (baht/PO)	**113.64**	**14.00**	**19.00**

6.3 Problem of Healthcare Supply Chain and Information Exchange

Focusing on information sharing on the pharmaceutical buying-selling process described Section 6.1, the common issues occurred in case of inventory onhand is insufficient, it needed to revise original purchase order and take more time in ordering of pharmaceuticals. This is similar to step of receiving. If the pharmaceuticals, quantity and ship-to-location delivered are different to the information stated on purchase orders, the hospital needed to inform the supplier as soon as possible by phone and indicated the errors on the shipment. These situation can increasing the risk of a stock out and can be critical in providing patient care provision as there may be no alternative treatments for the patient.

Table 6.1 presented the current practice of information sharing between hospital and its suppliers. Although, they have had their internal pharmaceutical codes and ERP systems, they still unable to share information efficiency and effectiveness. It tended to have a lot of processes, waste time and cost, and also manpower to confirm information on business documents.

To analyze the process related to communication protocols, it contained 19 processing steps involved in information sharing between hospital and suppliers. The supply chain process at hospital can be classified into 8 steps; including issue a draft purchase order, distribute the draft purchase order to selected supplier, revise draft purchase order based on supplier's acknowledgement and submit for approval, approves the purchase order based on authorization, inform the PO status, plans for receiving of pharmaceutical shipment, inspects incoming pharmaceuticals, delivers pharmaceutical to stores or fridge and record receiving transactions in ERP system, signs off the DO as a proof of product receipts to shipper. According to these processes, it hired 4 operators including a buyer, purchasing manager, store checker and an authorized inspector. In the meantime, the supplier's selling process can be classified into 9 steps that are: capture the order details, check for the availability of pharmaceuticals, inform the availability and schedule ship dates, arrange messenger to pick up original purchase order at hospital's purchasing department, enter sales order in ERP system, send sales order acknowledgement, pick & pack and printing shipping labels based on hospital's requirements, issue invoices, notify the delivery schedules, and deliver pharmaceuticals in together with shipping documents to the hospitals. According to these processes, it hired 4 operators including a sales representative, messenger, store picker and shipper. Table 6.4 summarized the current situation of information exchange between hospital and its suppliers.

Table 6.4 The summary of current situation between hospital and supplier

Situation	Description
Number of process	The number of process is 17 steps: 8 steps in hospital's site and 9 steps in supplier's site.
Number of process interaction with communication	There are 7 steps involved with data exchange between hospital and suppliers includes: • H2:Buyer distributed the draft PO to selected supplier • S3:Sales representative informed the availability of products and ship dates to buyer • H5:Buyer informed the PO status to sales representative • S4:Messenger picked up the approved PO at hospital's purchasing department • S6:Sales representative communicated sales order acknowledgement to buyer • S8:Sales representative notified for the shipment of products to buyer • H8:Store checker signed the DO as a proof of product receipts to shipper
Process time associated with communication process	60 minutes/PO
Operating cost	148.76 baht/PO classified as 115.76 baht for labour cost, 19.00 baht for communication cost, and 14.00 baht is material and supplies cost
Number of hospital's operators	4 operators including a buyer, purchasing manager, store checker and an authorized inspector
Number of supplier's operators	4 operators including a sales representative, messenger, store picker and shipper
Track and trace ordered products	It is hardly to capture locations and status of product shipment
Information quality, accuracy and reliability	X

Table 6.4 indicated number of inefficiencies due to human errors and lack of data standards—standard pharmaceutical code and data attributes. It presented time-consuming at the process of issuing draft purchase order and picking up purchase order at purchasing department. Moreover, the potential risks, errors or mistakes in information sharing are occurred. It found that:

1. There are number of manual works in information sharing processes between hospital and its suppliers.
2. Different internal pharmaceutical codes are used between hospital and its suppliers.
3. Lack of standardized pharmaceutical name, description and its related information such as incomplete supplier and product information, nonstandard supplier names, overly abbreviated product descriptions, ship-to-location, etc.
4. Adoption of different methods of written records in each stakeholder section.

However, to cope with all those potential risks and errors or mistakes, Muangchoo and Kritchanchai (2015), Kritchanchai and Muangchoo (2013), Kritchanchai (2012) and Kobayashi et al. (2004) suggested that all these following actions are needed.

1. Unify pharmaceutical code and its information.
2. Introduce automate collation processing function with the unified pharmaceutical code.
3. Standardize definition of trading rules and EDI settings between hospital and supplier.
4. Introduce of an online IT system between hospital and its suppliers.

Furthermore, it seemed difficult to unify all existing pharmaceutical codes in order to establish a single standard one for pharmaceuticals because various kinds of pharmaceutical codes have existed and in use, based on the individual code of each stakeholder. Therefore, in our approach, we applied an integrated datapool for establishing this connection.

6.4 Healthcare EDI and Data Transmission Code

Witte et al. (2003) illustrated that EDI infrastructure require three different settings as follows: (1) business transaction, (2) standard data formatting and, (3) standard data translators. EDI primarily is used to electronically transfer repetitive transactions such as purchase orders, invoices, shipping notices, remittance advices, and so on. Therefore, it is initially important to understand the current practice of EDI collation processing. Later on, standard pharmaceutical code and standard data exchange attributes.

Because EDI messages are repetitive, it makes sense to use standard pharmaceutical codes and standard data exchange attributes. An integrated datapool can shorten the length of the messages and eliminate data entry errors, because data entry occurs only once. EDI deals with standard data message transactions. If there are missing or incorrect data, the EDI converter offers assistance. EDI fosters collaborative relationships and enhance collaboration among healthcare stakeholders. Lastly, EDI adapters, an EDI adapter automatically translates data between ERP systems and EDI system. The detailed for each EDI infrastructure is described as follows:

6.4.1 EDI and Collation Processing

In hospital case study, we examined information sharing method among healthcare stakeholders, focusing on relationship between a hospital and suppliers. As mentioned earlier, it is important to ensure the accurate and consistent information as well as the stock out can be critical during providing patient care provision as there may be no alternative treatments for the patient. Hence, it is crucial to introduce an integrated datapool. This intervention improvements would allow the interconnection and interoperability of information and allow multiple operators especially hospitals and suppliers to access into pharmaceutical information (Muangchoo and Kritchanchai, 2015). However, these problems may occur in collation processing as follows:

1. Different pharmaceutical codes and different data transmissions format are currently used among healthcare stakeholders. Hence, they are unable to process information exchange in a standard format for interoperability.

2. Mainly of information pertaining to a pharmaceutical are currently kept in text format. It is difficult to extract and manage information from separate data sources. This involves slow down the processing documents and introduces errors.

To overcome all these problems in an integrated datapool—a standard identification code adding with some data standards, and also standard exchange data attributes are analyzed and proposed for data transmission among healthcare stakeholders in HSC as shown in Section 6.3.2.

6.4.2 Standard product code for Healthcare Supply Chain

According to literature review in Chapter 2, three main significant pharmaceutical codes in Thailand are existed and in use as follows: the FDA's registration code granted for all trial-use and trade pharmaceuticals in Thailand, the NHSO's 24-digit code developed for health expenditure reimbursement, and the TMT code created for clinical use and capture volume of purchased pharmaceuticals based on to government regulations. Moreover, there are internal pharmaceutical codes used in individual hospitals have been widely used to discriminate pharmaceuticals. All these existing pharmaceutical codes are unable to ignore since it is regulated by the Ministry of Public Health (MoPH) to all MoPH's hospitals.

However, these existing pharmaceutical codes have never been used in business transactions. It is because all those pharmaceutical codes are not able to identify the uniqueness at the trading-level of pharmaceuticals and unable to be connected in global level. The pharmaceutical code is purposefully used to interconnect, track, and trace in the HSC, the information of a pharmaceutical must also be synchronized at the same level of details. For this purpose, we proposed a *global trade identification number (GTIN-13)* and developed *standard data attributes* provided by an integrated datapool designed in Chapter 4. The former is the most basic pharmaceutical code necessary for identify the uniqueness of pharmaceuticals. Standard pharmaceutical code should work with an integrated datapool as a primary key. The latter can indicates the characteristics of pharmaceuticals. Further logistics management could be achieved by this pharmaceutical code as well as standard exchange data attributes.

6.4.3 Standard data exchange attributes

Here, a workshop is organized between operators from hospital and suppliers. After compiling the complete list of data attributes stated in Chapter 4, the data attributes are selected with regard to the HSC settings in Thailand. The operators are with representatives from healthcare stakeholders in Thailand. The interviewees are doctors, pharmacists, supply chain practitioners and IT specialists. The participant and their roles are presented in Table 6.5.

Table 6.5 Participant in experiment

Role	# of organizations	# of persons
Hospital	1	12
Supplier	3	8
Total	**4**	**20**

In the workshop, the operator was asked to verify the necessity of the list of data attributes. Their criterion was selecting only data attributes that fit to the use of exchanging business documents. Finally, 13 data attributes are selected as outlined in Table 6.6.

Table 6.6 Standard data transmission attributes

No	Attribute	Description
1	Hospital code	Indicate the location code of hospital
2	Supplier code	Indicate the location code of supplier
3	Supplier pharmaceutical code	Indicate the internal pharmaceutical code in supplier's ERP system.
4	Supplier pharmaceutical description	Indicate the description of pharmaceutical in supplier's ERP system, such as trade name; strength; dosage form; routes of administration, etc.

Table 6.6 Standard data transmission attributes (cont.)

No	Attribute	Description
5	Supplier pharmaceutical UOM	Indicate the selling unit of measure code of the pharmaceutical, such as boxes, bottle, carton, etc.
6	Hospital pharmaceutical code	Indicate the internal pharmaceutical code in hospital's ERP system.
7	Hospital pharmaceutical description	Indicate the hospital's product description such as trade name; strength; dosage form; routes of administration
8	Hospital pharmaceutical UOM	Indicate the purchasing unit of measure code of the pharmaceutical, such as boxes, bottle, carton, etc.
9	Item UOM conversion	Indicate the conversion rate between packaging and prescription unit of measure. For instance, 10 represents a box of 10 tablets
10	GTIN-13	Indicate the GTIN-13 digit of pharmaceutical at prescription unit
11	Barcode number	Indicate the barcode number affixed on delivered packages of pharmaceutical
12	FDA's Registration code	Indicate the FDA's registration code
13	TMT Code	Indicate the Thai Medicines Terminology (TMT) code
14	NHSO's 24 digit	Indicate the NHSO's 24 digit code

6.4.4 Standard EDI attributes

According to literature review, survey and workshop with respondents from hospitals including doctors, pharmacists who have their roles in purchasing and warehousing, and also with sales representative, store checker and shipper—the respondent from suppliers, the minimum data attributes needed in electronic POs and ASNs are presented in Table 6.7 and 6.8.

Table 6.7 The minimum data attributes needed in EDI-PO

No	Attribute	Description
1	PO Number	A unique purchase order number granted by ERP systems
2	PO Date	Indicate the issue date of purchase order
3	PO Type	Indicate the type of purchase order, including draft purchase order, purchase order and contract purchase agreement.
4	Hospital code	Indicate the hospital code, the issuer of draft purchase order, purchase order and contract purchase agreement.
5	Currency code	Indicate the functional currency of draft purchase order, purchase order and contract purchase agreement.
6	Buyer	Enter the buyer in a particular purchase order
7	Buying department	Indicate the requestor's department for the purchase order.
8	Discount percentage	Indicate the discount percentage according to trade agreement between hospital and selected supplier
9	Total amount	Display the total purchase amount
10	Payment terms	Indicates the payment terms of purchase order

Table 6.7 The minimum data attributes needed in EDI-PO (cont.)

No	Attribute	Description
11	PO Line number	Enter the PO line number of a particular purchase order
12	Pharmaceutical code	Indicate the internal pharmaceutical code that hospital want to purchase from selected supplier
13	Pharmaceutical description	Display the description of the pharmaceutical in hospital's ERP system
14	Packaging description	Indicate the packaging information e.g. a box of 10 blister packs, a bottle of 100 tablets, etc.
15	Ordered quantity	Enter the ordered quantity of a pharmaceutical on each PO line number
16	Ordered UOM	Indicate the purchase unit of measure of each pharmaceutical in each PO line number
17	Unit price	Indicate the unit price for the pharmaceutical purchased from selected supplier
18	Free item flag	Indicate whether pharmaceutical on the purchase order line is free of charge.
19	Need by date	Enter the expected shipment date and time that the supplier promised for delivery of pharmaceutical
20	Contract number	If purchased pharmaceutical belongs to purchase contract agreement, indicate the contract agreement number.

Table 6.8 The minimum data attributes needed in EDI-ASN

No	Attribute	Description
1	ASN Number	Indicate the number of the Advance Shipment Notice (ASN) generated in supplier's ERP system
2	ASN Date	Indicate the creation date of ASNs
3	Shipped date	Enter the shipment date of pharmaceutical
4	PO Number	Refer the purchase order numbers that ASNs are created against for pharmaceutical shipment
5	Hospital code	Refer to the hospital code, the issuer of purchase order
6	Ship to location	Indicates the ship-to location or buying department for the shipment
7	ASN Line number	Enter the ASN line number for the shipment
8	Item code	Indicate the pharmaceutical code that included in shipment
9	Shipped quantity	Indicate the quantity of pharmaceutical due in specific shipment
10	Shipped UOM	Indicate the unit of measure of the pharmaceutical in the ASN line number
11	Country of origin	Indicate the country in which the pharmaceutical is manufactured.
12	Lot number	Enter the manufactured lot number of the pharmaceutical
13	Lot quantity	Enter the lot quantity in pharmaceutical shipment
14	Expiry date	Enter expiration date of each manufactured lot number

For this experiment, the electronic PO and ASN are selected because both of them are the initial EDI documents using in the buying-selling process and the

success of this experiment is able to implement for additional EDI documents such as electronic invoices and also able to extend to implementation of Vendor-managed Inventory (VMI) and consignment.

6.5 Healthcare EDI System Model

Section 6.2 described that the current information exchange method is relied on paper-based system. That means PO and DO forms are exchanged by postal mail, fax and email. The Figure 6.3 illustrated the current information exchange model.

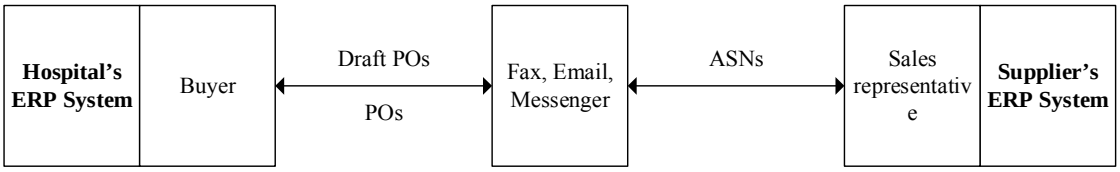

Figure 6.3 Conceptual of Paper-based system

From Figure 6.3, the following process typically occurred in the paper-based system as follows: buyer enters purchasing data onto the screen of the ERP system, print out and send it to a selected supplier by postal mail, fax and email. After that, the sales representative manually enters it into their ERP system as a sales order. Generally, the exchange of trade documents by postal mail, fax and email consume a week to the process. If it causes errors by manual data entry, the time can be greatly increased.

Then, compared with EDI systems, after the PO is generated in ERP system, it can automatically sends an EDI formatted PO to a selected supplier. This electronic PO is automatically converted into a sales order, notifies the store picker to pick the pharmaceuticals and generates an electronic ASN to be transmitted directly to buyers and the process can be completed within hours.

Hence, after we examined the method to exchange EDI documents in the hospital case study, the mode for EDI system model was designed to demonstrate the power of proposed datapool. This is to facilitate efficient the process of operational

performance improvement and HSC collaboration such as streamline the process, minimize workload and communication costs in both hospital and suppliers. To develop an experiment, the following conditions are considered as description of developed EDI system model between hospital and suppliers.

Engel et al. (2011) classified EDI system as traditional or direct EDI standards that every business document exchange stands for its own. Similarity to Philip et al. (2011), they classified EDI system as traditional EDI systems and web based EDI system. While Ratnasingham (1998) indicated that EDI system has shifted from traditional to the internet EDI Transmission. In addition, Wenninger (1999) described that some networks exchange information on a point-to-point basis rather than using a centralized EDI system to store messages. Furthermore, Zilbert (2000) and Yao et al. (2009) categorized EDI into point-to-point EDI transmission and internet EDI transmission. This idea supported by Janssens (2011), he argued that web EDI system enables integrating stakeholder's closer collaboration in supply chain, meanwhile, traditional EDI system tends to reduces cost and error, but cannot cover its comparatively huge investment and maintenance cost at all, especially for small stakeholders.

From literatures above, it can concludes that there are two main EDI system including traditional EDI system or point-to-point system and web-based EDI system in which using internet as a protocol for collaboration. In order to understand the practical value and cost reduction of electronic PO and ASN, alternative scenarios were defined, depending on the adoption of datapool in both documents exchanged electronically. The models examined were the following:

Model 1: Traditional or point-to-point EDI system

In traditional or point-to-point EDI system model, hospital has communicated to individual supplier over the Internet. That means it need to manage number of separate connection protocols. The conceptual design for point-to-point EDI system is illustrated in Figure 6.4.

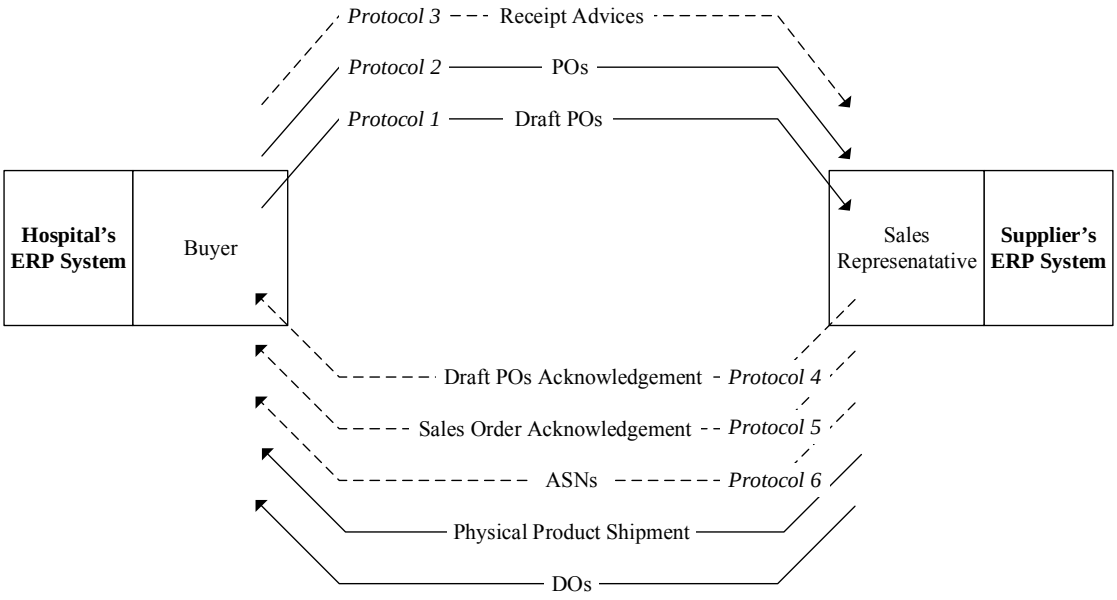

Figure 6.4 Conceptual of Direct EDI system

Figure 6.4 presented that buyer enters a draft PO in ERP system and automatically sends EDI-PO to a sales representative of a selected supplier. At supplier's side, the sales representative receives the EDI-PO, automatically converts to a sales order, notifies the store picker to ship the products and generates an EDI advance shipment notice to be transmitted directly to buyers. Unfortunately, in the hospital case study, hospital has 3 different EDI documents exchange with 4 suppliers so that it must developed for 12 different connection protocols; EDI-draft PO, EDI-PO and EDI-ASN for an individual supplier. This situation results in many of connections, complex and resource intensive if its suppliers use different communication protocols. Figure 6.5 illustrated the process of exchanging EDI documents via the direct EDI without datapool system.

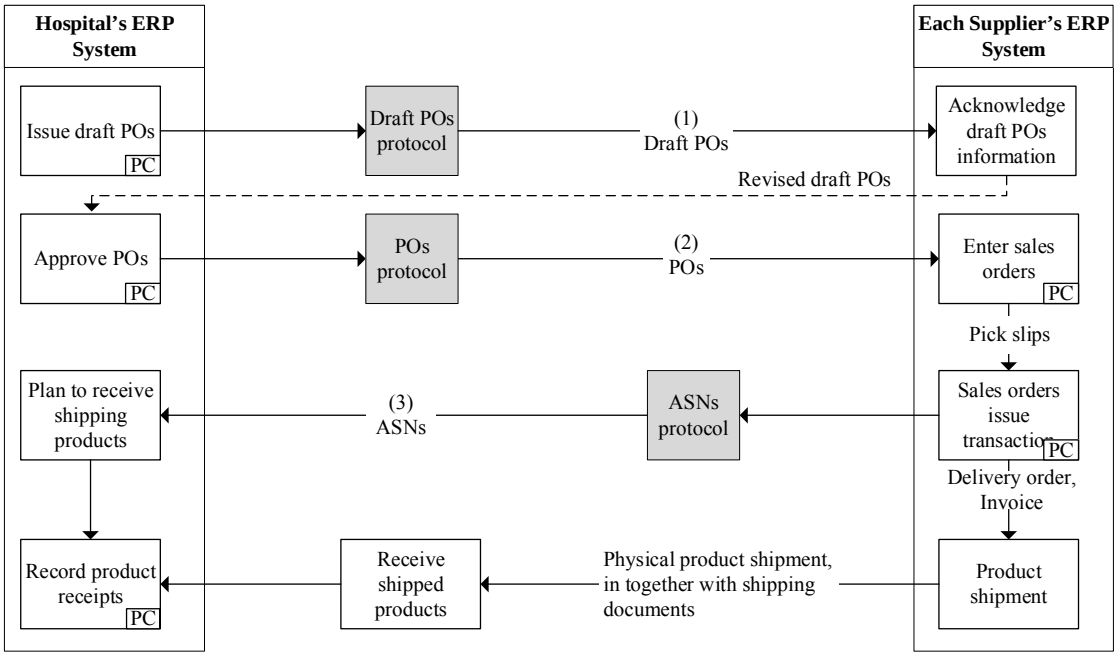

Figure 6.5 The process of direct EDI without datapool system

Figure 6.5 argued that before exchanging EDI documents, the protocol must be developed, in use and supported for all agreed EDI documents. In addition, both parties must be agreed upon each specific settings upon exchanging of EDI documents. Therefore, number of budgets must be allocated for point-to-point EDI initialization regarding to any additional EDI documents.

Model 2: Web-based EDI system model using an integrated datapool

In the web-based EDI system using an integrated datapool model, the EDI documents are exchanged through the Internet browser. It replicated paper-based documents as a web form. The form will contain standardized fields where users can enter information. Once all the relevant information is added, it is automatically converted into an EDI message and sent via secure Internet protocols such as File Transfer Protocol Secure (FTPS), Hyper Text Transport Protocol Secure (HTTPS) or AS2. In this stage, the EDI relevant information is verified with standard pharmaceutical code and standard data attributes kept in the proposed datapool before transmission of EDI messages. The conceptual of web-based EDI system model using an integrated datapool is illustrated in Figure 6.6.

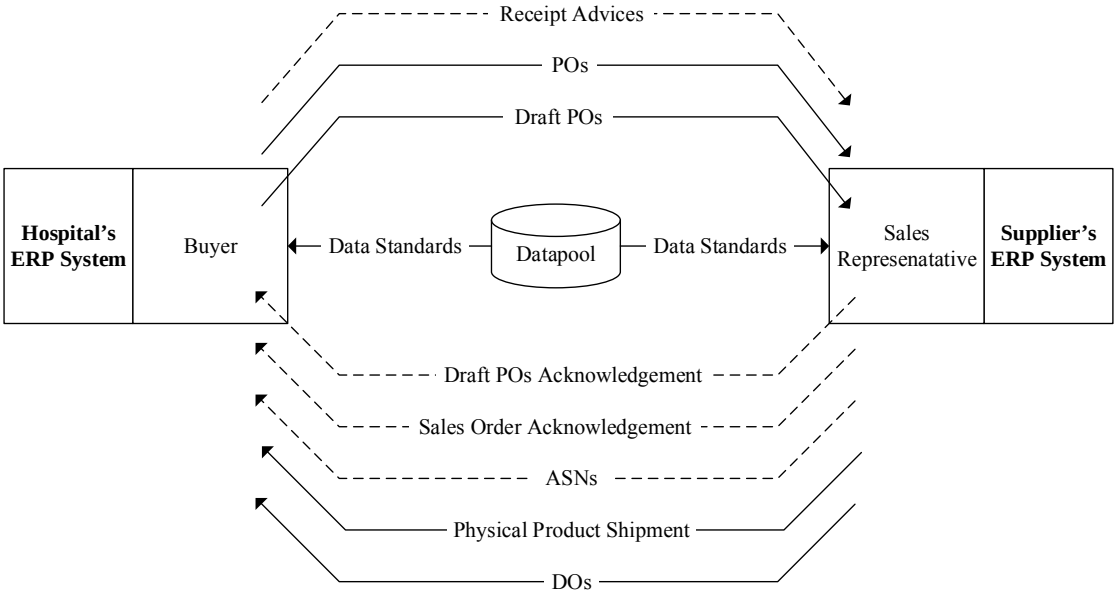

Figure 6.6 Conceptual of web EDI with datapool system

Figure 6.6 presented buyer enters a draft PO and send EDI-PO to a sales representative of the selected supplier via the Internet. At supplier's side, the sales representative receives the EDI-PO, automatically converts into a sales order, notifies the store picker to ship the products and generates an EDI-ASN to be transmitted directly to buyers. However, in web-based EDI system with datapool, all EDI documents must be verified to standard pharmaceutical code, data standards and translated exchanged attributes into standard data attributes before start exchanging any EDI documents. By this, an integrated datapool illustrated its powerful to reduce numerous connection protocols between hospital and suppliers. Additionally, it will help in error proofing subjected to human errors or mistakes elimination. Figure 6.7 illustrated the process of exchanging EDI documents via the web-based EDI system with datapool.

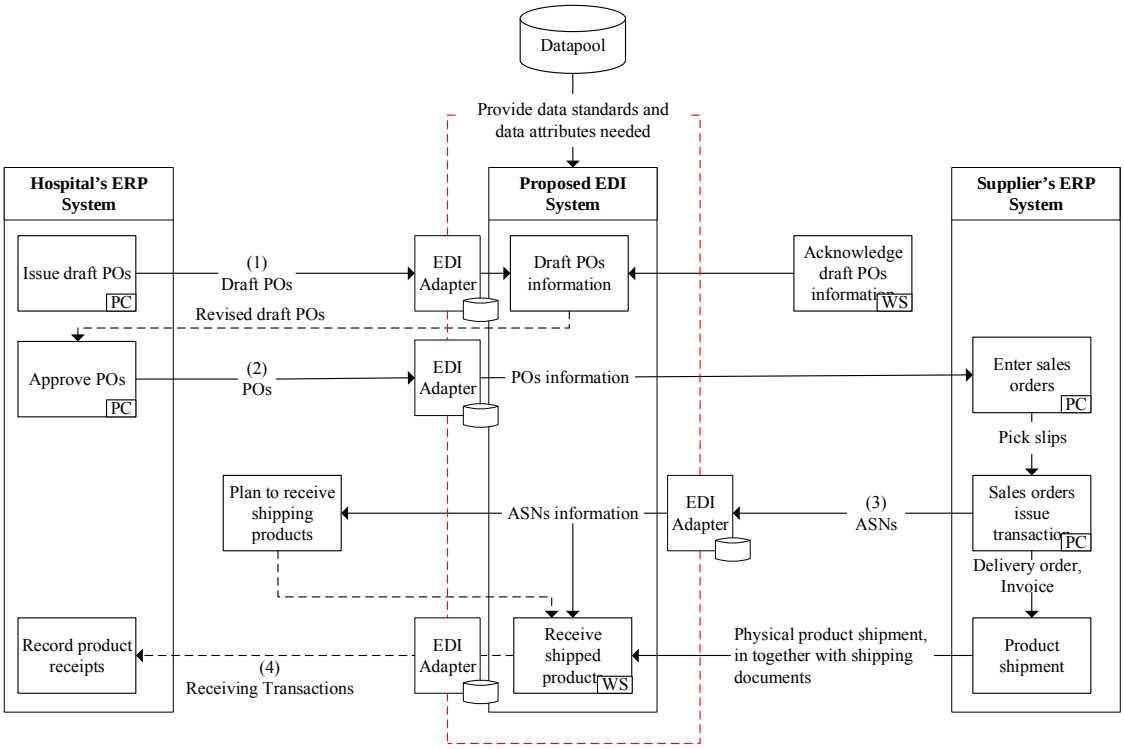

Figure 6.7 The web EDI with datapool system

From Figure 6.7, when buyer issued a draft PO in ERP system, it conveyed to sales representative for pharmaceutical availability checking. After receiving the information regarding to availability, this draft PO may revised according to availability and submit for approval. After the draft PO got approved from purchasing manager, it communicated to sales representative for sales order process. In both stages, the data is transferred from hospital's ERP system to EDI system and supplier's ERP systems.

In this step, the web-based EDI system translated internal pharmaceutical codes to standard pharmaceutical codes and standard data attributes kept in an integrated datapool—a centralized database storing standardized information of particular pharmaceuticals. At the supplier side, the sales representative received the notifications and then access into web-based EDI system to capture POs and also converts it into their ERP systems. In this step, the web EDI system will automatically translated standard pharmaceutical code and data attributes into supplier internal pharmaceutical code. In supplier's ERP system, the sales representative will process for their sales process such as book order, make a reservation to pharmaceuticals,

schedule ship dates and also send sales order acknowledgement to buyers via the web EDI system. Then, the store picker picked and packed, generated shipment labels as per hospital's requirement, and transferred pharmaceuticals to staging areas. Before the shipper consolidated pharmaceutical and delivered it to hospitals, the shipping transaction is performed. The pharmaceutical, quantity, unit of measure, lot and expiration date are recorded in supplier's ERP system. In this step, the EDI-ASN would be created according to supplier's shipping transactions and translates into standard pharmaceutical code and data attributes based on datapool, and sending it upfront to buyer for preparing on pharmaceutical receipts.

Next, when the pharmaceutical arrived at hospitals, the store checker in together with buyer and authorized inspector inspected incoming pharmaceuticals. The incoming pharmaceuticals that pass acceptance criteria will be delivered to storage areas, recorded for receiving transaction in hospital's ERP system, and signed on DO form as a receipt confirmation document. Till this end, the pharmaceutical onhand is available in ERP system and ready for any prescription orders.

6.6 Datapool Implementation

To implement this proposed datapool, the environment and procedure for experiment are configured. Here after, the detailed discussion for datapool implementation is described as follows:

6.6.1 Experiment environment

To implement the experimental web-based EDI system in the hospital case study, four of suppliers are invited for participation. This system pilot run on two EDI system model: direct EDI system and web-based EDI system using an integrated datapool as described in Section 6.4. The historical data of purchase order are collected from ERP system from June 2013 to May 2014 and it presented that hospital placed 9,880 purchase orders accounted for 11,589 PO lines.

These EDI systems have been implemented experimentally in a hospital case study. Both hospital and suppliers operated their jobs in their ERP systems while a new server for web-based EDI system was installed to test the use of an integrated

datapool on the Cloud Server which composes of Database Server and Application Server in order to support connection protocols between hospital and suppliers. The connection protocols of EDI Server is presented in Figure 6.8.

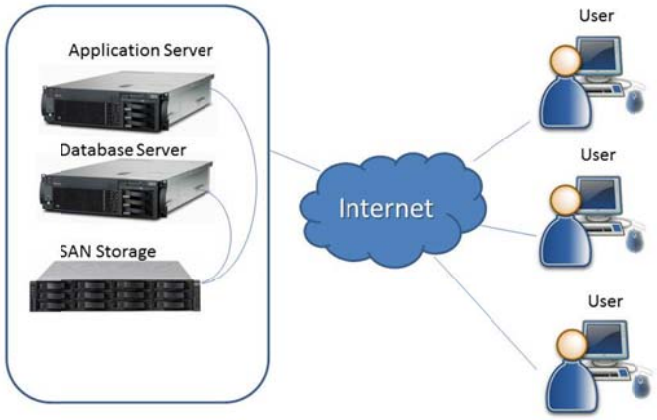

Figure 6.8 Data connection of EDI server

Database server used for storage important data. In this experiment, we installed free-license version of Oracle Database R11 with 4GB storage capacity. Application server used to provide both web-based EDI forms for hospital and supplier's operators mentioned in Table 6.1 to access into the web forms entering PO and interfacing data files from hospital or supplier's ERP systems. For Database server and Application server, we used Windows Server 2012 for operation system and Server IBM x3550 for data storage. The details of web-based EDI system's components are shown in Table 6.9.

Table 6.9 The EDI system component

Component	Quantity (Unit)	Specification
Database Server	1	OS: Windows Server 2012 CPU: Server IBM x3550 HDD: 4 GB
Application Server	1	OS: Windows Server 2012 CPU: Server IBM x3550

6.6.2 Procedure

To conduct the experiment, it operated over an eight weeks period from December 2014 to January 2015. To confirm system effectiveness, we examined the process of information exchange in 3 different settings as follows: 1) exchange business documents by postal mail, fax and email, 2) exchange business documents using point-to-point or direct EDI system and, 3) exchange business documents using web-based EDI system with proposed datapool as described in Table 6.10.

Table 6.10 The EDI Experimental settings

Setting	Experiment	Description
-	Paper-based system (Current practice)	Experiment on exchanging EDI documents based on paper-based manner. This setting is the current transaction process in the hospital case study.
1	Direct EDI system without datapool adoption	Experiment on exchanging EDI documents through the direct EDI system over the Internet.
2	Datapool with web EDI system	Experiment on exchanging EDI documents using datapool with web EDI system over the Internet browser.

During the experiment, operators in hospital and suppliers performed routine tasks in their ERP systems; while the proposed EDI system model is implemented and recorded the standard transmission data attributes in its individual servers and the Server Centre. Later, these records were analyzed to compare each EDI system use with their current practice.

Prior to operate proposed EDI system model experiment, there are some pre-requisition tasks that both hospital and supplier should be completed. Firstly, the master data of pharmaceuticals which hospital purchased from suppliers. These relevant information are kept in an integrated datapool and used for translating

individual data attributes into standard transmission data attributes for both dyads on exchanging EDI documents.

6.7 Experimental Results

From those two EDI system models described in section 6.4 in comparison to current practice. Therefore, there are two experimental settings can be presented as follows: point-to-point EDI system and web-based EDI system compared to current practice. The experiment result of each experimental setting will be illustrated as follows:

Setting 1: Point-to-point EDI system and current practice

In current practice, buyer manually enters order details in ERP system, while sales representative also manually enters sales order details, and store picker create DO in their ERP system, prints out and send all those business documents by postal mail, fax and email. Compare to point-to-point EDI system, these business documents are transmitted directly between ERP systems. Thus, the process time on data transmission is faster than current practice. Additionally, the process related to pick up approved purchase orders at hospital is eliminated. However, the point-to-point EDI system model is unable to eliminate the purchasing follow up tasks such as pharmaceutical availability notification, sales order acknowledgement, etc. It still needs buyer and sales representative to manage this communications. Figure 6.9 illustrated the process and time spending in the Direct EDI system.

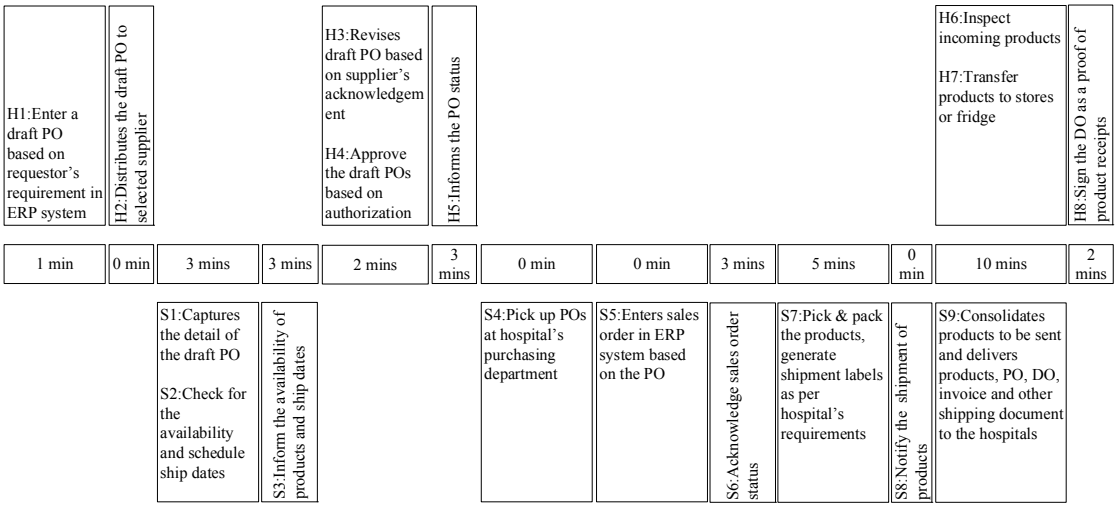

Figure 6.9 Process and time of direct EDI without datapool system

The Figure 6.9 described activity and process time associated with each activity dealing in information exchange on direct EDI without datapool adoption settings. Thus, the activity and process time collected in direct EDI system without datapool adoption illustrated as in Table 6.11.

Table 6.11 The activity and process time of direct EDI without system

ID	Activity	Actor	Time (min)	Document	Communication
H1	Enter a draft PO based on requestor's requirement in ERP system	Buyer	1		
H2	Distributes the draft PO to selected supplier	Buyer	0		EDI
S1	Captures the detail of the draft PO	Seller	0		EDI
S2	Check for the availability and schedule ship dates	Store picker	3		
S3	Inform the availability of products and ship dates	Seller, Buyer	3		Fax, Email

Table 6.11 The activity and process time of direct EDI without system (cont.)

ID	Activity	Actor	Time (min)	Document	Communication
H3	Revise draft PO based on supplier's acknowledgement	Buyer	1		
H4	Approve the draft POs based on authorization	Manager	1		
H5	Inform the PO status	Buyer, Seller	3		Phone
S4	Pick up POs at hospital's purchasing department	Messenger	0	PO	EDI
S5	Enters sales order in ERP system based on the PO	Seller	0		EDI
S6	Acknowledge sales order status	Seller, Buyer	3		Phone
S7	Pick & pack the products, generate shipment labels as per hospital's requirements	Store picker	5	DO	
S8	Notify the shipment of products	Seller, Buyer	0		EDI
S9	Consolidates products to be sent and delivers products, PO, DO, invoice and other shipping document to the hospitals	Shipper	5		
H6	Inspect incoming products	Authorized inspector	1		

Table 6.11 The activity and process time of direct EDI without system (cont.)

ID	Activity	Actor	Time (min)	Document	Communication
H7	Transfer products to stores or fridge	Warehouse operator	4		
H8	Sign the DO as a proof of product receipts	Warehouse operator	2		Man
	Total process time (min)		**30**		

From Table 6.11, it could explored labour costs, documentation cost and communication costs associated with the information exchange in the direct EDI without datapool system. Table 6.12 illustrated the cost of direct EDI without datapool system.

Table 6.12 The costs associated with direct EDI without datapool system

ID	Activity	Labour cost	Documentation cost	Communication cost
H1	Enter a draft PO based on requestor's requirement in ERP system	1.89	-	-
H2	Distributes the draft PO to selected supplier	0.00	-	-
S1	Captures the detail of the draft PO	0.00	-	-
S2	Check for the availability and schedule ship dates	5.67	-	-
S3	Inform the availability of products and ship dates	1.89	-	-

Table 6.12 The costs associated with direct EDI without datapool system (cont.)

ID	Activity	Labour cost	Documentation cost	Communication cost
H3	Revise draft PO based on supplier's acknowledgement	1.89	-	-
H4	Approve the draft POs based on authorization	4.25	-	-
H5	Inform the PO status	5.67	-	-
S4	Pick up POs at hospital's purchasing department	0.00	-	-
S5	Enters sales order in ERP system based on the PO	0.00	-	-
S6	Acknowledge sales order status	5.67	-	-
S7	Pick & pack the products, generate shipment labels as per hospital's requirements	9.45	-	-
S8	Notify the shipment of products	0.00	-	-
S9	Consolidates products to be sent and delivers products, PO, DO, invoice and other shipping document to the hospitals	9.45	7.00	-
H6	Inspect incoming products	1.89	-	-

Table 6.12 The costs associated with direct EDI without datapool system (cont.)

ID	Activity	Labour cost	Documentation cost	Communication cost
H7	Transfer products to stores or fridge	7.56	-	-
H8	Sign the DO as a proof of product receipts	3.78	-	-
	Total (baht/PO)	**59.06**	**14.00**	**0.00**

The experiment results in Figure 6.8 indicated that direct EDI without datapool system eliminated the process steps from 17 to 12 steps including buyer distributed the draft PO to selected supplier, sales representative captured the detail of the draft PO, messenger picked up POs at hospital's purchasing department, sales representatives entered sales order in ERP system based on the PO, and sales representatives notified the shipment of products. Based on this elimination, it reduced messenger, hence number of operators eliminated from 8 to 7 operators participated in exchanging EDI documents. Additionally, it reduced processing time to exchange EDI documents from 60 to 30 minutes. In term of processing costs, it reduced costs from 148.76 to 95.84 baht per PO. Furthermore, Direct EDI system can increase the supply chain efficiencies including visibility and ability to track and trace pharmaceutical moving from supplier to hospital, as well as reduce human errors or mistakes—leads to increasing information quality, accuracy and reliably. The experiment results of point-to-point EDI system compared to current practice is illustrated in Table 6.13.

Table 6.13 The experiment results of direct EDI system

Indicator	Paper-based system	Direct EDI system
Number of processes (steps)		
Hospital	8	7
Supplier	9	5
Number of operators (person)		
Hospital	4	4
Supplier	4	3
Process time (Mins)	60 minutes/POs	30 minutes/PO
Operating cost (Baht)	148.76 baht/PO classified as 115.76 baht for labour cost, 19.00 baht for communication cost, and 14.00 baht is material and supplies cost	95.84 baht/PO classified as 62.84 baht was labour cost, 19.00 baht was communication cost, and 14.00 baht was material and supplies cost
Annual operating cost (Baht)	1,469,774 Baht	909,578 Baht
Product visibility	X	√
Information quality, accuracy and reliability	X	√

Setting 2: Web-based EDI system using datapool and current practice

In current practice, the process of information sharing is similar to setting 1. Compare to the web-based EDI system using datapool, the EDI documents are transmitted directly between ERP systems and proposed EDI system by verifying with standard data kept in an integrated datapool and translating internal datasets of individual stakeholder. Thus, the process time on data transmission is faster than current practice. Additionally, the process related to pick up approved purchase orders

at hospital is eliminated. Moreover, the purchasing follow up tasks such as pharmaceutical availability notification, sales order acknowledgement, etc.

In any stages in regard to data transmission process, the EDI adapter will verify and translate the individual internal pharmaceutical codes and data attributes into standard pharmaceutical code and standard data attributes. Therefore, it can eliminate human errors, system errors or mistakes due to data fragmentation as well. Figure 6.10 illustrated the process and time spending in the proposed EDI system using datapool.

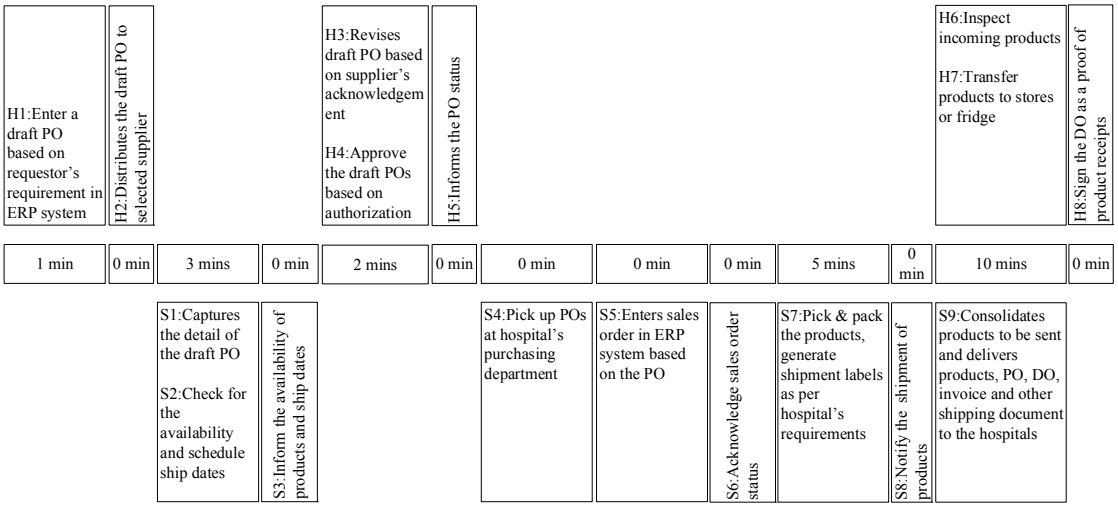

Figure 6.10 Process and time spending for web EDI system with datapool

The Figure 6.10 described activity and process time associated with each activity dealing in information exchange on EDI with datapool adoption settings. Thus, the activity and process time collected in EDI with datapool adoption illustrated as in Table 6.14.

Table 6.14 The activity and process time of EDI with datapool system

ID	Activity	Actor	Time (min)	Document	Communication
H1	Enter a draft PO based on requestor's requirement in ERP system	Buyer	1	-	-
H2	Distributes the draft PO to selected supplier	Buyer	0	-	EDI
S1	Captures the detail of the draft PO	Seller	0	-	EDI
S2	Check for the availability and schedule ship dates	Store picker	3	-	-
S3	Inform the availability of products and ship dates	Seller, Buyer	0	-	EDI
H3	Revise draft PO based on supplier's acknowledgement	Buyer	1	-	-
H4	Approve the draft POs based on authorization	Manager	1	-	-
H5	Inform the PO status	Buyer, Seller	0	-	EDI
S4	Pick up POs at hospital's purchasing department	Messenger	0	PO	EDI
S5	Enters sales order in ERP system based on the PO	Seller	0	-	EDI
S6	Acknowledge sales order status	Seller, Buyer	0	-	EDI

Table 6.14 The activity and process time of EDI with datapool system (cont.)

ID	Activity	Actor	Time (min)	Document	Communication
S7	Pick & pack the products, generate shipment labels as per hospital's requirements	Store picker	5	DO	-
S8	Notify the shipment of products	Seller, Buyer	0	-	EDI
S9	Consolidates products to be sent and delivers products, PO, DO, invoice and other shipping document to the hospitals	Shipper	5	-	-
H6	Inspect incoming products	Authorized inspector	1	-	-
H7	Transfer products to stores or fridge	Warehouse operator	4	-	-
H8	Sign the DO as a proof of product receipts	Warehouse operator	0	-	EDI
	Total process time (min)		**21**		

From Table 6.14, it could explored labour costs, documentation cost and communication costs associated with the information exchange in the EDI with datapool system. Table 6.15 illustrated the cost of direct EDI without datapool system.

Table 6.15 The costs associated with EDI with datapool system

ID	Activity	Labour cost	Documentation cost	Communication cost
H1	Enter a draft PO based on requestor's requirement in ERP system	1.89	-	-
H2	Distributes the draft PO to selected supplier	0.00	-	-
S1	Captures the detail of the draft PO	0.00	-	-
S2	Check for the availability and schedule ship dates	5.67	-	-
S3	Inform the availability of products and ship dates	0.00	-	-
H3	Revise draft PO based on supplier's acknowledgement	1.89	-	-
H4	Approve the draft POs based on authorization	4.25	-	-
H5	Inform the PO status	0.00	-	-
S4	Pick up POs at hospital's purchasing department	0.00	-	-
S5	Enters sales order in ERP system based on the PO	0.00	-	-
S6	Acknowledge sales order status	0.00	-	-
S7	Pick & pack the products, generate shipment labels as per hospital's requirements	9.45	-	-

Table 6.15 The costs associated with EDI with datapool system (cont.)

ID	Activity	Labour cost	Documentation cost	Communication cost
S8	Notify the shipment of products	0.00	-	-
S9	Consolidates products to be sent and delivers products, PO, DO, invoice and other shipping document to the hospitals	9.45	7.00	-
H6	Inspect incoming products	1.89	-	-
H7	Transfer products to stores or fridge	7.56	-	-
H8	Sign the DO as a proof of product receipts	0.00	-	-
	Total (baht/PO)	**42.05**	**14.00**	**0.00**

From experiment results in Figure 6.9 indicated that web EDI system using datapool presented the most attractive results compared to both current practice and point-to-point EDI system. It can eliminates the process steps from 17 to 8 steps including buyer distributed the draft PO to selected supplier, sales representative captured the detail of the draft PO, sales representative informed the availability of products and ship dates, messenger picked up POs at hospital's purchasing department, sales representatives entered sales order in ERP system based on the PO, sales representatives notified the shipment of products, and warehouse operator signed off the DO as a proof of product receipts. Based on this elimination, it reduced messenger, hence number of operators eliminated from 8 to 7 operators participated in

exchanging EDI documents. In addition, it reduced process time regarding to exchange EDI documents from 60 to 21 minutes baht. Moreover, this EDI system is connected to an integrated datapool with using global trade identification number (GTIN-13) as a primary key, the visibility and movement status of pharmaceuticals can be tracked and traced regarding to EDI transmissions. Moreover, this EDI system can reduces human errors or mistakes—increasing the information quality, accuracy and reliably. The web-based EDI system with datapool experiment results compared to current practice are illustrated in Table 6.16.

Table 6.16 Experiment results of datapool with web EDI system

Indicator	**Paper-based system**	**EDI with datapool system**
Number of processes (steps)		
Hospital	8	5
Supplier	9	3
Number of operators (person)		
Hospital	4	4
Supplier	4	3
Process time (min)	60 minutes/POs	21 minutes/PO or 65%
Operating cost (baht)	148.76 baht/PO classified as 115.76 baht for labour cost, 19.00 baht for communication cost, and 14.00 baht is material and supplies cost	56.05 baht/PO classified as 42.05 baht was labour cost and 14.00 baht was material and supplies cost

Table 6.16 Experiment results of datapool with web EDI system (cont.)

Indicator	Paper-based system	EDI with datapool system
Annual operating cost (baht)	1,469,774 Baht	553,799 Baht
Product visibility	X	√
Information quality, accuracy and reliability	X	√

6.8 HSC Collaboration Enhancement

To validate the effect of data standards, EDI and HSC collaboration, a number of interviews has been made with participants in data standards experiment. The informant invited from the hospital and supplier's representatives. There had 2 informants from hospital and 3 informants from suppliers. Figure 6.11 presented the participants involved in interview.

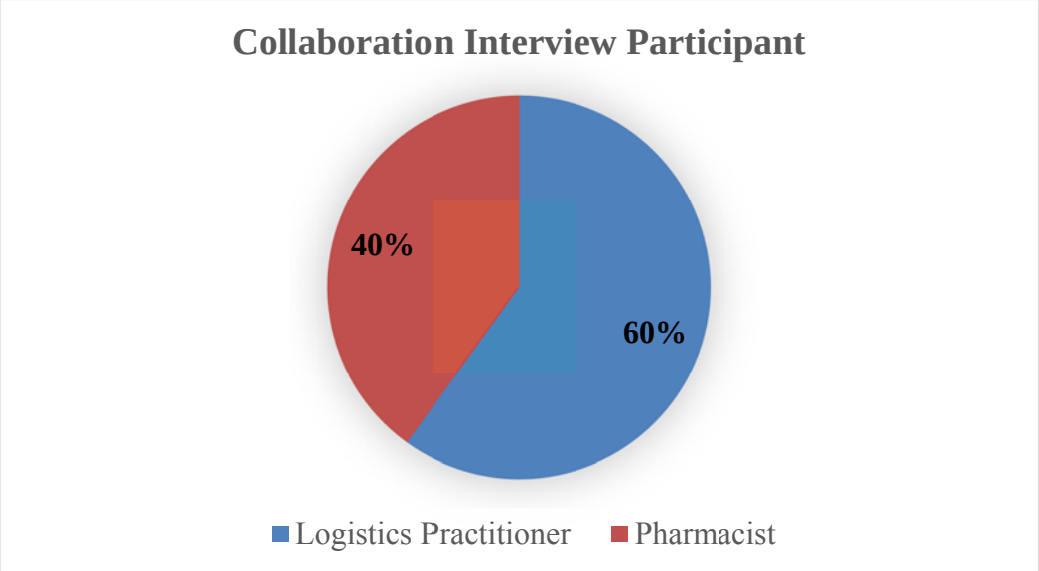

Figure 6.11 Collaboration Interview Participant

Based on the interview results, it indicated that the hospital see the EDI with datapool and data standards as a way to improve collaboration performance in multiple areas such as cost savings, quality and increased efficiency. In turn of supplier, the participation in collaboration seem to more increased share of the hospital's business. However, they were not realized much in benefits in short term but pursue deeper collaboration that include technical advice or joint investments such as third-party logistics or outsourcing for storages or transportation within hospitals.

Improved Trading Partner Relationships

Based on interview with informants participated in EDI experiment, both hospital and suppliers stated that the adoption of EDI at the hospital case study required greater cooperation with their business partners. All EDI participants might agree to some standard data formats which enable them to transfer information between different IT systems via an internet protocol. The good partnerships between both parties were important to achieve the standard data format and to improve the existing standard data format. EDI, therefore, fosters good partner relationships. Based on this, hospital and supplier would able to solve problems regarding stakeholder's rollover in a timely manner which, in turn, enhance business partner's satisfaction.

Enhance Responsiveness and Customer Service

Both hospital and suppliers agreed that the strong relationships among trading partners allow them to better understand demand's patterns and be able to quickly rectify any collaboration problems. Thus, with stronger collaboration among healthcare stakeholders, their staffs would be more willing and quicker to serve requirements and solve problems and, hence, the responsiveness to demand needs could be enhanced with the EDI implementation. Both hospital and suppliers agreed that the adoption of EDI could release a number of personnel time, since EDI automated from a number of labour intensive tasks, which required significant manual efforts. These personnel could then be assigned to other valuable tasks, such as improving patient care or customer service quality. The quality service could be perceived from different dimensions such as ease of enquiry, accurate and complete information regarding any queries, and competitive administration costs.

Overall Level of Collaboration

To justify collaboration level, both of hospital and suppliers stated that the collaboration between hospital and supplier currently was relied on transaction integration by automating purchase order (PO) and advance shipment notice (ASN), using EDI system and the internet. In addition, according to participant's interviews, both parties planned to extend their collaboration level into information sharing for product price and promotions from suppliers, and inventory availability in hospital's warehouses. However, they were not confident to extend EDI into VMI due to the level of trust, align benefits and incentives.

Based on the foundation of datapool with data standards, hospital highlighted for better intra-organization collaboration in term of streamlining supply chain operations through adopting data standards into material management system, CPOE and EMR systems. They argued that data standards can reduce time that their staffs spending on information administration.

To success on implementing collaboration, all informants from hospital and supplier argued that change management is critical. It needs to shift from the typical buyer-supplier relationship toward a dynamic of greater trust, more information sharing, and enhanced transparency. This manner can be happened if enabling accountable leaders, an engaged organization, a clear governance structure, clear objectives, and agreed-on KPIs. Table 6.17 summarized level of collaboration between hospital and suppliers effected by adopting data standards through EDI system implementation.

Table 6.17 Level of collaboration

HSC Collaboration	Hospital	Supplier
Trading Partner Relationships	The EDI system made more confident on supply sustainability and be able to quickly reflect to any supply problems	The EDI system allowed suppliers to better understand demand's patterns and be able to quickly response to any demand problems
Responsiveness and customer services	The automotive in EDI system released a number of personnel time and allowed them to focus on significant and required manual efforts	The automotive in EDI system released a number of personnel time and allowed them to focus on significant and required manual efforts
Information quality, accuracy and reliability	The datapool helped to standardize pharmaceutical information	The datapool helped to speed up pharmaceutical recalls.
Supply chain collaboration Visibility	The EDI system increased supply visibility within supply chain relationships.	The faster purchase order process helped on recognize the demand from hospitals
Level of collaboration	The datapool with data standards could help on increasing intra-collaboration within hospitals by utilizing through front and back IT systems.	The datapool with data standards could help on increasing efficiency for pharmaceutical recalls.

6.9 Result Analysis

From section 6.6, both direct EDI system and web EDI system using datapool are experimented. The experiment's objective is to evaluate the ability to increase operational performance and enhance HSC collaboration in the hospital case study. According to the experimental results, it can reduce process time, manpower and operating cost in exchanging EDI documents based on the following settings, including point-to-point EDI system and web-based EDI system compared with current practice. Table 6.18 illustrated the comparison of both settings.

Table 6.18 The EDI system experiment results

Named Factors	Paper-based system	Direct EDI system	Web EDI system with Datapool
Number of processes (steps)			
Hospital	8	7	5
Supplier	9	5	3
Number of operators (person)			
Hospital	4	4	4
Supplier	4	3	3
Process time (mins)	60 minutes/POs	30 minutes/PO	21 minutes/PO
Operating cost (baht)	148.76 baht/PO classified as 115.76 baht for labour cost, 19.00 baht for communication cost, and 14.00 baht is material and supplies cost	95.84 baht/PO classified as 62.84 baht is labour cost, 19.00 baht is communication cost, and another 14.00 baht is material and supplies cost	56.05 baht/PO classified as 42.05 baht for labour cost, and 14.00 baht for material and supplies cost

Table 6.18 The EDI system experiment results (cont.)

Named Factors	Paper-based system	Direct EDI system	Web EDI system with Datapool
Annual operating cost (baht)	1,469,774 Baht	909,578 Baht	553,799 Baht
Product visibility	X	√	√
Information quality, accuracy and reliability	X	√	√

Table 6.18 indicated that both EDI systems could results in dramatic operational performance improvement and HSC collaboration enhancement. However, the experiment results indicated for web EDI system with datapool is more effectiveness and efficiency. In comparison, the web EDI system with datapool can reduce number of process from 17 to 8 steps resulting in reduction of process time from 60 to 21 minutes per PO or 60% reduction. While the direct EDI without datapool system eliminated the information sharing process from 17 to 12 steps and process time from 60 to 30 minutes per PO or 50% reduction.

From the perspective of operating cost, the web-based EDI system using datapool can reduce operating cost including labour, communication, and material and supplies from 1,469,774 to 553,799 baht per year based on annually average 9,880 purchase orders. Nevertheless, both EDI systems can serves for traceability of pharmaceuticals, manufactured lots and lot expiration from supplier's warehouses to hospital's warehouses. Due to the web-based EDI using datapool has lack of human interactions, thus it is errors proofing or can delivers more information accuracy, reliability and quality.

Compared between both EDI systems, the web EDI system using datapool has lower total cost of ownership. The point-to-point EDI system require new financial investment for additional connection protocols aligned with number of EDI documents as well as the number of participants causes increasing of implementing costs.

In this experiment, the point-to-point EDI system resulted in complex and resource intensive. Hence, it sound that it is more beneficial in exchange a high volume of EDI documents. While, the web-based EDI system using datapool sounds ease rolling out to facilitate the participants adding into EDI networks. Additionally, this EDI system can be especially beneficial when exchanging EDI documents with hospitals and suppliers where IT and EDI skills are limited. The hospital and also supplier are not needed to installed any EDI software or manage EDI environment in particular with their ERP systems. In the simplest way, it enables small and medium sized of hospitals and suppliers to create, receive, turnaround and manage EDI documents by using Internet browser. Therefore, the hospitals and suppliers, anywhere can connect to the proposed solution without dedicating IT staffs to the implementation of their EDI systems.

From the experiment analysis above, it can conclude that the web EDI system using datapool can enhance HSC collaboration by implementing electronic documents replicated for the paper-based in current practice. Moreover, it can introduce number of operational performance improvement such as reduce number of process, resources, process time and operating cost. Table 6.19 summarized the outcomes generated according to the web-based EDI system using datapool experiment.

Table 6.19 The impact of web EDI system with datapool

Outcome	Description
HSC Collaboration Enhancement	
Supply chain efficiency	• The web-based EDI system using datapool can reduces paper-based tasks and allows the operators to concentrate on higher-value tasks. • Process more accurate on exchanging EDI documents that leads to less re-work of orders, fewer stock outs and fewer cancelled orders • The automatic collation processing function through ERP systems can ensure that the critical data is sent on time and can be tracked and traced. • Enable shortening the order processing and pharmaceutical delivery time that leads to reduce inventory levels at hospitals.
Track and Trace	Enables nearly real-time visibility of pharmaceutical movement according to EDI transaction status.
Operational Performance Improvement	
Operating cost	• Reduce the cost of entering POs manually at 1,469,774 baht compared to 553,799 baht annually or 62.3% reduction. • Eliminate errors due to illegible faxes, lost POs or incorrectly taken phone-call orders, and time for handling data disputes.
Process time	Reduce process time from 60 to 21 minutes
Information speed and accuracy	Improve information quality, accuracy and reliability through standard pharmaceutical codes and standard data attributes kept in an integrated datapool.

Next, in Chapter 7, the discussion on the results of experimental use and its further perspectives to increase operational performance and enhance HSC collaboration would be presented, and finally drawn conclusion of this study.

CHAPTER VII
DISCUSSION AND CONCLUSION

From Chapter 6, the use of an integrated datapool is tested with web-based EDI system model in a hospital case study. Experiment results carried out outputs and outcomes in regard to operational performance improvement and HSC collaboration enhancement. Therefore, in this chapter, the main purposes are to discuss on results of experiment use, future perspectives and draw conclusion of this study.

The discussion on the experiment results and conclusion are discussed as follows;

7.1 Discussion

7.1.1 On results of experiment use

In Chapter 6, we conducted an experiment focusing on exchanging EDI documents in three different settings as follows: 1) exchange business documents using postal mail, fax and email, 2) exchange business documents using point-to-point EDI system and, 3) exchange business documents using web-based EDI system by leveraging an integrated datapool. To evaluate experiment results, the process time, number of operator involvement, operating costs and also level of product visibility and traceability are compared among those settings. The experiment results are illustrated in Table 7.1.

Table 7.1 The experiment result

Key indicator	**Paper-based system**	**Direct EDI system**	**Datapool with web EDI system**
Number of processes	19	14	8
Key indicator	**Paper-based system**	**Direct EDI system**	**Datapool with web EDI system**
Number of operators	9	8	8
Process time	60 minutes/POs	30 minutes/POs	21 minutes/POs
Operating cost	148.76 baht/PO	95.84 baht/PO	56.05 baht/PO
Product visibility	X	√	√
Information accuracy, reliability and quality	X	√	√

Table 7.1 presented that exchange business documents through web EDI system with an integrated datapool showed out the best settings. This settings reduced number of process from 17 to 8 processes, reduced one supplier's operator involved in grapping PO at hospitals, reduced PO process time from 60 minutes to 21 minutes, and also reduced operating cost, including labour, communication and material and supplies from 148.76 to 56.05 baht per purchase order.

From those results, we discussed the current deployment of EDI system in Thailand healthcare supply chain. Even though, its stakeholders agreed on EDI benefits but there are few hospitals and suppliers implemented this system. Mainly of them still relied on information exchange in paper-based format. Therefore, it leaved some opportunities to installed web-based EDI system using an integrated datapool in HSC in Thailand. Table 7.2 illustrated number of hospitals in together with average monthly POs gathered from survey in the previous projects.

Table 7.2 Number of hospitals in Thailand

Category	# of hospitals	Avg. monthly POs (PO)	Total annual POs (PO)
University hospital	23	650	179,000
Tertiary hospital	29	550	191,400
Secondary hospital	63	225	170,100
Primary hospital	684	50	410,400
		Total POs/year	**951,300**

Source: Thailand Health Profile 2008-2010 (MoPH, 2010)

Hence, in case of rolling out this experiment to the number of hospitals shown in Table 7.2, in particular with the cost savings presented in Table 6.17. In Table 6.17 EDI without datapool could save for 52.92 baht/PO and EDI system with datapool could save for 92.71 baht/PO comparing to current paper-based exchange. Hence, the estimate cost on information exchange in buying-selling process was illustrated in Table 7.3.

Table 7.3 The outcomes for datapool adoption with EDI system implementation in Thailand

Key indicator	Paper-based system	EDI system without datapool	EDI system with datapool
Process time (Manhours)	951,300	475,650	332,955
Labour cost (baht)	110,124,866	59,782,070	40,004,543
Communication cost (baht)	18,074,700	18,074,700	0
Material and supplies cost (baht)	13,318,200	13,318,200	13,318,200
Total operating cost (baht)	**141,517,766**	**91,174,970**	**53,322,743**

From Table 7.3, it illustrated that implementing web-based EDI system using an integrated datapool in national scale could reduce process time from 951,300 to 332,955 man-hours or 65% reduction and reduce operating costs from 141,517,766 to 53,322,743 baht annually or 62% reduction.

Moreover, this experiment was conducted against only two EDI documents: EDI-PO and EDI-ASN. In case of this system model further extended to other EDI documents such as EDI-Invoices, EDI-RFQ, EDI-Quotation, and etc., additionally the number of participants, it can amplifies more benefits in process time reduction and cost savings.

7.1.2 Standard datapool attributes use

In the proposed datapool, it composed of three groups of datapool attributes as follows: pharmacological, clinical and logistics information. Apart from standard transmission data attributes, the pharmacological, clinical and logistics attributes can be synchronized with legacy ERP systems to enable more accurate product name, description, and its relevant information. These sets of standard data attributes are another power of an integrated datapool to increase information quality, accuracy and reliability among healthcare stakeholders and leads to increase operational efficiency and enhance patient safety.

7.1.3 Future perspectives

Apart from process time, cost savings and information quality, the proposed datapool can enhance its capability in several point of views as follows:

Automatic Identification and Data Capture (AIDC) technology

AIDC technology has become an essential tool for successful supply chains. Barcode and RFID were widely acknowledged as one of the most cost-effective methods for increasing data accuracy and consistency effected to patient safety improvement (GS1, 2013). Both of it offered the benefit of flexible, open-system technology that can improve efficiency through standalone applications, or integrate with legacy ERP systems in retails (ZIH, 2006). In healthcare, Barker *et al.* (2002) studied barcode application estimation and stated that the barcoding

applications would prevent 50% of medication administration errors. The barcoding system has highly impacted in many medication administrations, for instance, barcoded patient wristbands, unit-dose labels with bar codes, bedside scanning equipment, the software application to confirm the drug administration, and also traditional product issue or receipt at storeroom.

In this study, it pointed out an opportunity to adopt Barcode or RFID system in shipping and receiving processes. At shipping process, suppliers depended on barcode or RFID to ship pharmaceuticals more accurate, quick and efficient from their warehouses to hospitals. This just about affixed shipping cartons with some sort of AIDC labels to help aid in its shipment. These labels included information regarding the supplier, PO, product code, ship-to-location or other relevant information. It might also print small label to affix to the packaging slip or bill of ladings to track the pharmaceuticals at a later date. These pharmaceuticals were then tracked internally to show that it went to the right warehouse accordingly. In the receiving process, hospitals scanned the label affixed to pharmaceutical's packaging and also shipping documents to capture information regarding to the supplier, PO number, pharmaceutical code, ship-to-location or other relevant information into their ERP systems.

Based on this, both hospital and supplier could utilize more accurate data, consistent information on which pharmaceuticals they buy or sell and send. Moreover, barcode and RFID also enabled operators to work faster by data entry speed improvement, alleviates the need for correcting data entry errors; a costly of manual data entry.

Extended use of Vendor-managed inventory (VMI)

From Chapter 6, one of the experiment results indicated that implementation of web-based EDI system model using an integrated datapool enabling nearly real-time visibility of pharmaceutical movement according to EDI transaction status. This result shows an important readiness for VMI concept adoption. De Toni and Zamolo (2005) indicated that approximately 25% of hospital costs are supply-related and VMI is a collaborative initiative where a hospital shifts the ownership of inventories to its immediate upstream supplier and allows the supplier to access

its demand information in return. Additionally, Stank *et al.* (2011) described that the HSC is characterized by forward buying in anticipation of price increases while there is little hospital's demand signals. Auramo et al. (2005) argued that implementing a VMI with EDI information transmission can lead to substantial reduction of inventories, and at the same time increase material availability. Cachon and Fisher, 2000; Zachariassen et al. 2014 stated that the VMI approach can improve supply chain performance by decreasing inventory-related costs and increasing customer service level.

Under this circumstance, it is aligned with our hospital case study; the suppliers have little demand signals from hospital. In particular with experiment results, it convinced that HSC needs to move toward an integrated demand-driven model, so that suppliers have much earlier visibility into actual purchase orders. This integrated supply chain enables suppliers to align their distribution more closely with actual demands. To some extent, this builds on the information requirements of stockless inventory systems. For VMI to work successfully, Mathew *et al.* (2013) suggested that there is a need for accurate information on current stock levels and consumption.

From the experiment results, it showed that using an integrated datapool in web-based EDI system model increasing more accurate information on current stock levels and consumption via the EDI transactions. Therefore, it is initially significant settlement for VMI implementation. Moreover, if the purchase volume is sufficient, it can introduces a Group Purchasing Organization (GPO) for hospitals in order to consolidate their demands for purchase amount negotiation.

To summarize, the proposed datapool that are composed of pharmaceutical identification code in together with standard data attributes are the fundamental infrastructure for adoption of AIDC technology, electronic order management such as e-ordering, e-procurement, EDI transmission, etc. These applications could lead to increase supply chain visibility and also traceability of pharmaceutical movement into the end-to-end performance. Moreover, standard data attributes tied to a pharmaceutical could results in standardization of pharmaceutical information such as name, description and other relevant information. The standardization of pharmaceutical information helps on automatic collation processing and acts as a

single source of pharmaceutical information for healthcare stakeholders. Furthermore, this integrated datapool with standard data attributes could benefits on inefficiency reduction for the entire HSC as follows: 1) reduce inefficiencies through implementing AIDC technology and electronic ordering systems, 2) increase traceability and enhance patient safety through the pharmaceutical visibility and traceability and 3) increase information quality through the application of standard data attributes. Finally, in turn, can improve efficiencies, collaboration, cost savings and patient safety at the top agenda.

7.2 Conclusion

As background of this study, we identified the nature of healthcare supply chain, level of information sharing and collaborations and also its problems struggling HSC collaborations among healthcare stakeholders.

In Thailand healthcare system, variety of national identification codes are existed and in use as well as individual pharmaceutical codes operate in individual IT systems of hospitals and suppliers, product names and its relevant information are also differed and fragmented. Moreover, it found that the visibility and traceability of pharmaceutical movement are neglect; raising the risk in providing patient care as there may be no alternative treatment for the patient.

Furthermore, in this study, the literatures and existing cases are analyzed to ground the problems and intervention improvements to enhance HSC collaboration. The problems preventing information sharing among healthcare stakeholders are showed as follows: 1) data inconsistencies—lack of data standards, variety of pharmaceutical codes are existed and in use and also the information pertaining to a pharmaceutical is differed among healthcare stakeholders and, 2) existing ERP systems are fragmented among manufacturers, distributors and hospitals. These problems impacted to poor quality and speed of information sharing consequently to poor HSC collaboration. To propose intervention improvements, also the literature and existing case reviews are utilized and it leads to the intervention improvements that an integrated datapool could lead to enhance HSC collaboration and improve operational

performance. Therefore, in this study, we proposed the new initiative; *combining variety of pharmaceutical codes and relevant information into an integrated datapool*.

To construct an integrated datapool, number of focus groups and semi-structure interview are considered. Focus group discussions are organized to clarify the needed characteristics of standard pharmaceutical code, semi-structure interview is used to justify minimum data attributes that should be kept in the proposed datapool. In proposed datapool, eleven originality data attributes are introduced. Finally, number of focus groups are held to clarify the requirement and specification of the proposed datapool. Hence, this proposed datapool use the global trade identification number (GTIN-13) as the primary key and mapping to existing national identification codes including FDA's Registration Code, the NHSO's 24 digit reimbursement code and the TMT code. The standard data attributes tied to a pharmaceutical also kept in an electronic transmission format. Therefore, both standard pharmaceutical code and its standard data attributes were used to automate collation processing through ERP systems among healthcare stakeholders.

To test the power of an integrated datapool, a case study is organized. Thus, we applied direct observation in together with experiment at a leading public hospital in Thailand. Initially, the direct observation is considered to examine the information sharing between hospital and suppliers. It indicated that these problems block the efficient information sharing between both dyads as follows:

1. The internal pharmaceutical codes are differed among individual healthcare stakeholders
2. Pharmaceutical names and its relevant information are differed among individual healthcare stakeholders
3. Conditions of pharmaceutical were effected to the patient-care provision
4. ERP systems are fragmented among individual healthcare stakeholders

Based on these problems, the initiative of web-based EDI system model using an integrated datapool which was effected to automatic collation processing. As mentioned earlier, in the proposed datapool, the GTIN 13 acted as the primary key and

tied up with standard data attributes relevant to a pharmaceutical. In this experiment, both hospital and supplier still use their existing ERP systems on conducting their trading activities. Even though, they buy and also sell pharmaceuticals, they also use their individual internal pharmaceutical codes in ERP systems. In this stage, their information is translated through the automatic collation processing system or EDI adapter, in which their internal pharmaceutical codes are converted to GTIN-13 and standard data transmission attributes. Therefore, the automatic collation processing system should include translating functions between internal pharmaceutical codes and GTIN-13 and standard data transmission attributes. So that, this EDI system model using an integrated datapool aims to carry out efficient information sharing and HSC collaboration in the entire healthcare supply chain.

According to this proposed EDI system model, we implemented experimental system and conducted experimental use for 8 weeks at a hospital case study. There are a hospital and four suppliers participated in the experiment. In the case study, the process of purchase order, sales orders, product shipment and pharmaceutical receipts are recorded and analyzed along the following settings: 1) implement the point-to-point EDI system comparing with current practice, 2) implement the web-based EDI system using an integrated datapool comparing with current practice. Experiment results indicated that implementing web-based EDI system using an integrated datapool reduce process time, operating costs, ability to track and trace pharmaceutical movement and increases information quality, accuracy and reliability. These results indicated the effectiveness of the EDI model using an integrated datapool presented in Chapter 5. Finally, the power of an integrated datapool can summarized as follows:

7.2.1 Operational Performance Improvements

The implementation of web-based EDI system model using an integrated datapool result in number of performance improvement as follows: cost savings such as reduce the cost of entering POs manually at 1,446,821 baht to 387,865 baht annually or 73.2% reduction; and eliminate errors due to illegible faxes, lost POs or incorrectly taken phone-call orders, and time for handling data disputes. Discuss on process time, it can reduces the PO cycle time from 52 minutes to 7 minutes or 86.5%

reduction, as well as the improvement on information quality, eliminates errors from illegible handwriting, lost faxes/mail and keying and re-keying errors.

7.2.2 HSC Collaboration Enhancement

The implementation of web-based EDI system model using an integrated datapool can reduce paper-based tasks and allows the operators to concentrate on their higher-value tasks, the proposed datapool can lead to more accurate on exchanging electronic PO and ASN documents resulting in less rework of orders, fewer stock outs and fewer cancelled orders. Due to the automatic collation processing is automatic is handle through ERP systems, it can ensure that the critical data is sent on time and can be tracked and traced. In addition, it enables shortening the purchase order processing time; consequently reducing of inventory level in hospitals. Furthermore, the proposed web-based EDI system model enables nearly real-time visibility of pharmaceutical movement according to EDI transaction status. Hence, it enables suppliers to faster decision-making and improvement of their responsiveness to the changing hospital's demands, and allow them to adopt a demand-driven model such as VMI and stock consignment.

To conclude, this study created eleven originality data attributes as follows: standard pharmaceutical code, referral identification code to other healthcare authority's coding systems in Thailand, brand owner, dosage and presentation unit of measurement and its unit conversion, barcode number and symbology, unit weight, unit volume, packaging dimension, and image of pharmaceuticals and its packages.

Moreover, an integrated datapool, the centralized database that use GTIN-13 as the standard identification code adding with some standard data attributes including pharmacological, clinical and logistics information could be a mean to HSC collaboration in term of enabling visibility and traceability into the end-to-end of pharmaceutical movement through the EDI transaction status and leads to more accurate on information quality, accuracy and reliability due to it act as a single source of pharmaceutical information, and less human interactions in automatic collation processing. Furthermore, it could be a mean to operational performance improvement as well. The standard pharmaceutical code and some standard data attributes in

datapool could reduce process time and cost savings in exchanging EDI documents among healthcare stakeholders.

7.3 Issues of Readiness for EDI system model

There are several costs accrued during the lifetime of the EDI system experiment for the hospital case study. The EDI costs included:

Hardware Costs

The database and application server was only hardware to run the EDI system for hospital case study. The hardware, an IBM x3550 were used to facilitate this EDI system. Hence, the hardware cost at the beginning of the EDI system for the hospital case study was estimated to be 200,000 baht in 2015. In term of direct EDI system, the hardware was utilized an IBM x3550 to facilitate direct EDI system. Therefore, the hardware cost was estimated to be 200,000 baht as well.

Software Costs

The software used to enable the EDI system for the hospital case study was the IBM x3550 Database, which was undertaking using existing hardware. Hence, there was no additional cost at the beginning of the EDI system. The development cost of this software was estimated to be 700,000 baht. However, there are additional costs used for customization existing ERP system in order to interfacing purchase order and advance shipment notice with EDI system. This cost estimated to 120,000 baht.

To implement the direct EDI system, the development cost depended on number of connections for implementing EDI documents. There are 12 connections required in the hospital case study, hence the development cost for EDI software was 4,800,000 baht.

Training Costs

Both EDI system required one-day training period for the participants involved in hospital case study based on information from the purchase order and advance shipment notice. The cost of the training was estimated to be 20,000 baht.

Maintenance Costs

The maintenance costs included both hardware and software annual maintenance costs. According to survey with software companies, the hardware and

software annual maintenance costs were estimated to be 23% of hardware and software cost or 4,600 and 161,000 baht respectively, for EDI system. In term of direct EDI system, the maintenance cost was 1,104,000 baht.

In this hospital case study, the cost of implementing point-to-point EDI system composed of 6,124,000 baht for setting up 12 connections. Compare to the web-based EDI system using datapool, it invested for 1,143,500 baht. Table summarized the cost and benefits for data standards adopting with EDI system.

Table 7.4 Cost-Benefit for the datapool adoption with EDI system

EDI system	**Web EDI with datapool system**	**Direct EDI without datapool system**
Costs of EDI System		
Hardware Costs	200,000	200,000
Software Costs	820,000	4,800,000
Training Costs	20,000	20,000
Maintenance Costs	103,500	1,104,000
Total cost (baht)	**1,143,500**	**6,124,000**
Benefits of EDI System		
Documentation Cost Savings	0	0
Labour Cost Savings	915,975	522,850
Processing Communication Cost Savings	187,720	0
Total benefit (baht)	**1,103,695**	**522,850**

7.4 Limitation and Difficulties of implementing EDI model in Thailand

The benefit of implementing EDI system model in term of buyer can easily track and trace pharmaceuticals' prices and specifications purchased from suppliers, and able to submit their orders by using electronic forms. On the other hands, sales representatives can easily track and trace their pharmaceuticals' shipment by using electronic forms as well. However, although EDI served as an accelerator and a tool to assisting in simplifying the buying-selling process between buyers and sales representatives, there are some limitations and difficulties for implementing this technological system in Thailand. These limitations and difficulties were described as follows:

7.4.1 EDI Business Process

Within hospital and supplier, to implement this EDI system in hospital case study, it is necessitated to integrate of this system with an existing IT systems such as accounting, asset management, inventory management, accounts payable, and cash management. This means making investment only in an EDI system is not sufficient for deriving benefits; besides, this would cause undesirable results such as lack of information, dual entries leading to complications, and increasing time consumptions. In term of external business process, to adopt an EDI system and integrating it with IT systems of hospital and supplier might not guarantee the success of the new EDI process. This is because of buying-selling process normally have two sides, adjusting only their own processes in the hospital or supplier could be insufficient. The suppliers which are known or unknown by the hospital constitutes the other side of the purchasing process, and they have to be well organized in terms of performing electronic transactions. These suppliers have to offer sufficient catalogue choices to satisfy the requirements of their hospitals and necessary update for pharmaceutical catalogues should be made on time. Otherwise, the expected benefits from EDI system could be diminished. Therefore, Business Process Reengineering (BPR) would be applied into buying-selling process before adopting EDI system model.

During the experiment, there was an issue raised by participants regarding to the network security and the reliability. They mentioned that instead of signing PO documents, but applying digital signature in approval process. This could help on reduce more process time and documentation costs. However, it could need to verify regulations by regulators.

The network security was another main concerns for EDI system. Mainly of hospitals' personals worried about the security in term of supplier accessing into their existing IT systems.

7.4.2 Existing IT Systems

There are differed IT systems implemented in different healthcare organizations. Each IT system has different technologies in used. The problem is finding the most suitable integration of EDI system, since every IT systems have its own specifications. For instance, direct Electronic Data Interchange (EDI) provides more rapid, frequent data transfer and security potential; however, the cost of setting up an EDI system is also more than setting up the internet. If the transactions made by a healthcare organization were highly dedicated and proprietary, direct EDI system might well suit that healthcare organization; nonetheless, if the aim of the healthcare organization is only searching and procuring pharmaceuticals alternatives, or using an outdated IT systems the Internet Electronic Data Interchange (EDI) might be the right choice by using file exchanging. Hence, the EDI system model should be determined according to the level of existing IT systems and the needs of healthcare organizations.

Hospital and supplier with a strong support to EDI system model from the organizations' management are more likely to adopt EDI system model at a faster rate. The organizations' management should be motivated towards personal learning that will create the awareness of the need and importance of EDI adoption in their organizations. If this done, there is that likelihood for the management to embrace EDI. In addition, hospitals and suppliers that have the requisite IT and business skill competence will stand a better chance at adopting EDI system model. They also should encourage education of staff to meet current trends in technology required knowledge, with this the needed IT skills could be improved. Hence they could have the motivation to adopt EDI system model. IT skills made compulsory at work; it

could be a basis for promotion and even gaining employment into work and contract. Furthermore, hospitals and suppliers that have sound existing IT technologies were in a better position to adopt EDI system model. Based on those discussion, hospitals and suppliers have that have sound IT systems could better adopting EDI system model since adopting EDI needed some further customization to existing IT systems especially on data extraction and data retrieval interfacing between EDI system and legacy IT systems. This means there is additional investment costs for hospitals and suppliers which planning for EDI adoption.

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APPENDICES

APPENDIX A
DESIGN OF DATAPOOL

In Chapter 5, the design of datapool is presented. Therefore, in Appendix I, it presented the design of datapool ED diagram. To design datapool, the ED diagram is organized into 3 different categories as follows:

1.1 Datapool Design

The block relationship diagram in Figure A.1 represents the base tables of each block of the form (vertical) and tables referenced for validation or lookups (horizontal) in to develop datapool for the experiment.

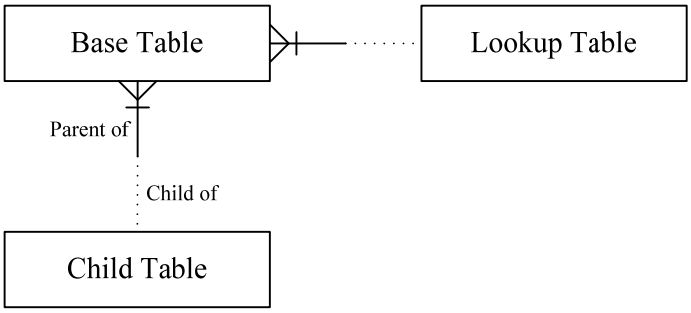

Figure A.1 Block relationship diagram

The entity relationship diagram graphically represents datapool tables and the relationship between them, organized by building blocks. The database diagram for datapool application building blocks is included: Suppliers, Registrations, and Items. The database diagram for each building block is described as follows;

1.2 Supplier Diagram

The supplier diagram presented the tables and relationships through implementing of the supplier master. This diagram also indicates the relationship between items and registration information of pharmaceutical products. Figure A.2 represents the supplier ER diagram.

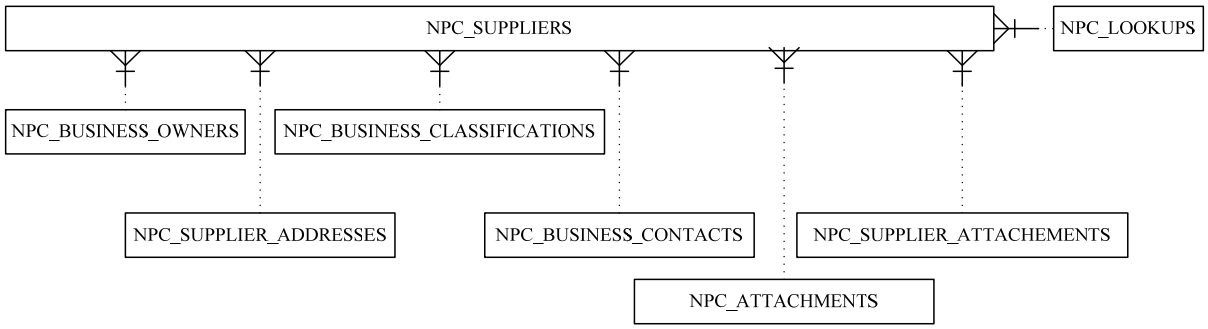

Figure A.2 Supplier ER diagram

The database tables and a brief description of each of those tables in Figure A.2 are presented in Table A.1.

Table A.1 Supplier tables

Table name	Description
NPC_SUPPLIERS	Detailed supplier information
NPC_ATTACHMENTS	Detailed supplier related documents e.g. company registration, tax legalization, VAT registration document and etc.
NPC_SUPPLIER_ADDRESSES	Detailed supplier location address information
NPC_BUSINESS_OWNERS	Detailed the shared holders of suppliers, chief executive and business authorization

Table A.1 Supplier tables (cont.)

Table name	Description
NPC_BUSINESS_CLASSIFICATIONS	Detailed supplier classification such as SMEs, woman owned business, state enterprise, ISO certified companies and etc.
NPC_BUSINESS_CONTACTS	Detailed supplier contact person and contact information
NPC_SITES	Detailed supplier sites such as head office, production plants, branch and ect.

The detailed design of each database table and its detailed definitions of tables describe as follows:

NPC_SUPPLIERS

NPC_SUPPLIERS stores information regarding to the providers of product information into NPC datapool such as brand owners, manufacturers and authorized suppliers or distributors. Each row includes the supplier name as well as address, shared holders, classification, and general information. The SUPPLIER_ID is the unique identification number system–generated receipt header number invisible to the user. The column description of NPC_SUPPLIERS table is described in Table A.2.

Table A.2 NPC_SUPPLIERS table

Column Descriptions

Field	Null Flag	Data Format	Description
SUPPLIER_ID (PK)	NOT NULL	NUMBER	Supplier identifier
SUPPLIER_NAME_TH	NOT NULL	VARCHAR2(120)	Supplier name in Thai

Table A.2 NPC_SUPPLIERS table (cont.)

Field	Null Flag	Data Format	Description
SUPPLIER_NAME_EN	NULL	VARCHAR2(120)	Supplier name in English
SUPPLIER_NAME_ALT	NULL	VARCHAR2(60)	Alternate supplier name
DESCRIPTION	NULL	VARCHAR2(200)	Description of supplier
NAME_PRONUNCIATION	NULL	VARCHAR2(120)	Supplier name pronunciation
INDUSTRIAL_CLASSIFICATION	NULL	VARCHAR2(25)	Supplier classification
NATIONAL_INSURANCE_NUMBER	NULL	VARCHAR2(30)	Supplier national insurance number
TAX_REGISTRATION_NUMBER	NULL	VARCHAR2(15)	Tax registration number
TAX_PAYER_ID	NULL	VARCHAR2(80)	Tax payer identifier
DUNS_NUMBER	NULL	VARCHAR2(80)	Data Universal Numbering System
FDA_NUMBER	NULL	VARCHAR2(80)	Registration number granted by the Thai FDA
URL	NULL	VARCHAR2(50)	Supplier website
NOTE	NULL	VARCHAR2(320)	Note to supplier
COUNTRY_REGISTERED	NULL	VARCHAR2(80)	Indicate country that supplier is registered
CAPITAL_REGISTERED	NULL	NUMBER	Indicate capital registered
FISCAL_YEAR_ESTABLISHED	NULL	VARCHAR2(4)	Year of supplier establishment

Table A.2 NPC_SUPPLIERS table (cont.)

Field	Null Flag	Data Format	Description
FUNCTIONAL_CURRENCY	NULL	VARCHAR2(40)	Base currency
MISSION_STATEMENT	NULL	VARCHAR2(200)	Supplier mission statement
EMPLOYEE_TOTAL	NULL	NUMBER	Number of total employee
EMPLOYEE_TOTAL_TYPE	NULL	VARCHAR2(10)	Indicate data source of number of total employee
TAX_REGISTRATION_NUMBER	NULL	VARCHAR2(80)	Tax registration number
TAX_COUNTRY	NULL	VARCHAR2(80)	Tax payable country
FISCAL_YEAR_END	NULL	VARCHAR2(40)	Indicate month of fiscal year end
ANNUAL_REVENUE	NULL	NUMBER	Annual revenue
POTENTIAL_REVENUE_GROWTH	NULL	NUMBER	Planned next year revenue
BRAND_OWENER_FLAG	NULL	VARCHAR2(1)	Indicates that the supplier is a brand owner
MANUFACTURER_FLAG	NULL	VARCHAR2(1)	Indicates that the supplier is a manufacturer
DISTRIBUTOR_FLAG	NULL	VARCHAR2(1)	Indicates that the supplier is a distributor
GOVERNMENT_OWNED_FLAG	NULL	VARCHAR2(1)	Indicate that the supplier is state enterprise
STATUS	NULL	VARCHAR2(1)	Indicate status of supplier

NPC_SUPPLIER_ADDRESSES

NPC_SUPPLIER_ADDRESSES stores information about supplier location addresses. Each row includes the located address, preferred language, geographical latitude and longitude, map, and contact information. The SUPPLIER_ADDRESS_ID is the unique identification number system–generated number invisible to the user. The column description of NPC_SUPPLIER_ADDRESSES table is described in Table A.3.

Table A.3 NPC_SUPPLIER_ADDRESSES table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_SUPPLIERS	SUPPLIER_ID	SUPPLIER_ID

Column Descriptions

Field	**Null Flag**	**Data Format**	**Description**
SUPPLIER_ADDRESS_ID(PK)	NOT NULL	NUMBER	Supplier address unique identifier
SUPPLIER_ID(FK)	NOT NULL	NUMBER	Supplier identifier
ADDRESS_NAME	NULL	VARCHAR2(80)	Supplier address name
ADDRESS_SHORT_NAME	NULL	VARCHAR2(120)	Supplier address short name
LANGUAGE	NULL	VARCHAR2(80)	Local language used in the address
ADDRESS_LINE1	NOT NULL	VARCHAR2(200)	First line of supplier address
ADDRESS_LINE2	NULL	VARCHAR2(200)	Second line of supplier address
ADDRESS_LINE3	NULL	VARCHAR2(200)	Third line of supplier address
CITY	NULL	VARCHAR2(80)	City
PROVINCE	NULL	VARCHAR2(80)	Province
ZIP	NULL	VARCHAR2(20)	Postal code

Column Descriptions (cont.)

Field	Null Flag	Data Format	Description
COUNTRY	NOT NULL	VARCHAR2(80)	Country name
PHONE	NULL	VARCHAR2(25)	Supplier phone number
FAX	NULL	VARCHAR2(25)	Supplier fax number
EMAIL	NULL	VARCHAR2(120)	Supplier contact email address
LATITUDE	NULL	VARCHAR2(80)	Latitude in GIS map
LONGITUDE	NULL	VARCHAR2(80)	Longitude in GIS map
LOCATION_MAP	NULL	VARCHAR2(120)	Supplier address map
GLN	NULL	VARCHAR2(14)	Supplier address GLN according to GS1 granted number
STATUS	NULL	VARCHAR2(1)	Indicate status of supplier address

NPC_BUSINESS_OWNERS

NPC_BUSINESS_OWNERS stores information regarding to the shared holders of suppliers such as name, the authority and business authorization. Each row includes the shared holders and business authorization. The OWNER_ID is the unique identification number system–generated receipt header number invisible to the user. The column description of NPC_BUSINESS_OWNERS table is described in Table A.4.

Table A.4 NPC_BUSINESS_OWNERS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_SUPPLIERS	SUPPLIER_ID	SUPPLIER_ID

Column Descriptions

Field	**Null Flag**	**Data Format**	**Description**
OWNER_ID(PK)	NOT NULL	NUMBER	Supplier owner unique identifier
SUPPLIER_ID(FK)	NOT NULL	NUMBER	Supplier identifier
LINE_SEQ		NUMBER	Line number
TITLE	NULL	VARCHAR2(30)	Title
GIVEN_NAME	NOT NULL	VARCHAR2(120)	Name
GENDER	NULL	VARCHAR2(1)	Gender
CHIEF_EXECUTIVE_FLAG	NULL	VARCHAR(1)	Indicate whether given name is a chief executive of supplier
BUSINESS_AUTHORIZATION	NULL	VARCHAR2(240)	Indicate the condition of legal authorization

NPC_BUSINESS_CLASSIFICATIONS

NPC_BUSINESS_CLASSIFICATIONS store business classification of a supplier e.g. woman owned, SME, veteran, ISO certified companies and etc. Each row includes classification as well as the certification number they are hold. The CLASSIFICATION_ID is the unique identification number system–generated receipt header number invisible to the user. The column description of NPC_BUSINESS_CLASSIFICATIONS table is described in Table A.5.

Table A.5 NPC_BUSINESS_CLASSIFICATIONS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_SUPPLIERS	SUPPLIER_ID	SUPPLIER_ID

Column Descriptions

Field	**Null Flag**	**Data Format**	**Description**
CLASSIFICATION_ID(PK)	NOT NULL	NUMBER	Supplier classification unique identifier
SUPPLIER_ID(FK)	NOT NULL	NUMBER	Supplier identifier
CLASSIFICATION	NOT NULL	VARCHAR(80)	Classification
MINORITY_TYPE	NULL	VARCHAR(80)	Minority of share holders
CERTIFICATION_NUMBER	NULL	VARCHAR(80)	Certification number
CERTIFY_AGENCY	NULL	VARCHAR(80)	Certify agency who issued certification number
EXPIRATION_DATE	NULL	DATE	Expire date of certification number
STATAS	NULL	VARCHAR(1)	Indicate status of classification

NPC_BUSINESS_CONTACTS

NPC_BUSINESS_CONTACTS store name of contact person for a supplier. Each row includes contact name as well as the contact information such as email address, phone number, fax number and etc. The SUPPLIER_CONTACT_ID is the unique identification number system–generated receipt header number invisible to the user. The column description of NPC_BUSINESS_CONTACTS table is described in Table A.6.

Table A.6 NPC_BUSINESS_CONTACTS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_SUPPLIERS	SUPPLIER_ID	SUPPLIER_ID
NPC_SUPPLIER_SITES	SUPPLIER_SITE_ID	SUPPLIER_SITE_ID

Column Descriptions

Field	**Null Flag**	**Data Format**	**Description**
SUPPLIER_CONTACT_ID(PK)	NOT NULL	NUMBER	Supplier contact unique identifier
SUPPLIER_ID(FK)	NOT NULL	NUMBER	Supplier identifier
SUPPLIER_SITE_ID(FK)	NOT NULL	NUMBER	Supplier site identifier
SUPPLIER_CONTACT_NAME	NOT NULL	VARCHAR2(80)	Supplier contact name
TITLE	NULL	VARCHAR2(40)	Title
GIVEN_NAME	NULL	VARCHAR2(120)	Name of contact person
GENDER	NULL	VARCHAR2(1)	Gender
JOB_TITLE	NULL	VARCHAR2(80)	Job title of contact person
DEPARTMENT	NULL	VARCHAR2(80)	Department of contact person

Column Descriptions (cont.)

Field	Null Flag	Data Format	Description
EMAIL	NULL	VARCHAR2(80)	Contact email address
PHONE	NULL	VARCHAR2(80)	Contact phone number
FAX	NULL	VARCHAR2(80)	Contact facsimile number
STATUS	NULL	CHAR(1)	Indicate active or inactive contact name

1.3 Item Registration Diagram

Item Registration Diagram presented the tables and relationships through implementing of the pharmacological and clinical information. This diagram also indicates the relationship between a pharmaceutical product and its supplier. Figure A.3 represents the registration ER diagram.

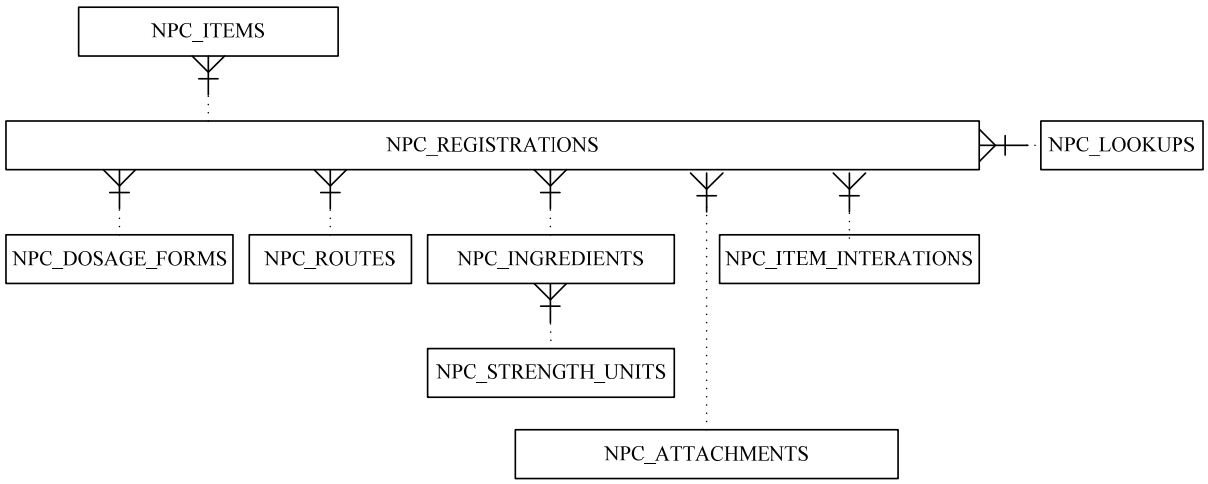

Figure A.3 Registration ER diagram

The database tables and a brief description of each of those tables are presented in Table A.7.

Table A.7 Pharmaceutical product registration tables

Table name	Description
NPC_REGISTRATIONS	Detailed registration information including pharmacological and clinical information that already submitted and certified by the FDA Thailand
NPC_ITEM_ATTACHMENTS	Detailed the attached document of pharmaceutical products e.g. certificate of analysis, patient information leaflet, certificate of pharmaceutical products, and etc.
NPC_INGREDIENTS	Detailed the chemical substance, nomenclature, validation of analytical procedure of pharmaceutical products
NPC_STRENGTH_UNITS	Detailed the strengths of chemical substance of a pharmaceutical product
NPC_DOSAGE_FORMS	Detailed the dosage forms of a pharmaceutical product
NPC_ROUTES_OF_ADMINISTRATION	Detailed routes of administration
NPC_ITEM_INTERACTIONS	Detailed the interaction information of a pharmaceutical product to other products, foods, and etc.

The detailed design of each database table and its detailed definitions of tables describe as follows:

NPC_REGISTRATIONS

NPC_REGISTRATIONS store pharmacological and clinical information of pharmaceutical products. Each row includes registration code granted by the FDA Thailand as well as trade name, generic name, pregnancy category, and etc. The primary key for a pharmaceutical product is the REGISTRATION_ID. The field of NPC_REGISTRATIONS table is presented in Table A.8.

Table A.8 NPC_REGISTRATIONS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_ITEMS	ITEM_ID	ITEM_ID
NPC_SUPPLIERS	SUPPLIER_ID	BRAND_OWNER_ID
NPC_SUPPLIERS	SUPPLIER_ID	MANUFACTURER_ID

Column Descriptions

Field	Null Flag	Data Format	Description
REGISTRATION_ID (PK)	NOT NULL	NUMBER	Registration unique identifier
ITEM_ID(FK)	NULL	NUMBER	Item identifier
REGISTRATION_CODE	NOT NULL	VARCHAR2(80)	Thai FDA registration code
TRADE_NAME_TH	NULL	VARCHAR2(120)	Trade name in Thai
TRADE_NAME_EN	NULL	VARCHAR2(120)	Trade name in English
GENERIC_NAME	NULL	VARCHAR2(400)	Generic name
REGISTERED_UNIT	NULL	NUMBER	Registered quantity
REGISTERED_UOM	NULL	VARCHAR2(40)	Registered unit of measurement
DESCRIPTION	NULL	VARCHAR2(200)	Description
GENERIC_DRUG_FLAG	NULL	VARCHAR2(1)	Indicate whether pharmaceutical product is generic drugs
MONOPOLY_FLAG	NULL	VARCHAR2(1)	Indicate whether pharmaceutical product is monopoly sale in Thailand
PREGNANCY_CATEGORY	NULL	VARCHAR2(80)	Indicate pregnancy category
DOSAGE_FORM_CODE	NULL	VARCHAR2(80)	Dosage form

Column Descriptions (cont.)

Field	Null Flag	Data Format	Description
ROUTE_CODE	NULL	VARCHAR2(80)	Route of administration
INDICATIONS	NULL	VARCHAR2(400)	Indications
INDICATIONS_TH	NULL	VARCHAR2(400)	Indications in Thai
CONTRAINDICATIONS	NULL	VARCHAR2(400)	Contraindications
CONTRAINDICATIONS_TH	NULL	VARCHAR2(400)	Contraindications in Thai
DOSAGE	NULL	VARCHAR2(400)	Dosage
DOSAGE_TH	NULL	VARCHAR2(400)	Dosage in Thai
OVERDOSE	NULL	VARCHAR2(400)	Overdose
OVERDOSE_TH	NULL	VARCHAR2(400)	Overdose in Thai
ADMINISTRATIONS	NULL	VARCHAR2(400)	Drug administrations
ADMINISTRATIONS_TH	NULL	VARCHAR2(400)	Drug administrations in Thai
ADVERSE_DRUG_REACTIONS	NULL	VARCHAR2(400)	Adverse drug reactions
ADVERSE_DRUG_REACTIONS_TH	NULL	VARCHAR2(400)	Adverse drug reactions in Thai
PRECAUTIONS	NULL	VARCHAR2(400)	Precautions
PRECAUTIONS_TH	NULL	VARCHAR2(400)	Precautions in Thai
SPECIAL_PRECAUTIONS	NULL	VARCHAR2(400)	Special precautions
SPECIAL_PRECAUTIONS_TH	NULL	VARCHAR2(400)	Special precautions
BRAND_OWNER_ID	NULL	NUMBER	Indicate the brand owner of pharmaceutical product
MANUFACTURER_ID	NULL	NUMBER	Indicate the manufacturer of pharmaceutical product

Column Descriptions (cont.)

Field	Null Flag	Data Format	Description
MARKETING_AUTHORIZATION_PROCEDURE	NULL	VARCHAR2(80)	Indicate the marketing authorization procedure of pharmaceutical product
MARKETING_STATUS	NOT NULL	VARCHAR2(1)	Indicate marketing status of pharmaceutical product
MARKETING_START_DATE	NULL	DATE	Marketing start date of pharmaceutical product
MARKETING_END_DATE	NULL	DATE	Marketing end date of pharmaceutical product

NPC_DOSAGE_FORMS

NPC_DOSAGE_FORMS store dosage form information of pharmaceutical products such as tablet, capsule, syrup and etc. Each row includes dosage form code, name and description. The primary key for a dosage form is the DOSAGE_FORM_CODE. The field of NPC_DOSAGE_FORMS table is presented in Table A.9.

Table A.9 NPC_DOSAGE_FORMS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_REGISTRATIONS	REGISTRATION_ID	REGISTRATION_ID

Column Descriptions

Field	**Null Flag**	**Data Format**	**Description**
DOSAGE_FORM_CODE (PK)	NOT NULL	VARCHAR2(80)	Dosage form code
REGISTRATION_ID	NOT NULL	NUMBER	Registration unique identifier
DOSAGE_FORM_NAME	NULL	VARCHAR2(120)	Dosage form name
DESCRIPTION	NULL	VARCHAR2(240)	Dosage form description
DISABLE_ON	NULL	DATE	Date that dosage form is no longer used

NPC_ROUTE_OF_ADMINISTRATIONS

NPC_ROUTE_OF_ADMINISTRATIONS store routes of administration information such as oral, nasal, rectal and etc. Each row includes route of administration code, name and description. The primary key for an item is the ROUTE_CODE. The field of NPC_ROUTE_OF_ADMINISTRATIONS table is presented in Table A.10.

Table A.10 NPC_ROUTE_OF_ADMINISTRATIONS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_REGISTRATIONS	REGISTRATION_ID	REGISTRATION_ID

Column Descriptions

Field	Null Flag	Data Format	Description
ROUTE_CODE (PK)	NOT NULL	VARCHAR2(80)	Route of administration code
REGISTRATION_ID	NOT NULL	NUMBER	Registration unique identifier
ROUTE_NAME	NULL	VARCHAR2(120)	Route of administration name
DESCRIPTION	NULL	VARCHAR2(240)	Route of administration description
DISABLE_ON	NULL	DATE	Inactive date

NPC_INGREDIENTS

NPC_INGREDIENTS is the definition table of ingredients or chemical composition of a pharmaceutical product. This table holds the specific related-information fields such as active ingredients name, strength, strength unit and etc. The primary key for an item is the INGREDIENT_ID. The field of NPC_ INGREDIENTS table is presented in Table A.11.

Table A.11 NPC_INGREDIENTS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_REGISTRATIONS	REGISTRATION_ID	REGISTRATION_ID
NPC_ITEMS	ITEM_ID	INGRDIENT_ID

Column Descriptions

Field	**Null Flag**	**Data Format**	**Description**
SEQ_NUM	NOT NULL	NUMBER	Line number
INGRDIENT_ID (PK)	NOT NULL	NUMBER	Ingredient unique identifier
INGREDIENT_NAME	NOT NULL	VARCHAR2(80)	Ingredient name
INGREDIENT_DESCRIPTION	NULL	VARCHAR2(240)	Ingredient description
STRENGTH	NULL	NUMBER	Strength
STRENGTH_UNIT	NULL	VARCHAR2(80)	Strength unit of measure
EFFECTIVE_DATE_FROM	NULL	DATE	Indicate effective start date of ingredient
EFFECTIVE_DATE_TO	NULL	DATE	Indicate effective end date of ingredient

NPC_STRENGTH_UNITS

NPC_STRENGTH_UNITS store strength unit of measure e.g.mg/mL, mg, etc. Each row includes strength unit code, name and description. The primary key for an item is the STRENGTH_UNIT_CODE. The field of NPC_STRENGTH_UNITS table is presented in Table A.12.

Table A.12 NPC_STRENGTH_UNITS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_REGISTRATIONS	REGISTRATION_ID	REGISTRATION_ID
NPC_INGREDIENTS	STRENGTH_UNIT_CODE	STRENGTH_UNIT

Column Descriptions

Field	**Null Flag**	**Data Format**	**Description**
STRENGTH_UNIT_CODE(PK)	NOT NULL	VARCHAR2(80)	Strength unit code
STRENGTH_UNIT_NAME	NULL	VARCHAR2(120)	Strength unit name
DESCRIPTION	NULL	VARCHAR2(240)	Strength unit description
DISABLE_ON	NULL	DATE	Inactive date

NPC_ITEM_INTERACTIONS

NPC_ITEM_INTERACTIONS store drug-drug, drug-food interactions information. This table holds the information fields such as item, registration code, interactions, and etc. The primary key for an item is the INTERACTION_ID. The field of NPC_ITEM_INTERACTIONS table is presented in Table A.13.

Table A.13 NPC_ITEM_INTERACTIONS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_ITEMS	ITEM_ID	ITEM_ID
NPC_ITEMS	ITEM_ID	LINE_ITEM_ID
NPC_REGISTRATIONS	REGISTRATION_ID	REGISTRATION_ID

Column Descriptions

Field	Null Flag	Data Format	Description
ITEM_ID(FK)	NOT NULL	NUMBER	Item identifier
INTERACTION_ID(PK)	NOT NULL	NUMBER	Interaction unique number
LINE_ITEM_ID(FK)	NOT NULL	NUMBER	Item identifier
REGISTRATION_ID(FK)	NULL	NUMBER	Registration unique identifier
INTERACTIONS	NOT NULL	VARCHAR2(120)	Drug interactions
DESCRIPTION	NULL	VARCHAR2(240)	Item interaction description
DISABLE_DATE	NULL	DATE	Date on which the interactions can no longer be used

1.4 Item Diagram

The item diagram presented the tables and relationships through implementing of the item master. This diagram also indicates the relationship between registration information and suppliers of a pharmaceutical product. Figure A.4 represents the item ER diagram.

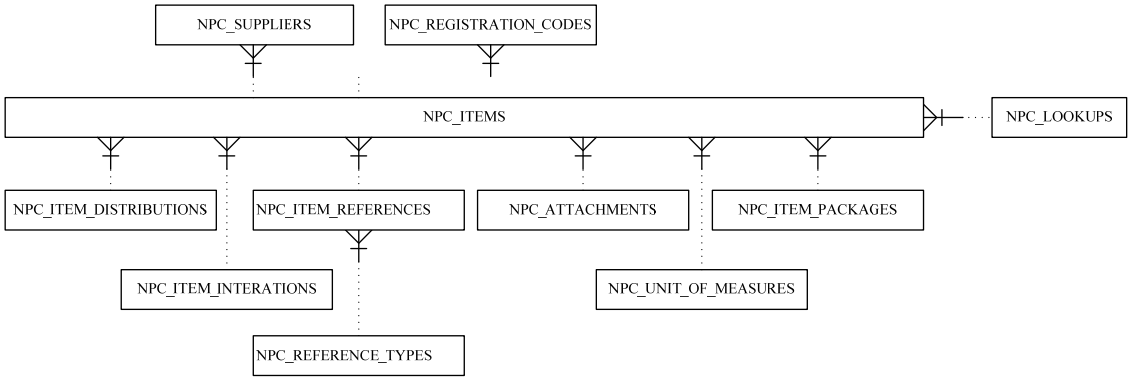

Figure A.4 Item ER diagram

The database tables and a brief description of each of those tables are presented in Table A.14.

Table A.14 Item Master tables

Table name	Description
NPC_ITEMS	Base table for storing item information such as item name, unit of measure, manufacturer and etc.
NPC_ITEM_ REFERENCES	Detailed the relationship of item and reference type values e.g. TMT, registration code, reimbursement codes, and etc.
NPC_ REFERENCE_TYPES	Detailed reference types e.g. TMT, reimbursement code, ATC, and etc.
NPC_UINT_OF_MEASUREMENTS	Detailed logistics unit of measurement
NPC_ITEM_PACKAGES	Detailed the hierarchy of pharmaceutical product packages for instance a 10 tablets contain in a blister, a 10 blisters contain in a box, a 24 boxes contain in a carton.
NPC_ITEM_DISTRIBUTIONS	Detailed the name of local authorized distributors of a pharmaceutical product

Table A.14 Item Master tables

Table name	Description
NPC_ITEM_INTERACTIONS	Detailed the interaction information between pharmaceutical products
NPC_ATTACHMENTS	Detailed the attached documents associated with a pharmaceutical product e.g. license document, COA, picture of products and etc.

NPC_ ITEMS

NPC_ITEMS is the definition table for logistics information of a pharmaceutical product. This base table holds the logistics information fields such as pharmacutical name, unit of measure, manufacturer and etc. The primary key for an item is the ITEM_ID. The field of NPC_ITEMS table is presented in Table A.15.

Table A.15 NPC_ ITEMS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_SUPPLIERS	SUPPLIER_ID	MANUFACTURER_ID
NPC_REGISTRATIONS	REGISTRATION_ID	REGISTRATION_ID
NPC_UNIT_OF_MEASUREMENTS	UOM_CODE	PRIMARY_UNIT_OF_MEASURE
NPC_UNIT_OF_MEASUREMENTS	UOM_CODE	SECONDARY_UNIT_OF_MEASURE

Column Descriptions

Field	Null Flag	Data Format	Description
ITEM_ID(PK)	NOT NULL	NUMBER	Inventory item identifier
REGISTRATION_ID(FK)	NULL	NUMBER	Registration unique identifier
DESCRIPTION	NOT NULL	VARCHAR2(240)	Item description is maintained in the installation base language only
LONG_DESCRIPTION	NULL		
PRIMARY_UNIT_OF_MEASURE	NOT NULL	VARCHAR2(25)	Primary stocking unit of measure for the item
SECONDARY_UNIT_OF_MEASURE	NULL	VARCHAR2(25)	Secondary stocking unit of measure for the item
CONVERSION_RATE	NULL	NUMBER	Conversion rate from secondary unit to primary unit
ITEM_TYPE	NOT NULL	VARCHAR2(30)	Item type
DISPENSING_UNIT	NULL	VARCHAR2(25)	Dispensing unit of measure
FEDERAL_REPORTING_FLAG	NULL	VARCHAR2(1)	Indicate that item is federal reportable
STORAGE_CONDITION	NULL	VARCHAR2(80)	Item storage condition
COMODITY_CODE	NULL	VARCHAR2(80)	Commodity code
REUSABILITY_TYPE	NULL	VARCHAR2(40)	Indicates whether the item is reusability
IMPLANTABLE_FLAG	NULL	VARCHAR2(1)	Indicates whether the item is implant

Column Descriptions (cont.)

Field	Null Flag	Data Format	Description
BLOOD_CONTAINED_FLAG	NULL	VARCHAR2(1)	Indicates whether the item is containing blood
LOT_CONTROLED	NULL	VARCHAR2(40)	Lot control code
SERIAL_CONTROLED	NULL	VARCHAR2(40)	Serial control code
SHELF_LIFE_DAYS	NULL	NUMBER	Length of shelf life days
BARCODE_MARKED_FLAG	NULL	VARCHAR2(1)	Indicates whether the item is barcode marked
UN_NUMBER	NULL	VARCHAR2(40)	Purchasing UN (United Nations)number
HAZARD_CLASS	NULL	VARCHAR2(40)	Hazard identifier
HANDLING_INSTRUCTIONS	NULL	VARCHAR2(240)	Item handling instructions
MANUFACTURER_ID	NULL	NUMBER	Indicates the manufacturer of item
COUNTRY_OF_ORIGIN	NULL	VARCHAR2(40)	Indicates the country of origin of item
ITEM_STATUS	NOT NULL	VARCHAR2(1)	Indicate active or inactive of item

NPC_UNIT_OF_MEASUREMENTS

NPC_UNIT_OF_MEASUREMENTS is the definition table for unit of measurement e.g. tablet, box, carton and etc. This table holds the information fields such as unit of measure code, unit of measure name, description and etc. The primary key for an item is the UOM_CODE. The field of NPC_UNIT_OF_MEASUREMENTS table is presented in Table A.16.

Table A.16 NPC_UNIT_OF_MEASUREMENTS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_ITEMS	ITEM_ID	ITEM_ID

Column Descriptions

Field	Null Flag	Data Format	Description
UOM_CODE(PK)	NOT NULL	VARCHAR(40)	Abbreviated unit of measure code
ITEM_ID(FK)	NOT NULL	NUMBER	Item identifier
UNIT_OF_MEASURE	NOT NULL	VARCHAR(80)	Unit of measure name
DESCRIPTION	NULL	VARCHAR(240)	Unit of measure description
DISABLE_ON	NULL	DATE	Date when the unit can no longer be used to define conversions

NPC_ITEM_DISTRIBUTIONS

NPC_ITEM_DISTRIBUTIONS is the definition table for the local authorized distributor of pharmaceutical products. This table holds the information fields such as item, distributor, and etc. The primary key for an item is the LINE_ID. The field of NPC_ITEM_DISTRIBUTIONS table is presented in Table A.17.

Table A.17 NPC_ITEM_DISTRIBUTIONS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_ITEMS	ITEM_ID	ITEM_ID
NPC_SUPPLIERS	DISTRIBUTOR_ID	SUPPLIER_ID
NPC_SUPPLIER_SITES	SUPPLIER_SITE_ID	SUPPLIER_SITE_ID

Column Descriptions

Field	Null Flag	Data Format	Description
LINE_ID(PK)	NOT NULL	NUMBER	Line number
ITEM_ID(FK)	NOT NULL	NUMBER	Item identifier
DISTRIBUTOR_ID(FK)	NOT NULL	NUMBER	Distributor unique identifier
DISTRIBUTOR	NULL	VARCHAR2(80)	Distributor name
SUPPLIER_SITE_ID(FK)	NULL	NUMBER	Supplier site unique identifier
SITE	NULL	VARCHAR2(80)	Distributor site name
DISABLE_DATE	NULL	DATE	Date on which the relationships can no longer be used

NPC_ITEM_REFERENCES

NPC_ITEM_REFERENCES is the definition table for identification code reference information e.g. ATC class, TMT code, NHSO reimbursement code and etc. This table holds the information fields such as item, reference type, reference values and etc. The primary key for an item is the ITEM_REFERENCE_ID. The field of NPC_ITEM_REFERENCES table is presented in Table A.18.

Table A.18 NPC_ITEM_ REFERENCES table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_ITEMS	ITEM_ID	ITEM_ID
NPC_REFERENCE_TYPES	REFERENCE_TYPE	REFERENCE_TYPE

Column Descriptions

Field	Null Flag	Data Format	Description
ITEM_REFERENCE_ID(PK)	NOT NULL	NUMBER	Item reference unique identifier
ITEM_ID(FK)	NOT NULL	NUMBER	Item identifier
REFERENCE_TYPE(FK)	NOT NULL	VARCHAR2(25)	Reference designator
REFERENCE_VALUE	NOT NULL	VARCHAR2(120)	Reference value
DESCRIPTION	NULL	VARCHAR2(240)	Item reference description
DISABLE_DATE	NULL	DATE	Date on which the cross reference type can no longer be used

NPC_REFERENCE_TYPES

NPC_REFERENCE_TYPES is the definition table for reference types e.g. TMT, reimbursement code, ATC and etc. This table holds the information fields such as reference code, reference name, description and etc. The primary key is the REFERENCE_TYPE. The field of NPC_REFERENCE_TYPES table is presented in Table A.19.

Table A.19 NPC_ REFERENCE_TYPES table

Column Descriptions

Field	Null Flag	Data Format	Description
REFERENCE_TYPE(PK)	NOT NULL	VARCHAR2(25)	Reference designator
DESCRIPTION	NULL	VARCHAR2(240)	Reference type description
DISABLE_DATE	NULL	DATE	Date on which the cross reference type can no longer be used

NPC_ITEM_PACKAGES

NPC_ITEM_PACKAGES store packaging information of pharmaceutical products for instance a 10 tablets packed into a blister pack, the 10 blister packs packed into a box and the 24 boxes packed into a carton. This table holds the information fields such as presentation unit, unit conversion, barcode number, packaging dimension and etc. The primary key for an item is the ITEM_PACKAGE_ID. The field of NPC_ITEM_PACKAGES table is presented in Table A.20.

Table A.20 NPC_ITEM_PACKAGES table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_ITEMS	ITEM_ID	ITEM_ID

Column Descriptions

Field	Null Flag	Data Format	Description
ITEM_ID(FK)	NOT NULL	NUMBER	Item identifier
ITEM_PACKAGE_ID(PK)	NOT NULL	NUMBER	Hierarchical level number
PRESENTATION_UNIT	NOT NULL	VARCHAR(40)	Package presentation unit
DISPENSING_UNIT	NOT NULL	VARCHAR(40)	Dispensing unit
CONVERSION	NOT NULL	NUMBER	Conversion factor between presentation and dispensing unit
DESCRIPTION	NULL	VARCHAR(120)	Description of relationship between presentation and dispensing unit
BARCODE_MARKED_FLAG	NULL	VARCHAR(1)	Flag indicating whether item is barcode marked
BARCODE	NULL	VARCHAR(40)	Barcode number
BARCODE_FORMAT	NULL	VARCHAR(40)	Barcode format
CUSTOMER_ORDER_ENABLED_FLAG	NULL	VARCHAR(1)	Indicate that customer can place order against the packaging
UNIT_WEIGHT	NULL	NUMBER	Unit weight

Column Descriptions (cont.)

Field	Null Flag	Data Format	Description
WEIGHT_UOM_CODE	NULL	VARCHAR(40)	Weight unit of measure code
UNIT_VOLUME	NULL	NUMBER	Unit volume
VOLUME_UOM_CODE	NULL	VARCHAR(40)	Volume unit of measurements
UNIT_DIMENSION_WIDTH	NULL	NUMBER	Unit width
UNIT_DIMENSION_LENGTH	NULL	NUMBER	Unit length
UNIT_DIMENSION_HEIGHT	NULL	NUMBER	Unit height
DIMENSION_UOM_CODE	NULL	VARCHAR(40)	Dimension unit of measurements
STATUS	NULL	VARCHAR(1)	Indicate active or inactive status of packaging

NPC_ATTACHMENTS

NPC_ATTACHMENTS store files or any other information related to a supplier, registration or pharmaceutical product e.g. picture, certification document, and etc. Each row includes attachment type as well as the attached documents. The ATTACHMENT_ID is the unique identification number system–generated receipt header number invisible to the user. The column description of NPC_ATTACHMENTS table is presented in Table A.21.

Table A.21 NPC_ATTACHMENTS table

Foreign Keys

Primary Key Table	Primary Key Column	Foreign Key Column
NPC_ITEMS	ITEM_ID	ITEM_ID
NPC_REGISTRATIONS	REGISTRATION_ID	REGISTRATION_ID
NPC_SUPPLIERS	SUPPLIER_ID	SUPPLIER_ID
NPC_SUPPLIER_SITES	SUPPLIER_SITE_ID	SUPPLIER_SITE_ID

Column Descriptions

Field	Null Flag	Data Format	Description
ATTACHMENT_ID(PK)	NOT NULL	NUMBER	Attachment unique identifier
ITEM_ID(FK)	NULL	NUMBER	Item identifier
REGISTRATION_ID(FK)	NULL	NUMBER	Registration identifier
SUPPLIER_ID(FK)	NULL	NUMBER	Supplier identifier
SUPPLIER_SITE_ID(FK)	NULL	NUMBER	Supplier site identifier
ATTACHMENT_NAME	NOT NULL	VARCHAR2(80)	Attachment name
DESCRIPTION	NULL	VARCHAR2(240)	Description of attachment
ATTACHMENT_TYPE	NULL	VARCHAR2(80)	Indicate type of attachment
URL	NULL	VARCHAR2(80)	URL attachment
TEXT	NULL	VARCHAR2(240)	Text attachment
STATUS	NULL	VARCHAR2(1)	Indicate active or inactive of attachment

NPC_LOOKUPS

NPC_LOOKUPS is the definition table for lookup codes used in any database tables. This table holds the information fields such as lookup code, value,

effective date and etc. The primary key is the LOOKUP_ID. The field of NPC_LOOKUPS table is presented in Table A.22.

Table A.22 NPC_LOOKUPS table

Column Descriptions

Field	Null Flag	Data Format	Description
LOOKUP_ID(PK)	NOT NULL	NUMBER	QuickCode unique identifier
LOOKUP_SEQ	NOT NULL	NUMBER	QuickCode sequence number
LOOKUP_CODE	NOT NULL	VARCHAR2(120)	QuickCode code
LOOKUP_VALUE	NOT NULL	VARCHAR2(120)	QuickCode meaning
DESCRIPTION	NULL	VARCHAR2(400)	Description
DEFAULT	NULL	VARCHAR2(1)	Indicate default value
DISABLE_DATE	NULL	DATE	The date when the QuickCode becomes inactive

APPENDIX B
DATAPOOL USER'S GUIDE

In Chapter 5, the design of datapool is presented. Therefore, in Appendix II, it presented the graphic user interface (GUI) forms. To use datapool, the GUI is organized into 3 different categories as follows:

Manage Suppliers, this set of GUI forms developed for managing information related to supplier of pharmaceutical products such as manufacturers, importers and brand owners.

Manage Items, this set of GUI forms developed for managing information related to logistics information and existing identification code reference of pharmaceutical products and;

Manage Registrations, this set of GUI forms developed for managing information related to pharmacological and clinical information of pharmaceutical products.

Next, the details of set of GUI forms and fields pertaining in each form will be described in the following sections.

2.1 Manage Suppliers

The Manage Suppliers form is developed for entering manufacturer, importer and distributor relevant information in the datapool. Figure B.1 presents the screen of Manage Suppliers.

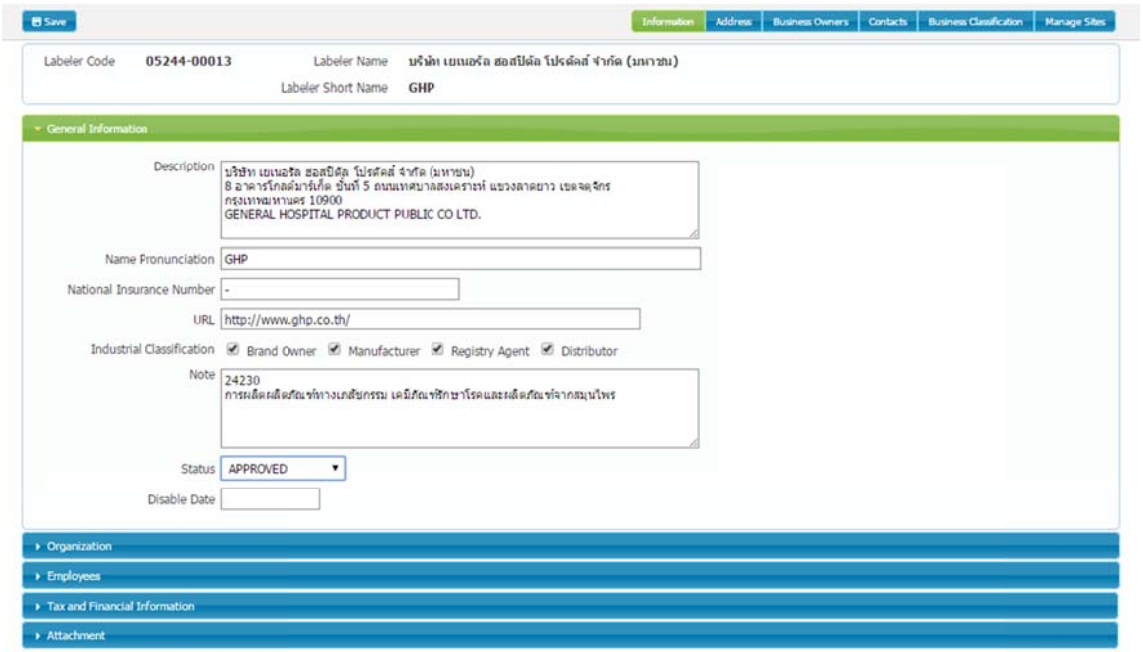

Figure B.1 Manage Labelers

Field	Description
General Information	
Labeler Name	Enter the name of a supplier both in Thai and English
Labeler Short Name	Enter the short name or alias of a supplier
Description	Enter a description for the supplier
Name Pronunciation	Enter the way to pronounce name of the supplier
National Insurance Code	Enter the supplier insurance number granted by the Revenue Department, Ministry of Finance
URL	Enter the website of supplier e.g. www.mnh.co.th is M&H MANUFACTURING

Field	Description	
Industrial Classification	Indicate the class of suppliers. Choose one of the following options	
	• Brand owner	Indicate that the supplier name is brand owner of products
	• Supplier	Indicate that the supplier name is supplier or distributor of products
	• Manufacturer	Indicate that the supplier is manufacturer of products
Note	Enter the free text note for further description of a supplier	
Status	Indicate status of suppliers. Choose one of the following options:	
	• Draft	The information provided is a draft version
	• Pending	The information provided waiting for checking
	• Provide Detail	The supplier requests to provide more details
	• Approved	The information provides has been checked and able to use as reference information
	• Rejected	The information provided is rejected
	• Discontinued	The supplier is discontinued their business
Organization Information		
D-U-N-S Number	Enter the Data Universal Numbering System (DUNS) number of supplier	
Thai FDA Number	Enter the supplier FDA number granted by the Thai Food and Drug Administration office, Ministry of Public Health e.g. 00852 is FDA number of M&H MANUFACTURING CO.,LTD.	

Field	Description
Year Established	Enter the year that supplier start their marketing e.g. M&H MANUFACTURING established on B.E.2502
Country	Enter the country that supplier established their business e.g. M&H MANUFACTURING established in Thailand
Registered Capital	Enter the registered capital of supplier e.g. 18 million bath is capital registered for M&H MANUFACTURING
Mission Statement	Enter the mission statement of supplier e.g. “M&H MANUFACTURING pledges to pursue quality excellence and the highest level of manufacturing standards”
Employee Information	
Organization Total	Enter the number of employee and indicate that the number is estimate or actual number.
Cooperate Total	In case of a supplier is multi-national firm, enter the number of employee in cooperate level and indicate that the number is estimate or actual number.
Tax and Financial Information	
Tax Register Number	Enter the VAT register number e.g. 0105502000761 is tax register number for M&H MANUFACTURING
Tax Country	Enter the country that supplier pay for taxes
Fiscal Year End	Enter the month-end of supplier e.g. June, December and etc.
Currency Preference	Enter the base currency used in tax and financial information that are submitted to country e.g. M&H MANUFACTURING submitted in Thai baht.
Annual Revenue	Enter the annual revenue of supplier
Potential Revenue Growth	Enter the potential growth rate of supplier

Field	Description	
Government Share-Holder	Indicate that supplier is a subsidiary of government. Choose one of the following options:	
	• Yes	The supplier is state enterprise or a subsidiary of state enterprise
	• No	The supplier is private sector

MANAGE SUPPLIER ADDRESS

The Manage Supplier Address form is used to enter and update address details for a labeler. Figure B.2 presents the screen of Manage Supplier Address.

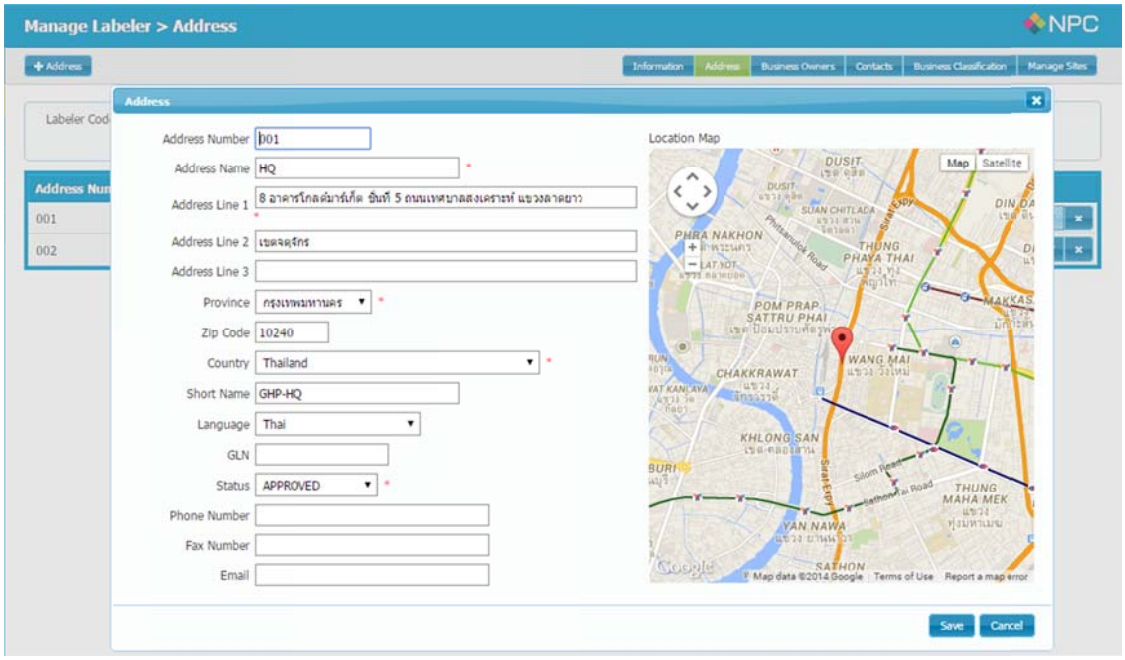

Figure B.2 Manage Supplier Address

Field	**Description**
Address Number	Enter the location identification codes. If the location has already GLN number, this location ID is equal to GLN number.
Address Name	Enter the name of address e.g. HQ is address for head quarter office
Short Name	Enter the short name or alias of address
Address Line1	Enter the house number, village number, alley, road and sub-district information
Address Line2	Enter the district information
Address Line3	Enter the additional address lines
Province	Enter the province
ZIP Code	Enter the postal code
Country	Enter the country
Language	Enter the local language used in the location address
GLN	In case supplier has registered GLN with GS1, enter the GLN number of associated location
Latitude and Longitude	Specify the latitude and longitude number of location address
Location Map	Attach the map of this specific supplier address
Phone Number	Enter the phone number. Format “area code-phone number” and delimitated by “,”
Fax Number	Enter the phone number. Format “area code-phone number” and delimitated by “,”
Email	Enter the email address for supplier contact address

Field	Description
Status	Indicate the status of supplier address. Choose one of the following options: • Draft — The address information provided is a draft version • Pending — The address information provided waiting for checking • Provide Detail — The supplier requests to provide more details • Approved — The address information provides has been checked and able to use as reference information • Rejected — The address information provided is rejected • Discontinued — The supplier is discontinued the address

BUSINESS OWNERS

The Business Owners form is used to enter share-holder information for a labeler. Figure B.3 presents the screen of Business Owners.

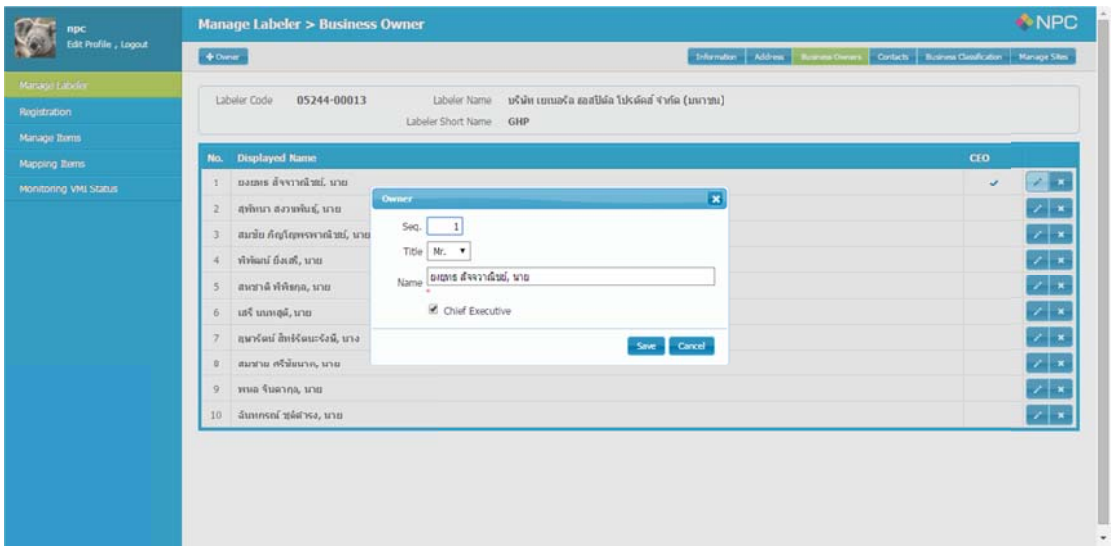

Figure B.3 Business Owners

Field	Description
Name	Enter the name of share-holders
Chief Executive	Indicate that particular share-holder is chief executive
Business Authorization	Enter the legal condition for contract and agreement of suppliers.

SUPPLIER CONTACTS

The Supplier Contacts form is used to enter contact person as well as contact information for a supplier. Figure B.4 presents the screen of Supplier Contacts.

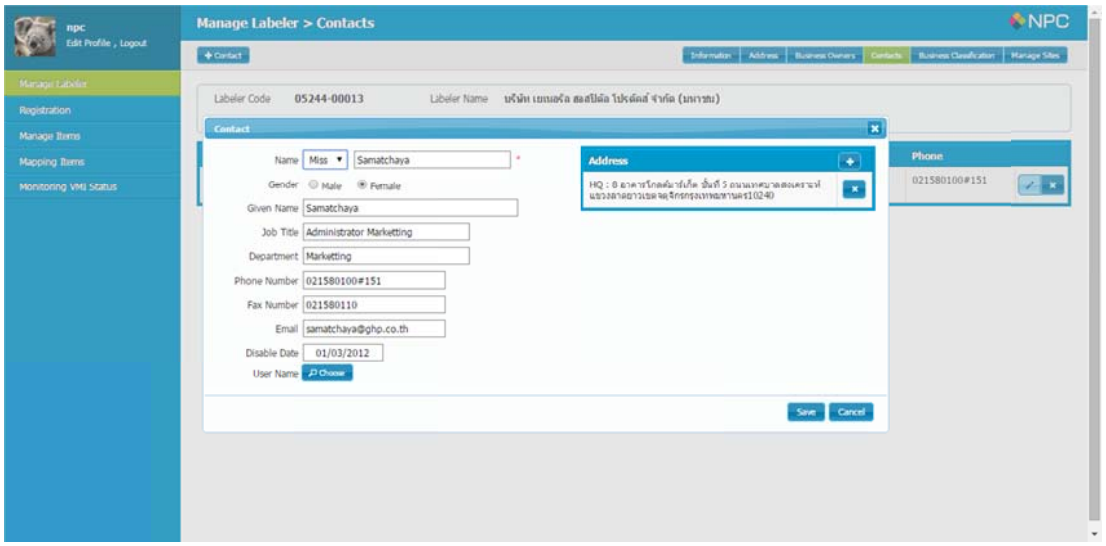

Figure B.4 Supplier Contacts

Field	Description
Name	Enter the contact person name
Gender	Enter the gender of contact person
Job Title	Enter the job title of contact person e.g. sales manager, marketing manager, sales representative, and etc.
Department	Enter the department of contact person e.g. sales department and etc.
Contact address	Enter the contact address

Field	Description
Phone Number	Enter phone number of contact person
Fax Number	Enter fax number of contact person
Email	Enter email address of contact person
Disable Date	Indicate date that contact person is no longer representative as contact person of the suppliers.

BUSINESS CLASSIFICATION

The Business Classification form is used to enter classification information for a supplier. Figure B.5 presents the screen of Business Classification.

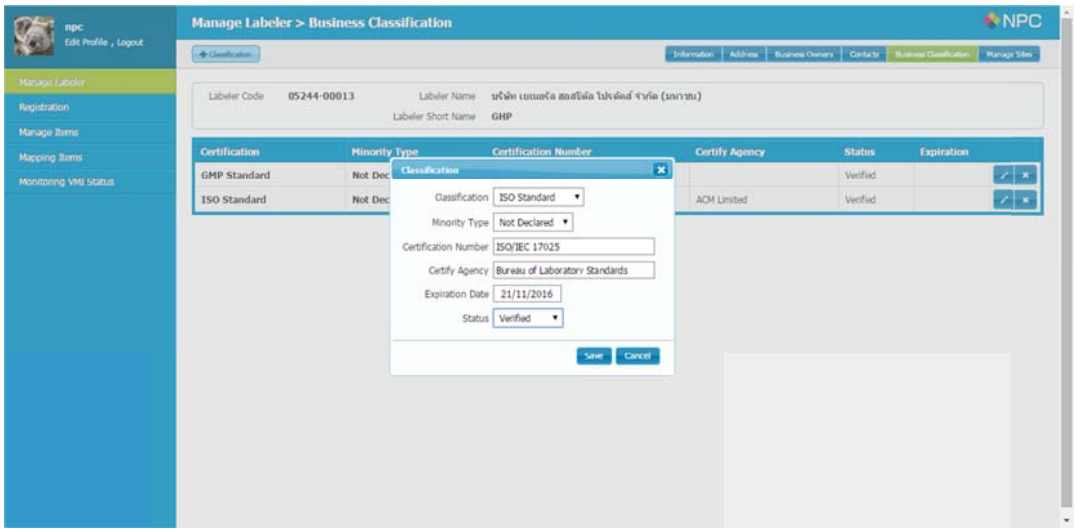

Figure B.5 Business Classification

Field	Description
Classification	Indicate the classification of business classification. Choose the following options: • GMP — The supplier has GMP certification • GDP — The supplier has GDP certification • GSP — The supplier has GSP certification • ISO — The supplier has ISO certification • Minority — Indicate the race of supplier share-holders • Woman — Indicate share-holder of supplier is woman • Veteran — Indicate share-holder of supplier is veteran
Minority Type	Indicate the minority of supplier share-holders. Choose the following options: • American — The American is minority of the suppliers • Asian — The Asian is minority of the suppliers • European — The European is minority of the suppliers • Not Declared — The minority of the suppliers is not declared
Certification Number	Enter the certification number or information
Certificate Agency	Enter the agency name who issued the certification number
Expiration Date	Specify expiry date or the date that certification number is no longer activate
Status	Indicate the status of certification numbers. Choose the following options: • Pending — The certification number is awaiting for checking • Verified — The certification number is already verified and suppliers provide correct information.

2.2 Manage Items

The Manage Items form is used to define and update items and the attributes associated with them such as name, description, unit of measure and etc. Figure B.6 presents the screen of Manage Items.

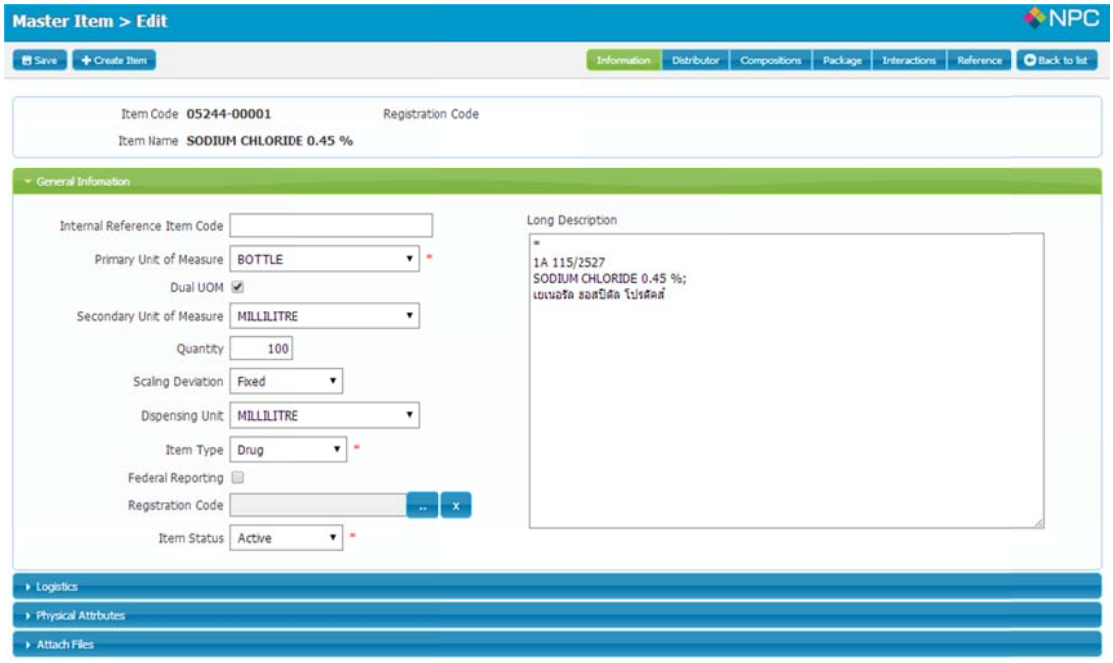

Figure B.6 Manage Items

Field	Description
Item Code	Enter the drug standard identification codes. If the drug has already GTIN number, this item ID is equal to GTIN number.
Name	Enter the trade name of pharmaceutical products
Long Description	Enter the description of pharmaceutical products
Primary UOM	Enter the primary unit of measure. The primary unit of measure is the stock keeping unit e.g. Bottle
Secondary UOM	Enter the secondary unit of measure of pharmaceutical products e.g. a bottle contains 100mL
Conversion	Enter conversion factor between primary and secondary UOM
Dispensing Unit	Enter the smallest dispensing unit of pharmaceutical products

Field	Description	
Item Type	Indicate the item types. Choose one of the following options:	
	• Prescription Drugs	The pharmaceutical products is prescription drugs
	• OTC	The pharmaceutical products is OTC drugs
	• Medical Supplies	The pharmaceutical products is medical supplies
	• Medical Devices	The pharmaceutical products is medical devices
	• Traditional Herbs	The pharmaceutical products is traditional drugs
	• Others	Other groups of pharmaceutical products
Federal Reporting	Indicate that the movement of pharmaceutical products required submitting to government agencies.	
Registration Code	In case of pharmaceutical product is drugs, enter the registration code that are granted by the FDA, Thailand	
Item Status	Indicate the status of pharmaceutical products. Choose one of the following options:	
	• Active	Pharmaceutical product still in use
	• Inactive	Pharmaceutical product is no longer use
Lot Controlled	Indicate that the pharmaceutical product is controlled lot or batch of manufacturing. Choose one of the following options:	
	• Full Control	Pharmaceutical product is under full lot control
	• No Control	Pharmaceutical product is not lot control

Field	Description
Serial Controlled	Indicate that the pharmaceutical product is serialization controlled. Choose one of the following options: • Full Control — Pharmaceutical product is under serial control • No Control — Pharmaceutical product is not serialization
Shelf life days	Enter the number of days before expiration
UN Number	Enter the four-digit numbers that identify hazardous substances, and articles
Hazard Class	Enter hazard classes. Choose one of the following options: • Explosives — The item which have the ability to rapidly conflagrate or detonate as a consequence of chemical reaction • Gases — Substances which have a vapour pressure of 300 kPa or greater at 50°c or which are completely gaseous at 20°c at standard atmospheric pressure, and items containing these substances. • Flammable Liquids — Liquids, mixtures of liquids or liquids containing solids in solution or suspension • Flammable Solids — Materials which, under conditions encountered in transport, are readily combustible or may cause or contribute to fire through friction • Oxidizing Substances — Substances which may cause or contribute to combustion • Toxic & Infectious Substances — Substances are those which are liable either to cause death or serious injury or to harm human health if swallowed

Field	Description	
	• Radioactive Material	Radioactive material as any material containing radionuclides where both the activity concentration and the total activity exceeds certain pre-defined values
	• Corrosives	Substances which by chemical action degrade or disintegrate other materials upon contact
	• Miscellaneous Dangerous Goods	Substances and articles which during transport present a danger or hazard not covered by other classes
Reusability Type	Indicate the reusability of pharmaceutical products	
Commodity Code	Enter the import and export commodity codes of pharmaceutical products according to harmonization codes e.g. 752 is Continuous Ambulatory Peritoneal Dialysis (CAPD) fluids used for treatment in renal failure cases	
Storage Condition	Indicate the storage conditions of pharmaceutical products. Choose one of the following options:	
	• Freezer	Temperature is maintained thermostatically between -25^{o} and -10^{o}C
	• Cold	Temperature is maintained thermostatically between 2^{o} and 8^{o}C
	• Cool	Temperature between 8^{o} and 15^{o}C
	• Controlled Room Temperature	Temperature maintained thermostatically between 2^{o} and 8^{o}C
	• Room Temperature	Temperature maintained thermostatically between 20^{o} to 25^{o}C

Field	Description
	• Warm Temperature between 30° and 40°C • Excessive Heat Temperature above 40°C
Handling Instructions	Enter the instructions for handling or transport of pharmaceutical products
Manufacturer	Enter the manufacturer of pharmaceutical products

MANAGE ITEM REFERENCE

The Manage Item Reference form is used to enter item relationship information for a pharmaceutical product e.g. TMT code reference, NHSO code reference, ATC class and etc. Figure B.7 presents the screen of Manage Item Reference.

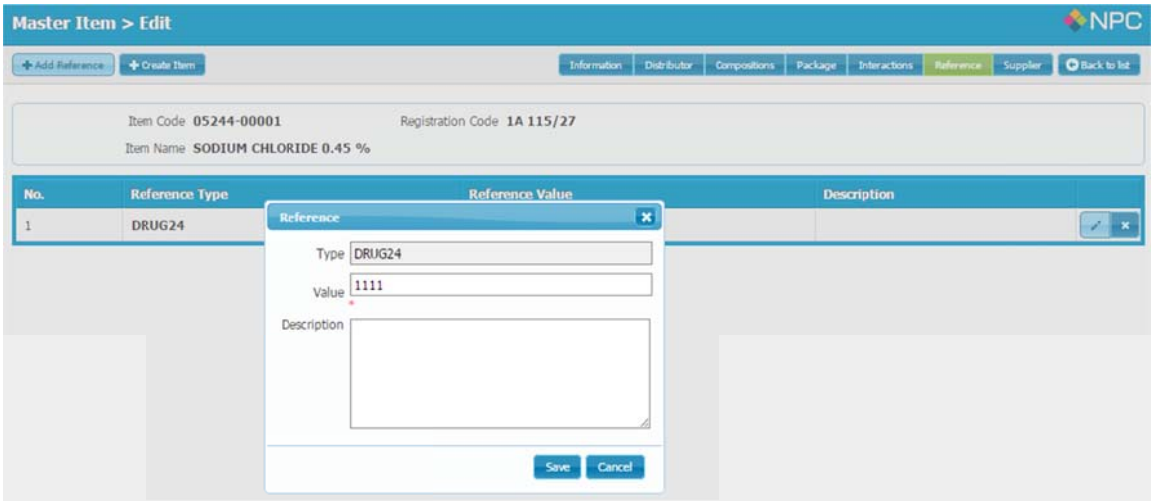

Figure B.7 Manage Item Reference

Field	Description
Reference Type	Indicate the reference types of pharmaceutical products. Choose one of the following options: • Drug24 — Reference to Drug24 code • Drug24T — Reference to Drug24T code • TMT — Reference to TMT code • Registration Code — Reference to TMT code • GPSC Code — Standard product and service code that are granted by the Comptroller Department
Value	Enter the value according to reference types
Description	Enter the description of item reference value

MANAGE PACKAGES

The Manage Packages form is used to add, update and delete drug packaging information e.g. tablet, blister pack, box and etc. Figure B.8 presents the screen of Manage Packages.

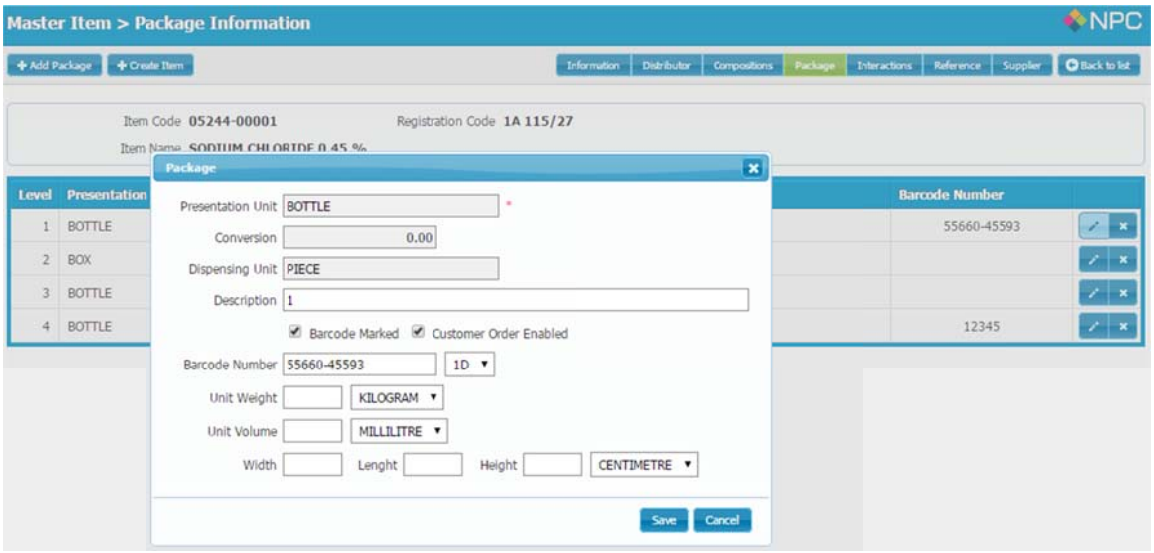

Figure B.8 Manage Packages

Field	Description
Presentation Unit	Enter the attachment name
Dispensing Unit	Enter the description of attachment
Conversion	Enter the unit conversion between presentation unit and dispensing unit e.g. a 100 tablets
Description	Enter the description of unit conversion e.g. a box contains 100 tablets 1x100's
Barcode Marked	Indicate that packaging of pharmaceutical products has barcode labeled.
Orderable Unit	Indicate that the customer can place a purchase order against the presentation unit of pharmaceutical products.
Barcode	Enter the alpha-numeric barcode labeled on primary or secondary packages of pharmaceutical products
Barcode Symbology	Indicate the symbology of affixed barcodes. Choose one of the following options: • 1D Barcode 1 dimension barcode symbol labeled on primary or secondary packages of drugs • 2D Barcode 2 dimension barcode symbol labeled on primary or secondary packages of drugs
Unit Weight	Enter the presentation unit weight of pharmaceutical products
Unit Volume	Enter the presentation unit volume of pharmaceutical products
Unit Dimension	Enter the presentation unit dimension of pharmaceutical products

MANAGE ATTACHMENTS

The Manage Attachments form is used to link data such as images, documents to a pharmaceutical product. These attachments are referred to as documents. Figure B.9 presents the screen of Manage Attachments.

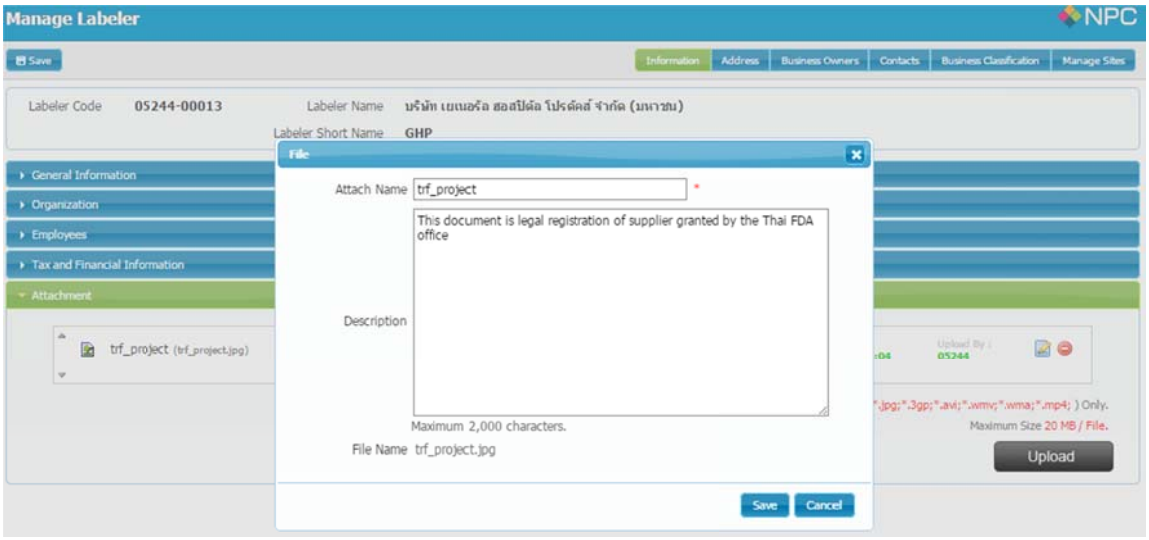

Figure B.9 Manage Attachments

Field	Description
Name	Enter the attachment name
Description	Enter the description of attachment
Data Type	Indicate the data type of attachments. Choose one of the following options: • Document — A reference to any type of document stored in a database • Text — Text stored in the database containing less than 2000 characters. • File — A file such as Microsoft Word or Microsoft Excel, image files such as .JPG files, or other types of files. • Web Page — A URL reference to a web page
File or URL	If the document is a file, specify the location of the document. If the document is a web page, specify the web page URL
Text	Enter the free text as an attached message
Enabled	Indicate the effective of attachments. Choose one of the following options: • Yes — Indicate that the attachment is still active • No — Indicate that the attachment is no longer in use

2.3 Manage Registrations

The Manage Registrations form is used to create, update and delete the registration information of pharmaceutical products. Figure B.10 presents the screen of Manage Registrations.

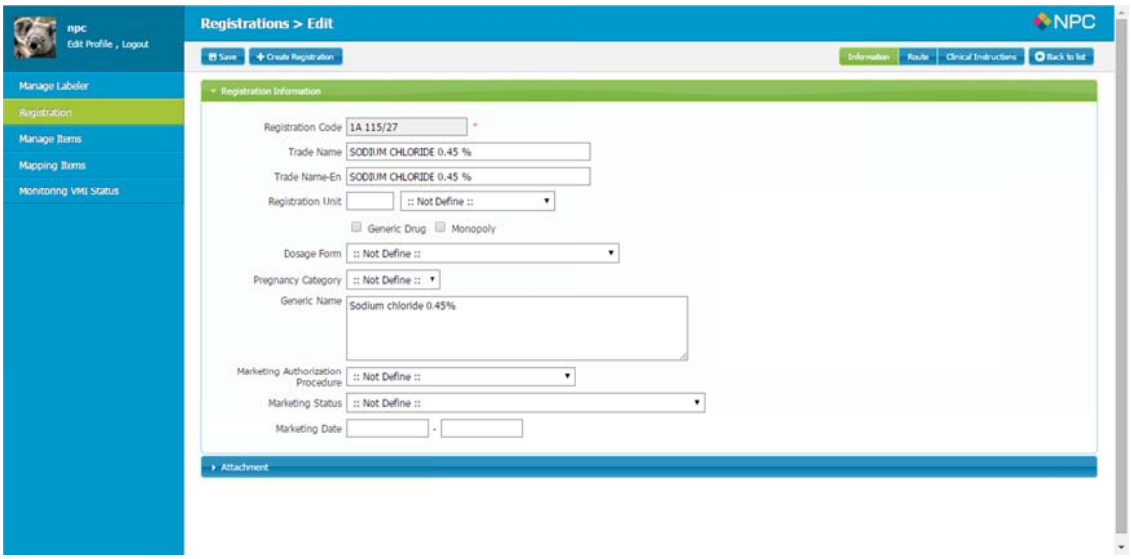

Figure B.10 Manage Registrations

Field	Description
Registration Code	Enter the registration code of pharmaceutical drug granted by the Food and Drug Administration
Trade Name	Enter the trade name in Thai and English that are submitted to the Food and Drug Administration
Generic Name	Enter the generic name that are submitted to the Food and Drug Administration
Brand Owner	Enter the brand owner of pharmaceutical products
Dosage Form	Enter the dosage form of pharmaceutical products

Field	Description
Pregnancy Category	Indicate the pregnancy category of pharmaceutical products. Choose one of the following options: • A: Adequate and well-controlled studies have failed to demonstrate a risk to the fetus in the first trimester of pregnancy (and there is no evidence of risk in later trimesters) • B: Animal reproduction studies have failed to demonstrate a risk to the fetus and there are no adequate and well-controlled studies in pregnant women. • C: Animal reproduction studies have shown an adverse effect on the fetus and there are no adequate and well-controlled studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks. • D: There is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience or studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks. • X: Studies in animals or humans have demonstrated fetal abnormalities and/or there is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience, and the risks involved in use of the drug in pregnant women clearly outweigh potential benefits.

Field	Description
	• N FDA has not classified the drug.
Marketing Status	Indicate marketing status of pharmaceutical products. Choose one of the following options: • Active The pharmaceutical drug still marketing • Discontinued-All The pharmaceutical drug end of marketing • Discontinued-Comp post-market The pharmaceutical drug end of marketing due to supplier hold production • Discontinued-Safety and Surveillance The pharmaceutical drug end of marketing due to safety and surveillance concerns
Marketing Authorization Procedure	Indicate the procedure of pharmaceutical products. Choose one of the following options: • NADA Abbreviated New Drug Application • NDA New Drug Application
Routes	Enter the routes of admission e.g. oral, nasal, injection and etc.
Indications	Enter the indications in Thai and English
Contraindications	Enter the contraindications in Thai and English
Dosage	Enter the dosage in Thai and English
Overdose	Enter the overdose in Thai and English
Administration	Enter the administration of pharmaceutical products in Thai and English
Adverse Drug Reactions	Enter the adverse drug reactions in Thai and English
Precautions	Enter precautions of taking pharmaceutical products in Thai and English
Special Precautions	Enter special precautions of taking pharmaceutical products in Thai and English

MANAGE COMPOSITIONS

The Manage Compositions form is used to create, update and delete the ingredient or chemical substance of a pharmaceutical product. Figure B.11 presents the screen of Manage Compositions.

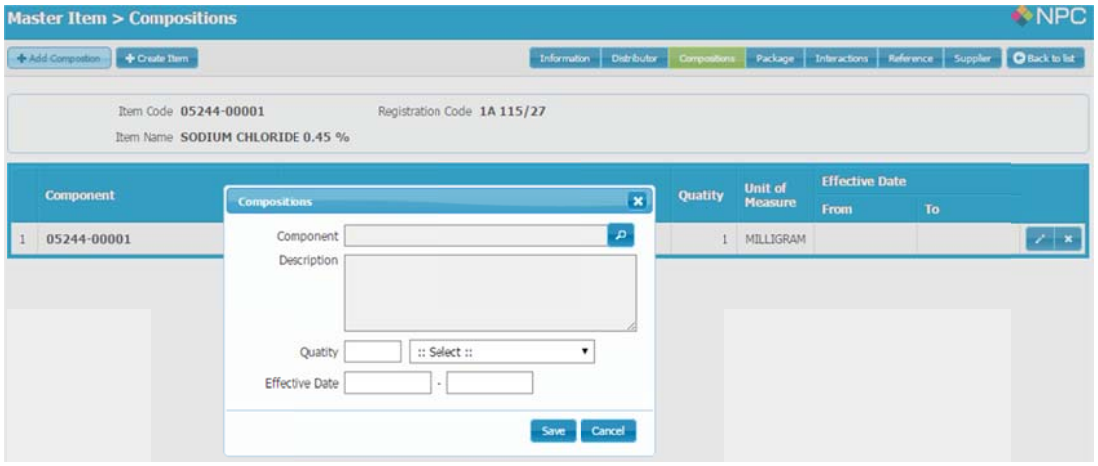

Figure B.11 Manage Compositions

Field	Description
Component	Enter the ingredient name or active pharmaceutical ingredients of pharmaceutical products
Description	Display the description of ingredients
Strength	Enter the strength of ingredients
Strength Unit	Enter the strength units e.g. mg/1mL, mg, and etc.
Effective Date From	Enter the start effective date of ingredients
Effective Date To	Enter the end effective date of ingredients

MANAGE ROUTES

The Manage Routes form is used to create, update and delete the ingredient routes of administration of a pharmaceutical product. Figure B.12 presents the screen of Manage Routes.

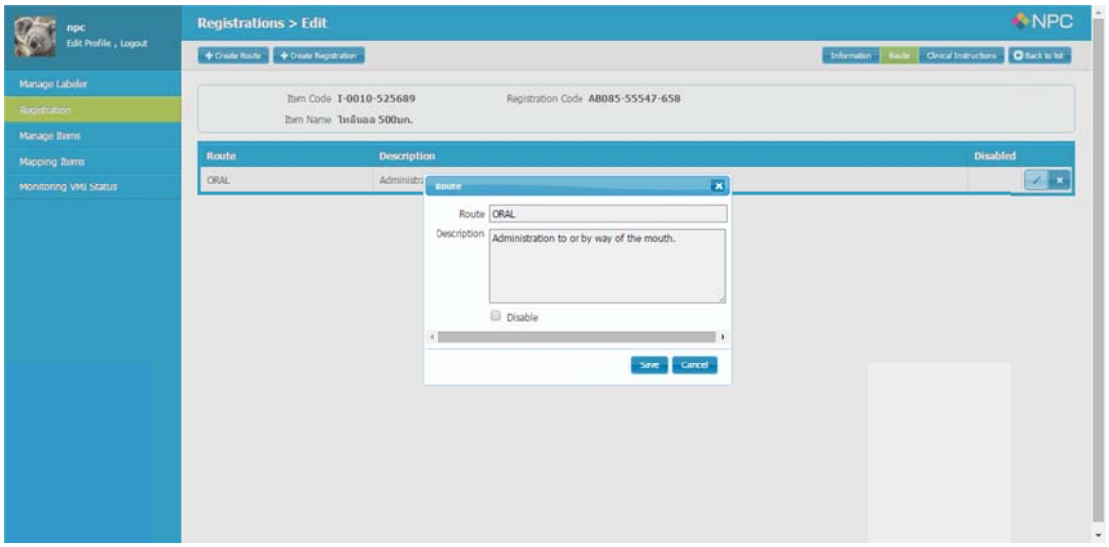

Figure B.12 Manage Routes

Field	Description
Route	Enter the routes of administration e.g. oral, injection, nasal, and etc.
Description	Display the description of routes of administration.

APPENDIX C
INTERVIEW AND FOCUS GROUP PARTICIPANT

The participants have involved in several stages of this study. The following tables listed participants in this study.

3.1 Indepth Interview Participant

No	Name	Roles	Organization
1	Sombat Siriruk	Manufacturer	Siam Pharmaceutical Co., Ltd.
2	Chantima Peerawaranupong	Manufacturer	Abbott Laboratories Co., Ltd.
3	Pornlada Suratin	Manufacturer	Novatis
4	Sunthorn Worakul	Pharmacist	Government Pharmaceutical Organization
5	Tivaporn Thumbunthu	Manufacturer	Unilab Pharmaceutical Co.,Ltd.
6	Vilailuck Anakmahan	Manufacturer	Great Eastern Drug Co.,Ltd.
7	Sunai Sirisupavich	Distributor	Zuellig Pharma (Thailand)
8	Chutima Wongsawat	Distributor	Zuellig Pharma (Thailand)
9	Kriengkrai Viasuwan	Distributor	Zuellig Pharma (Thailand)
10	Thunyaporn Chunnanond	Distributor	DKSH (Thailand)
11	Sirintorn Sayowan	Distributor	DKSH (Thailand)
12	Sutnai Hemsrichart	Distributor	DKSH (Thailand)
13	Narongrit Kanlaput	Distributor	N-Health

No	Name	Roles	Organization
14	Nuttawut Charumekin	Distributor	N-Health
15	Chusak Okascharoen	Doctor	Ramathibodi Hospital
16	Patcharin Suwannakut	Pharmacist	Ramathibodi Hospital
17	Weerawan Yaowiwat	Pharmacist	Ramathibodi Hospital
18	Oraluck Pattanaprateep	Pharmacist	Ramathibodi Hospital
19	Montri Suwanit	Pharmacist	Siriraj Hospital
20	Panita Taweethumchareun	Pharmacist	Siriraj Hospital
21	Vichit Tungjittiporn	Pharmacist	Siriraj Hospital
22	Premjit Suttipoom	Pharmacist	Siriraj Hospital
23	Cholathip Pongsakul	Doctor	Srinakharind Hospital
24	Apichart Jerawutpong	Doctor	Srinakharind Hospital
25	Somruk Teeratakulpisal	Pharmacist	Srinakharind Hospital
26	Suchet Chitpairot	Doctor	Songkhlanakarind Hospital
27	Kanya Tungkiatkumjai	Pharmacist	Songkhlanakarind Hospital
28	Dusit Suppawatnawong	Pharmacist	Songkhlanakarind Hospital
29	Wilawan Jomthong	Nurse	Songkhlanakarind Hospital
30	Chatree Duangnet	Doctor	Bangkok Hospital
31	Somsak Wankitcharoun	Doctor	Bangkok Hospital
32	Trithep Fongthong	Pharmacist	National Health Security Office
33	Pipat Yingsaeri	Doctor	Food and Drug Administration
34	Boonchai Kitsanayothin	Doctor	Thai Health Informatics Academy
35	Amporn Charoensomsak	Doctor	The Pharmaceutical Research and Manufacturers Association
36	Thun Pungchareonkul	Pharmacist	Thai Pharmaceutical Manufacturers Association

3.2 Semi-structured Interview Participant

No	Name	Roles	Organization
1	Cholathip Pongsakul	Doctor	Srinakharind Hospital
2	Suchet Chitpairot	Doctor	Songkhlanakarind Hospital
3	Sutee Tuwirat	Doctor	Thai Medical Informatics Association
4	Trithep Fongthong	Pharmacist	National Health Security Office
5	Chusak Okascharoen	Doctor	Ramathibodi Hospital
6	Patcharin Suwannakut	Pharmacist	Ramathibodi Hospital
7	Weerawan Yaowiwat	Pharmacist	Ramathibodi Hospital
8	Montri Suwanit	Pharmacist	Siriraj Hospital
9	Panita Taweethumchareun	Pharmacist	Siriraj Hospital
10	Non-disclosure	Pharmacist	Bangkok Hospital
11	Non-disclosure	Pharmacist	Chareunkrung Pracharuk Hospial
12	Non-disclosure	Pharmacist	Banpeaw Hospital
13	Non-disclosure	Pharmacist	Puthamonthol Hospital
14	Non-disclosure	Pharmacist	Bangyai Hospital
15	Soontriya Rongrongmuang	Pharmacist	Bangbuathong Hospital
16	Non-disclosure	Pharmacist	Kasemraj Prachacheun Hospital
17	Non-disclosure	Pharmacist	Nonthavej Hospital
18	Pratin Hungtrakul	Pharmacist	Pranungklao Hospital
19	Wilawan Jomthong	Nurse	Songkhlanakarind Hospital
20	Chanchai Sae-Tung	Nurse	Songkhlanakarind Hospital
21	Channarong Pankongngam	Logistics Practitioner	Ranbaxy

No	Name	Roles	Organization
22	Pannaporn Wanchaitas	Logistics Practitioner	Ranbaxy
23	Thitikarn Kunlasing	Distributor	DKSH (Thailand) Co., Ltd.
24	Kriengkrai Viasuwan	Distributor	Zuellig Pharma (Thailand) Co., Ltd.
25	Tanit Phoncharoun	Distributor	BJC Logistics Co.,Ltd.

3.3 Focus Group Participant

Focus Group Round 1

No	Name	Roles	Organization
1	Sutee Tuwirat	Doctor	Thai Medical Informatics Association
2	Chusak Okascharoen	Doctor	Ramathibodi Hospital
3	Boonsom Teerawattanapong	IT	Songkhlanakarind Hospital
4	Chayakrit Charoensiriwath	IT	NECTEC
5	Piyabut Ngaopaiboon	DBA	GS1
6	Sirintorn Sayowan	Logistics Practitioner	DKSH (Thailand)
7	Sunai Sirisupavich	Logistics Practitioner	Zuellig Pharma (Thailand)
8	Kitti Rahong	Logistics Practitioner	Government Pharmaceutical Organization
9	Pinthip Wattanasukchai	IT	Songkhlanakarind Hospital

Focus Group Round 2

No	Name	Roles	Organization
1	Anun Kanoksilp	Doctor	Lampraimas Hospital
2	Jakarin Somboonchan	Doctor	Wangthong Hospital
3	Thanachol Wonghirundecha	Doctor	Chiengdao Hospital
4	Wichai Rattaphunpanich	Doctor	Bangkruy Hospital
5	Buakao Sombatsangurai	Doctor	Danmakham-Tia Hospital
6	Nuanchan Vejsawanmanee	Doctor	Thongpapoom Hospital
7	Anukoon Thaitanund	Doctor	Thamaka Hospital
8	Paruhut Taoanun	Doctor	Thammasart Hospital
9	Chawalit Sungprasit	Doctor	Prachatipat Hospital
10	Payom Udomkham	Doctor	Potharam Hospital
11	Benjamas Piriyabenjawat	Doctor	Mahachai Hospital
12	Sukhum Piriyapornprapat	Doctor	Wattananakorn Hospital
13	Surachoke Tangwiwat	Doctor	Saraburi Hospital
14	Suwat Thanakornnuwat	Doctor	Saohai Hospital
15	Sutee Tuwirat	Doctor	Thai Medical Informatics Association
16	Witit Atthavejchakul	Doctor	Government Pharmaceutical Organization
17	Rachata Jirachaithorn	Pharmacist	Bangkruy Hospital
18	Angsana Chatrattanasang	Pharmacist	Saraburi Hospital
19	Duangkwan Prempinitpong	Pharmacist	Saraburi Hospital
20	Jariya Thumnanok	Pharmacist	Navamind Hospital
21	Suwimol Sitjongsataporn	Pharmacist	Navamind Hospital

No	Name	Roles	Organization
22	Orathai Sae-Jiew	Pharmacist	Siam Pharmaceutical Co.,Ltd.
23	Prachumporn Chanwerachai	Pharmacist	Siam Pharmaceutical Co.,Ltd.
24	Pichit Chanachai	Pharmacist	Vesco Pharmaceutical Co.,Ltd.
25	Somsak Chusakul	Pharmacist	Hudyot Hospital
26	Roongthip Pitukmongkol	Pharmacist	Bangplee Hospital
27	Pathipat Ngamsom	Pharmacist	Wangthong Hospital
28	Pongsriya Rattachanya	Pharmacist	Ladbualuang Hospital
29	Pichit Chanachai	Pharmacist	
30	Maneerat Pisantat	Pharmacist	Banpaew Hospital
31	Sorawit Pothikit	Pharmacist	Lopburi Hospital
32	Sittichai Chantarawongpaisarn	Pharmacist	Pranungklao Hospital
33	Cholthicha Ketsuwan	Pharmacist	Klongluang Hospital
34	Wanichaya Thepsawat	Pharmacist	Rayong Hospital
35	Nuttaya Parnsung	Pharmacist	U-Thong Hospital
36	Prapapan Tachatanung	Pharmacist	Wichaivej Hospital
37	Tampun Thongman	Pharmacist	Angthong Hospital
38	Somchai Khanchan	Pharmacist	Cholprathan Hospital
39	Yanita Paebut	Nurse	Wangthong Hospital
40	Manunyaporn Tinochung	Nurse	Bangkruy Hospital
41	Nayata Thanungkunakit	Logistics Practitioner	Siam Pharmaceutical Co.,Ltd.
42	Kul Pusathep	Logistics Practitioner	Siam Pharmaceutical Co.,Ltd.
43	Sukumaporn Sunirunkarn	Logistics Practitioner	Umeda Co.,Ltd

No	Name	Roles	Organization
44	Teeraporn Weerawong	Logistics Practitioner	Unique Industrial Products Co.,Ltd.
45	Jintana Lapwet Srikong	Logistics Practitioner	Unique Industrial Products Co.,Ltd.
46	Naowarat Wachanond	Logistics Practitioner	Government Pharmaceutical Organization
47	Nopporn Jittimetakul	Logistics Practitioner	Government Pharmaceutical Organization
48	Praneet Samitaset	Logistics Practitioner	Medicine Products Co.,Ltd.
49	Nithima Wongsakol	Logistics Practitioner	Pacific Healthcare (Thailand) Co.,Ltd.
50	Kanungnuch Apikitnun	Logistics Practitioner	Pacific Healthcare (Thailand) Co.,Ltd.
51	Amornrat Chanpaibool	Logistics Practitioner	Orex Trading Co.,Ltd.
52	Thummaporn Chaijumreun	Logistics Practitioner	American Tiwan Pharmaceutical Co.,Ltd.
53	Nutta-at Kulkanchanatorn	Logistics Practitioner	Far-East Pharmaceutical Co.,Ltd.
54	Vithit Monprasit	Logistics Practitioner	BJC Logistics Co.,Ltd.
55	Prapa Srisarikorn	Logistics Practitioner	T.O. Chemical Co.,Ltd.
56	Srasikarn Punyadee	Logistics Practitioner	Vision Care Co.,Ltd.
57	Atcha Limpattanasiri	Logistics Practitioner	Vision Care Co.,Ltd.
58	Netnipa Upasim	Logistics Practitioner	Osot Inter Laboratories Co.,Ltd.

Focus Group Round 3

No	Name	Roles	Organization
1	Chusak Okascharoen	Doctor	Ramathibodi Hospital
2	Artit Ungkanont	Doctor	Ramathibodi Hospital
3	Patcharin Suwannakut	Pharmacist	Ramathibodi Hospital
4	Weerawan Yaowiwat	Pharmacist	Ramathibodi Hospital
5	Krittaya Chunnguleum	Pharmacist	Ramathibodi Hospital
6	Ketsara Worawutputtipong	Pharmacist	Ramathibodi Hospital
7	Wathunyata Simawattana	IT	Ramathibodi Hospital
8	Pattama Wongsawas	IT	Ramathibodi Hospital
9	Anutsara Soonthonpruk	IT	Ramathibodi Hospital

3.4 Collaboration Interview Participant

No	Name	Roles	Organization
1	Sirintorn Sayowan	Distributor	DKSH (Thailand)
2	Sunai Sirisupavich	Distributor	Zuellig Pharma (Thailand)
3	Nuttawut Charumekin	Distributor	N-Health
4	Weerawan Yaowiwat	Pharmacist	Ramathibodi Hospital
5	Montri Suwanit	Pharmacist	Siriraj Hospital

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