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REDUCING MEDICAL WASTE IN UP-STREAM LOGISTICS PROCESS IN HOSPITAL PHARMACY – A CASE STUDY

Master´s Thesis
in Information Systems Science

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1 INTRODUCTION

1.1 Research area

In this global market, the world has shifted to a more complex and fast-paced economic environment where every small advantage and improvement can translate into success. In the grand scheme of things, even the government institutions, such as hospitals and bureaus, need to adapt to the ever-changing world and start focusing improving operational environments. Information systems in medical institutions have been a highly discussed topic in Finland for the past 30 years. Ever since the launch of the controversial Apotti-project, a new centralized customer- and patient information system for municipalities around the metropolis Helsinki area, media has been raising questions about legacy information systems in hospitals. Although in the case of Apotti-project the cost of the new system has been the main talking point, there are other factors in the current information systems that require attention. Chen et al. (2013) claim that IT adaptation in health sector at an international level drags 10 to 15 years behind other industries. The main concerns regarding these old systems seem to revolve around the costs which these old systems create. For example, Savon Sanomat reported in September 2013 that in University hospital of Kuopio alone there was 300 000 euros worth of waste in medicines. The main reason for waste in medicine, according to apothecary Toivo Naaralahti in Kuopio University hospital, is expiration (Savonsanomat.fi, 2013). On a larger scale, Turun Sanomat (2016) reported that on national level in Finland, the medical waste amounted to over 6.3 million euros.

In order to understand what is causing the waste in hospitals, one has to examine the supply chain networks and the information systems that are used in the procurement processes. Of course, there are many other things to consider when discussing the reasons for waste in hospitals. One example would be legislative requirements for safety stock of medicines which require hospitals to have a certain amount of medicine available at any given moment (finlex.fi, 2008). These requirements lead to inevitable waste in certain medicines which have short expiration period. However, this alone is not enough to explain the amount of waste that is created in hospitals. As the information systems in hospitals are getting more and more outdated, there is reason to believe that with better information systems and procurement processes there would be huge improvements in efficiency and hence cost savings.

At the moment, there are multiple different modernization projects in hospitals all over Finland. This gives us a great opportunity to examine their current information systems and their capabilities in the modern practice of medicine. Are the information systems up to date? Are there possibilities to simplify the supply chain networks and

consolidate the information systems involved in the procurement processes in order to remove waste?

1.2 Research gap

There has not been much current research done on the procurement processes in hospitals and information systems involved in aforementioned processes. De Vries and Huijsman (2011) see our knowledge and understanding of the health care sector, from the perspective of supply chain management, to be vastly fragmented. Moreover, they note the importance of further examining the role of information technology in supporting management and control of supply chain activities. It has been previously acknowledged that there are inefficiencies in hospitals, which create waste. The goal of this thesis is to better understand the procurement processes of medical supplies and medicines in university hospitals and to find out whether there are common patterns and procedures, which contribute towards generation of medical waste. The thesis also aims to determine best practices in processes and information systems relying on the literature reviewed. Furthermore, the future possibilities to enhance the current integrations in hospital procurement processes and information systems are explored.

1.3 Research questions

The research questions seek to guide this study into medical waste. In order to understand the root causes and focal points in the upstream pharmaceutical supply chain, this study attempts to answer the following questions:

(1) What are the best practices in medical supply chain management and how appropriate information systems can further enhance the procurement process?
(2) What is the current state of pharmaceutical procurement processes and information systems in Turku University hospital?
(3) What are the future prospects of integration in hospital procurement processes and information systems?

To find answers to the aforementioned questions, first an extensive literature review will be performed in order to establish the best practices relying on scientific literature. After this, interviews with medical professionals working in the hospital pharmacy will be conducted. Finally, the results of the interviews will be combined and thoroughly analyzed. Based on the comprehensive analysis, conclusions will be made.

1.4 Scope of the study

The scope of this study are the processes and procurement information systems used in Turku University hospital. This university hospital was chosen because it represents the state-of-the-art hospital in Finland and is prominent in modernization. The University hospital of Turku will be introduced further on.

2 LITERATURE REVIEW

This literature review will concentrate on different ways to set up, control and improve organization's logistics, more specifically inbound logistics in University hospitals. While Supply Chain Management presents a comprehensive philosophy on how to manage all aspects of logistics, Just-In-Time logistics (JIT), Vendor Managed Inventory (VMI) and Collaboration in Forecasting, Planning and Replenishment (CFPR) offer more specific alternatives. In this chapter we will go through the characteristics of these different models.

2.1 Supply chain management

Menzer et al. (2001) acknowledge that in research the term supply chain management can be defined very differently depending on the context. Jones and Riley (1985) define supply chain management to "deal with the total flow of materials from suppliers through end users…". On the other hand, Cooper et al. (1997) elaborates on the definition and describes supply chain management to be "…an interactive philosophy to manage the total flow of distribution channel from supplier to the ultimate user." Moreover, Harland (1996) recognizes four main meanings for supply chain management:

- The internal supply chain that integrates business functions involved in the flow of materials and information from inbound to outbound ends of business.
- The management of dyadic or two-party relationships with immediate suppliers.
- The management of a chain of businesses including suppliers, supplier's suppliers, customers and customer's customers and so on.
- The management of a network of interconnected businesses involved in the ultimate provision of product and service packages required by end customer.

Although supply chain management seems to create discussion among the academics, the definition of supply chain has been more commonly agreed upon. Menzer et al. (2001) define supply chain to be "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances and/or information from a source to the customer." In addition, even though the point of views may differ, the main issues in supply chain management are more universally accepted to be elimination of waste and performance improvements by coordinating supply chains (de Vries and Huijsman, 2011). De Vries and Huijsman (2011) also suggest that the health care sector lags behind the manufacturing industry sector in adapting the methods and practices of supply chain management. This thesis concen-

trates on the upstream flows of a hospital supply chain. Upstream flows in the context of hospital supply chain refer to the logistical activities that occur outside the hospital. For example activities between the pharmaceutical wholesaler and the hospital pharmacy. More specifically, this study focuses in the procurement of pharmaceuticals; the processes involved in procurement and the information systems that are being used in the process. Supply chain management practices in the health care sector are evaluated, by industry experts, to be roughly 10 years behind retail and manufacturing industries (Chen et al. 2013).

2.1.1 Supply chain

Supply chain is in the center of supply chain management and in order to understand supply chain management, we must understand what a supply chain is. Supply chain can also often be described as distribution channels. On its most basic level, a supply chain can be viewed as a three-player chain of material and information flows consisting of supplier, organization and customer. Figure 1 illustrates a direct supply chain and the material and information flows within it. The ellipses represent the parties within the supply chain and the arrows depict the information and material flows. (Mentzer et al. 2001)

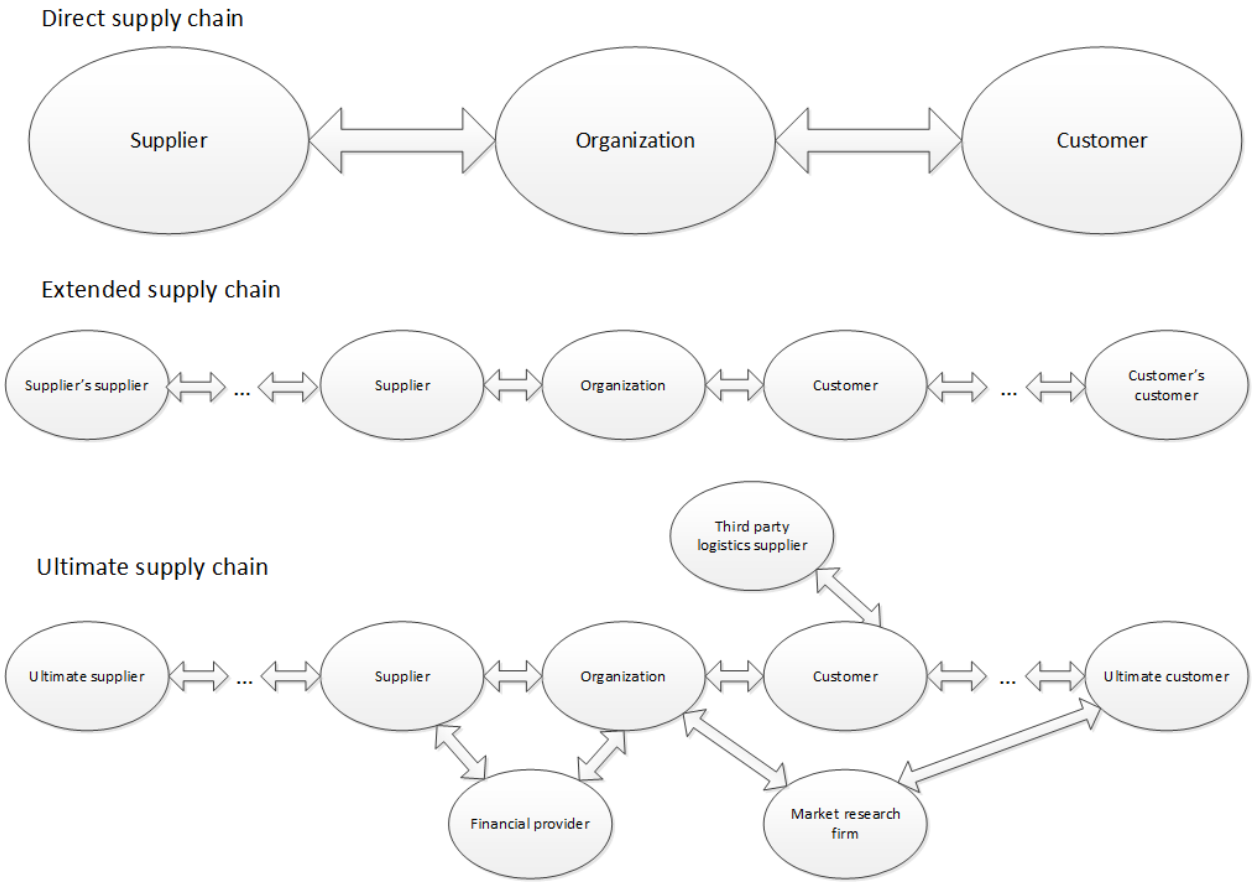

Figure 1 Different modes of supply chains (adapted from Mentzer et al. 2001)

The first supply chain pictured in Figure 1 can be found from the upstream or downstream of material and information flows. Thomas and Griffin (1996) determine supply chain to have traditionally three different stages: procurement, production and distribution. In Figure 1, the procurement occurs from supplier to organization. The organization then produces the product and then distributes it to its customers. This is a very simplified view of the supply chain and Mentzer et al. (2001) also present a second, more complex level of supply chains, an extended supply chain. In the extended supply chain, shown in Figure 1, the suppliers have suppliers and customers have customers.

Although the extended supply chain presented in Figure 1 gives a better understanding of supply chains in reality, it is still highly simplified version of the complex supply chains of today. Mentzer et al. (2001) extend their definition of supply chain into a third, more complex, model: an ultimate supply chain. The ultimate supply chain is also shown in figure 1.

The ultimate supply chain can be viewed as all the stakeholders that are involved in any exchange of information or material flows that occur between the ultimate supplier and the ultimate customer. The last supply chain in figure 1 exemplifies the complexities that may lie within a supply chain. In the ultimate supply chain financial provider, third party logistics firm and market research firm are introduced as new players in con-

trast to the extended supply chain. The financial provider may be lending capital to both the immediate supplier and the organization essentially financing their operations. The third-party logistics supplier may be handling all the logistics from warehousing to transportation between two firms in the supply chain. The market research firm may be conducting a survey to the organization about its ultimate customers and their needs in regard to their products. All these entities form a complex supply chain that has many different aspects to consider and manage. (Mentzer et al. 2001; Harland, 1996)

2.1.2 Supply chains in hospitals

According to some studies, 30% to 50% of hospital costs are related to logistical activities such as procurement, inventory management and provisioning (Poulin, 2003). Additionally, nearly half of these logistical expenses could be avoided with the use of best practices in logistical processes. Furthermore, it is generally accepted that information and communications technologies are able to play a notable part in improving the health care supply chain (de Vries & Huijsman, 2011). Poulin (2003) suggests that activities in the hospital supply chain can be broken down into three sub-processes: ordering and managing supplies, receiving orders and replenishing user departments. Ombaka (2009, 20) describes the procurement process as follows: *"An effective procurement process ensures the availability of drugs in the right quantities, available at the right time, for the right patient and at reasonable prices, and at recognizable standards of quality."* We will be examining the upstream processes, ordering and managing supplies and receiving orders, more closely. The sub-processes are described in more detail in table 1.

Table 1 Hospital logistics processes (adapted from Poulin 2003)

Stock ordering and management
Identify needs
Create, process and track orders
Review stores and pharmacy parameters
Order receipt
Take receipt of and check items
Transfer and stock items in stores or the pharmacy
Authorize payments to suppliers

While examining the processes presented in Table 1, one must also consider the manual labor of health care professionals involved in all the activities while labor costs are the

single largest cost for hospitals. Nowadays, all these activities are driven by information systems. Information and knowledge exchange between suppliers and medical institutions play key roles in supply chain management. Effective exchange of information and knowledge is not attainable without adequate investments in IT and other intangibles such as trust between hospitals and its suppliers. While health care organizations are more than willing to invest in technologies directly involved in patient care, they oftentimes overlook the other end of the supply chain. Investments in supply chain management technologies can be beneficial to both the quality of patient care and the bottom line of the organization. (Chen et al. 2013)

Figure 2 illustrates one possible logistics model for medical supplies and pharmaceuticals. In some hospitals, there may be a separate purchasing unit, which coordinates the purchasing activities of hospital pharmacy, hospital stores and departments. However, all orders for pharmaceuticals go through the hospital pharmacy. In other hospitals, the stores and pharmacies may also order their products directly from manufacturers or distributors. The logistics model pictured in figure 2 has a two-echelon inventory system which is common for health care institutions (LaPierre and Ruiz, 2007). In two-echelon inventory system, both the care units (requesting department here) and stores hold inventory and thus require inventory capacity. If a distribution center would be added in the figure, it would turn the inventory system into a three-echelon system.

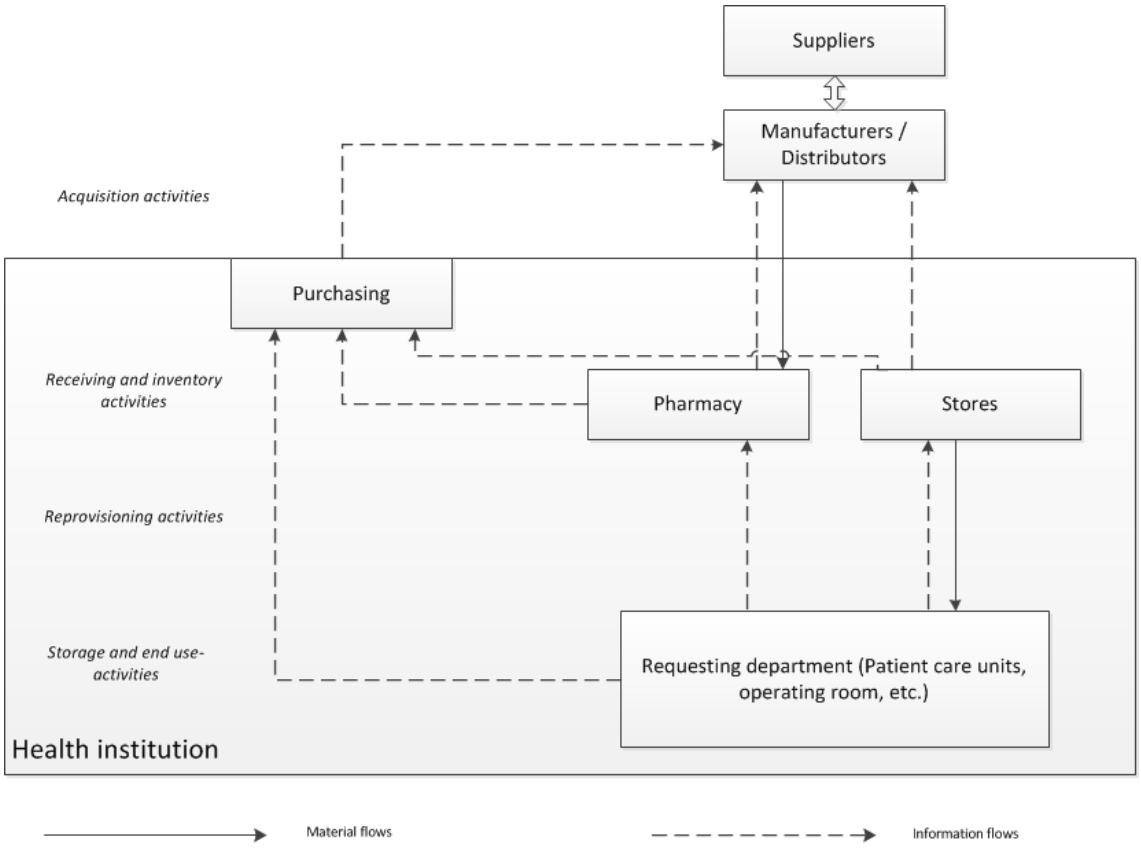

Figure 2 Hospital logistics (adapted from Poulin, 2003)

Acquisition activities happen in interface between health institution and distributors, as can be seen from figure 2. As noted earlier, the acquisition activities can be directly from pharmacies and stores or from a separate purchasing unit. Receiving and inventory activities happen in pharmacies and stores. In the pictured model of hospital logistics, stores handle the medical supplies and pharmacies deal with pharmaceuticals exclusively. Re-provisioning activities occur between hospital departments and pharmacies and stores. The stores and pharmacies receive orders from requesting departments and act accordingly. Storage and end use –activities are carried out in the requesting departments, which deliver the pharmaceuticals to patients and store some for later use. (Poulin, 2003)

Pan and Pokharel (2007) suggest that hospital logistics can be viewed as two main supply chains, internal and external. Due to the life and death nature of hospital logistics, the service level requirements in the internal supply chain are imminent and should have negligible lead time. This creates two areas of focus for hospital supply chain management; internal- and external supply chain. Regarding the management of the internal supply chain, the key issue is maximizing the service levels while the management of the external supply chain should concentrate on minimizing the costs. The logistics department plays an invaluable role in hospitals' routine operations, as it can be accountable for purchasing, receiving, inventory management, transportation, food services, medicine, home care services and inventory management system activities (Aptel and Pourjalali, 2001). Improvement in the logistics department can translate into cost reductions.

LaPierre and Ruiz (2007) recognize two principal approaches how to manage functions or actions within a health care supply chain: scheduling-oriented and inventory-oriented. The inventory-oriented approach revolves around the basic concept of reorder point. Whenever a product in inventory reaches its reorder point in the requesting department, a replenishment signal is sent to stores or pharmacy. The needed products will be transported to the requesting department. Consequently, the inventory levels decrease in the pharmacy and the stores and eventually trigger a reorder point at which point the pharmacies and stores prepare purchase orders to external suppliers. LaPierre and Ruiz (2007) also note that a mere reorder point model alone is not efficient in the context of hospitals and faces three limitations. The limitations are:

1. Model does not take limited human resources into consideration.
2. Model does not account for limited physical inventory capacity, especially in stores and pharmacies which are imperative in hospital logistics.
3. The decisions in the model are solely cost-based and do not account for inventory activities.

Replenishing inventories in the requesting departments tie up a lot of resources of the health care professionals. Hospitals have tackled the inefficiency problem by arranging

supply tours, which replenish many departments on the same runs. It is suggested that periodic replenishment model, where the replenishment decision is based on schedule rather than a reorder point, could suit health care organizations better. (LaPierre & Ruiz, 2007)

The limited storage capacities in the departments and pharmacies/stores are important while considering the reorder points. For example, stock-outs of certain pharmaceuticals may be life threatening and thus hospitals are not able to use the economic order quantity (EOQ) efficiently. EOQ is a calculated order quantity that minimizes the total holding and ordering costs. Also, stock-outs necessitate additional replenishment runs to the departments which effectively waste more time of the health care professionals. (LaPierre & Ruiz, 2007)

Thirdly, basing all replenishment activities in the reorder point model solely on costs does not consider the benefits of stock control. More frequent replenishment runs permit for quicker reactions to unusual demand, which enhances the service levels. Naturally, more frequent replenishment runs create more overall costs. (LaPierre & Ruiz, 2007)

The alternative for inventory-oriented approach is the scheduling approach which can also be recognized as supply chain optimization approach. It concentrates on examining the supply chain as a chain of operational decisions; who purchases which products at what time and where are those products delivered? Also, the decision where to store what and how much are important for the supply chain optimization approach. (LaPierre & Ruiz, 2007)

2.1.3 Supply chain integration and information systems

As information technologies (IT) have been evolving throughout the recent years, the supply chain management has been deeply affected through integration. IT has enabled inter-organizational sharing of knowledge and real-time information within the supply chain in logistics, operations and strategic planning. This form of integration between supply chain partners has created better ways of predicting the future through enhanced inventory management, distribution and production planning. Without IT, the simultaneous decision-making enabled by transmission and processing of data would not be possible. Thus, IT can be seen as the key component in supply chain management and in supply chain integration. (Sanders 2007)

Chen et al. (2013) determine three prominent factors, which affect supply chain integration the most:

1. IT integration,
2. Knowledge exchange and
3. Trust between the supply chain partners.

Vickery et al. (2007) learned that car manufacturers' IT integration with their first-tier suppliers directly improved the performance of the whole supply chain. According to Sanders (2007) introduction of e-business technologies between supply chain partners creates enhanced organizational performance both directly and indirectly via collaboration within an organization and inter-organizationally. Dyer and Chu (2003) noted that trust in the supplier-buyer relationship decreased transactional costs and increased information exchange in the automotive industry. Furthermore, according to their studies, trust and inter-organizational information sharing can be a source of competitive advantage.

Chen et al. (2013) concluded in their study, which was based on survey data collected from 117 supply chain executives in U.S. that hospital-supplier integration enables supply chain-wide performance improvements in supply chain speed, quality, flexibility and costs. The hospital-supplier integration is facilitated by the level of knowledge exchange, IT integration and trust between the parties involved. Test results show that hospitals, which had greatly integrated their logistics systems with their supply chain partners, performed at a higher level throughout the whole supply chain.

Study conducted by Gonzalez-Benito (2007) supports the notion that IT investments and IT integration within purchase function affect positively on performance in multitude of operational areas. Moreover, the introduction of IT integration allows organizations to implement better purchasing practices, provided that it enables higher strategic integration of the purchasing operations. The more advanced purchasing practices, which efficiencies and synergies in information sharing facilitate, include supplier evaluation, collaboration with suppliers and logistics integration. These more sophisticated purchasing activities transform investments in IT into improvements in dependability, flexibility and quality on the operational level. Gonzalez-Benito (2007) concludes that "*IT investment is key for the development and success of the purchasing function*".

Figure 3 (de Vries and Huijsman, 2011) portrays the different stages of supply chain integration. All the phases should be interpreted as macro level development. It is also important to note, that many different organizations still are in one of the primitive stages of supply chain integration, including health care sector. In the eyes of operations management, the health care sector has historically focused on optimization of individual processes, such as optimal inventory levels of pharmaceuticals and optimal ordering processes for drugs, rather than the wide spectrum that is supply chain management. As we have seen with conventional manufacturing companies, most of the optimization problems in health care organizations have to do with how a high customer service level can be aligned with high resource utilization. It is still debatable among the academics how this kind of integration can be best achieved in health care supply chains. (de Vries & Huijsman, 2011)

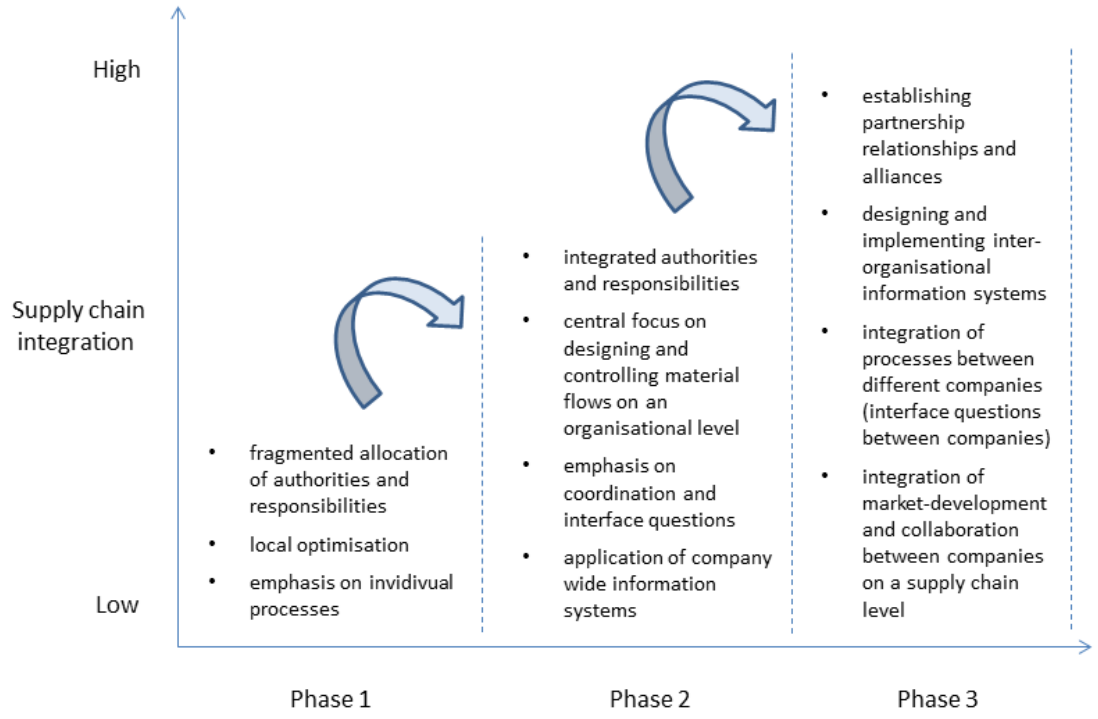

Figure 3 Different stages of supply chain integration (adapted from de Vries & Huijsman, 2011)

In figure 3, the phase 1 depicts the lowest level of supply chain integration. In phase 1, the authorities and responsibilities are fragmented, optimization is local and the emphasis is on individual processes. Traditionally, health care sector can be seen to be in this phase. In phase 2, authorities and responsibilities are integrated within the organization, central focus is on designing and controlling material flows on organizational level, emphasis is on coordination and interface questions and there is an organization-wide information system. Phase 3 illustrates high level of supply chain integration. In it, there are established partnerships and alliances. The central focus is on designing and implementing inter-organizational information systems as well as integration of processes (interface questions) between different organizations. In phase 3, the integration also reaches to market-development and collaboration between organizations on a supply chain level.

Health supply chains can be defined by different levels of integration. De Vries and Huijsman (2011) identify six different levels of supply chain integration in health care:

- Integration and co-ordination of processes.
- Integration and co-ordination of information flows.
- Integration and co-ordination of planning processes.
- Integration of intra-and inter-organizational processes
- Integration of market-approach.
- Integration of market-development.

The deployments of e-business and information technology are tightly connected to the co-ordination and integration of operational activities. In addition, there are multitude of different stakeholders related to health care supply chain. This makes it so that application of supply chain management methods in health care industry consist of, nearly by definition, allocating authorities and responsibilities, organizing interface processes and building relationships. Supply chain integration in health care sector can be mainly seen as integration and co-ordination of planning processes, but it can also be viewed as joint market development and creation of new health care products. (de Vries & Huijsman, 2011)

It is important to understand that the aforementioned levels of supply chain integration cannot be interpreted in a vacuum. Oftentimes an organization goes through multiple different phases of integration simultaneously. In summary, the continuous shift in health care towards more integrated and process oriented supply chains necessitates an adjustment in structure, strategy and control mechanisms. (de Vries & Huijsman, 2011)

In the following chapters we will be looking into different ways to improve the supply chain management performance. We will be looking into three different models how to set up the upstream supply chains and manage inventory; Just-In-Time (JIT), Vendor Managed Inventory (VMI) and Collaboration in Planning, Forecasting and Replenishment (CPFR). First, we will examine the models overall and later, we will discuss their applications in hospital environments.

2.2 Just-in-time JIT

2.2.1 History of JIT

Just-in-time, later on referred as just JIT, was seen in mid-2000s inherently as part of supply chain management, but in its early days in the 1970s and 1980s it was regarded as a tool to eliminate waste and reduce inventory (Giunipero et al. 2005). Throughout the decades it has been integral in lowering production costs, producing better quality products, achieving higher and faster throughputs, reducing inventory costs and having shorter lead times in purchasing. (Giunipero et al. 2005) The concept of JIT endorses the products to be delivered only in the right amount, to the right place at the right time (Hung et al. 2009). In this section we will be examining the JIT philosophy of inventory management and how it is applied in modern health care organizations as well as best practices which have emerged from JIT.

Originally, JIT was created in Japan by Toyota Motor Corporation in the late 1970s. It started out as a Kanban system, where the production line uses Kanban cards to iden-

tify when to order and request more supplies. Later on, it moved on to be called JIT after the US grocery industry adopted and renamed it. Basically JIT revolves around the basic concept of elimination of waste via continuous reorganization and improvement in manufacturing processes. (Giunipero et al. 2005)

Academics also recognize two different modes of JIT; JIT manufacturing and JIT purchasing. JIT manufacturing refers to Japanese Kanban production methods where reduced manufacturing lot sizes, reduced manufacturing lead times and enhanced quality assurance programs are essential (Dong et al, 2001). Alternatively, JIT purchasing can be recognized as actions which enable reduction of raw materials in inventory, such as frequent deliveries with small lot sizes (Dong et al, 2001). Dong et al. (2001) suggest that while JIT purchasing benefits the buyer it might not necessarily benefit the supplier. Moreover, Dong et al. (2001) identify four key elements of JIT purchasing:

- Reduction in order size.
- Reduction in order lead time.
- Quality control measures (supplier quality certification, preventive maintenance programs, receiving quality inspection).
- Supplier selection and evaluation where suppliers are chosen based on geographical locations, product and delivery qualities in such manner that it facilitates aforementioned JIT purchasing practices.

Two first elements can be seen as core elements in JIT purchasing and are essential. The latter two elements can be implemented separately or used with other supply chain practices such as vendor managed inventory. However, both of these must be implemented in order for JIT purchasing to function. (Dong et al. 2001)

2.2.2 Just-in-time logistics in hospitals

It is important to note that it is difficult to implement just-in-time logistics in hospitals due to the nature of health care industry; patient safety is paramount and lack of medical supplies or pharmaceuticals can have detrimental consequences (Kumar et al. 2008; Trinkhaus et al. 1996). However, there is evidence supporting the use of JIT strategies in health care supply chains (Kumar et al. 2008). For JIT to be viable way of managing inventory, it needs to fulfill the following criterion: the supply chain activities need to be high volume, repetitive and deal with concrete items (Jarrett, 1998). The mentioned criterion must be combined with good relationships with suppliers in order to enable JIT deliveries (Kumar et al. 2008). Trinkhaus et al. (1996, 2) strengthen this evaluation by stating that *"Having reliable vendors deliver smaller quantities at more frequents intervals allows the firm to reduce the size of its inventory while still ensuring the integrity of its production schedule."*

Kumar et al. (2008) conclude that if health care organizations wish to implement lean JIT strategies, they need to make two operational changes. Firstly, they need to seek collaboration with their suppliers through partnerships and co-operation. Secondly, they need to identify whether or not their current supply chain systems are capable to accurately support logistic decision making. It is also necessary to acknowledge that pharmaceuticals are highly regulated part of health care industry (Kumar et al. 2008). For instance, in Finland, there is also a minimum stock requirement for certain drugs (finlex.fi) which makes deployment of JIT strategies more difficult. In a survey study of 75 U.S. hospitals conducted by Kumar et al. (2008), they found out that many of the hospitals in the U.S. already had the infrastructure and capabilities to move into leaner JIT environment.

Traditionally, the majority of JIT systems in hospitals have been founded on the basis of outsourcing the logistics operations to a third-party logistics provider. The noted benefits of this consist of stock reduction, less time spent by health care specialists on the inventory management activities and less administrative activities for health care workers. However, there are also negatives sides to the use of third-party logistics providers; hospital may lose control over selection of products and if the relationship with its service provider lacks trust, it may cause the whole system to hinder. Also, if the implementation of the JIT system fails, it is hard to return to the old system. Pan and Pokharel (2007) noted in their study of Singaporean hospital logistics that outsourcing did not always reduce the costs of services and products in hospitals. To conclude, the success of an implementation of JIT system ultimately is tied to the ability to choose capable and trustworthy providers. (Trinkhaus et al. 1996)

Jarrett (2006) states that implementation of JIT systems and reengineering of hospital supply chains will be imperative for the health care industry to obtain control over the ever-rising costs. Prior to assessing the return on investment and estimations of the success factors of JIT systems, the health care management has to figure out answers to multiple questions. Firstly, what has been the stopping force that has kept the health care industry unwilling to adopt the equivalent competitive operational processes used in distribution and manufacturing industries? Secondly, there are many similarities in business processes between the aforementioned industries, particularly in the domain of inventory control, product production and supply distribution. Third, management needs to create an understanding on why these changes have not been seen as crucial before. (Jarrett, 2006)

2.3 Vendor managed inventory VMI

2.3.1 Different modes of VMI

Despite the JIT systems historically being prominent in the health care industry's inventory management, there has been continuously more interest and emphasis on different inventory control systems such as Vendor Managed Inventory (VMI) (Mustaffa & Potter, 2009). In VMI, the supplier will be responsible, partly or wholly, for the management of inventory and makes the decisions with respect to replenishment. According to Mustaffa and Potter (2009), VMI has similar requirements regarding information as a stockless inventory system, the biggest difference being the fact that the supplier will be accountable for controlling the stock and inventory levels since the ordering process is automated. In order for VMI to work to good effect, there must be timely and accurate information regarding consumption and current stock levels. To enable this, there needs to be some level of systems integration between the supplier and customer and investments made into the current ICT systems. (Mustaffa & Potter, 2009)

VMI offers a mutually beneficial setting for both supplier and buyer. In a true form of VMI, the supplier is free to make decisions and plans how and when to produce and replenish with respect to the customer-agreed service levels. The buyer receives benefits from administrative and inventory cost reductions simultaneously shortening lead times and limiting the risk of amplification of demand within the supply chain. In turn, the supplier is able to optimize transportation costs and create a steady and lean production plan. Prerequisites for these benefits are sharing of information throughout the supply chain and mutual trust. Mutual trust can be broken down into honesty, frequency of interaction, chemistry between parties, commitment, interdependency, openness and trust. Information sharing can be further dissected into completeness, information availability, reliability and information sharing (Claassen et al., 2008).

Kauremaa et al. (2009) identified three different patterns of VMI implementation:

- Basic VMI
- Cooperative VMI
- Synchronized VMI.

The three patterns of VMI implementation, their motivations and outcomes are pictured in figure 4.

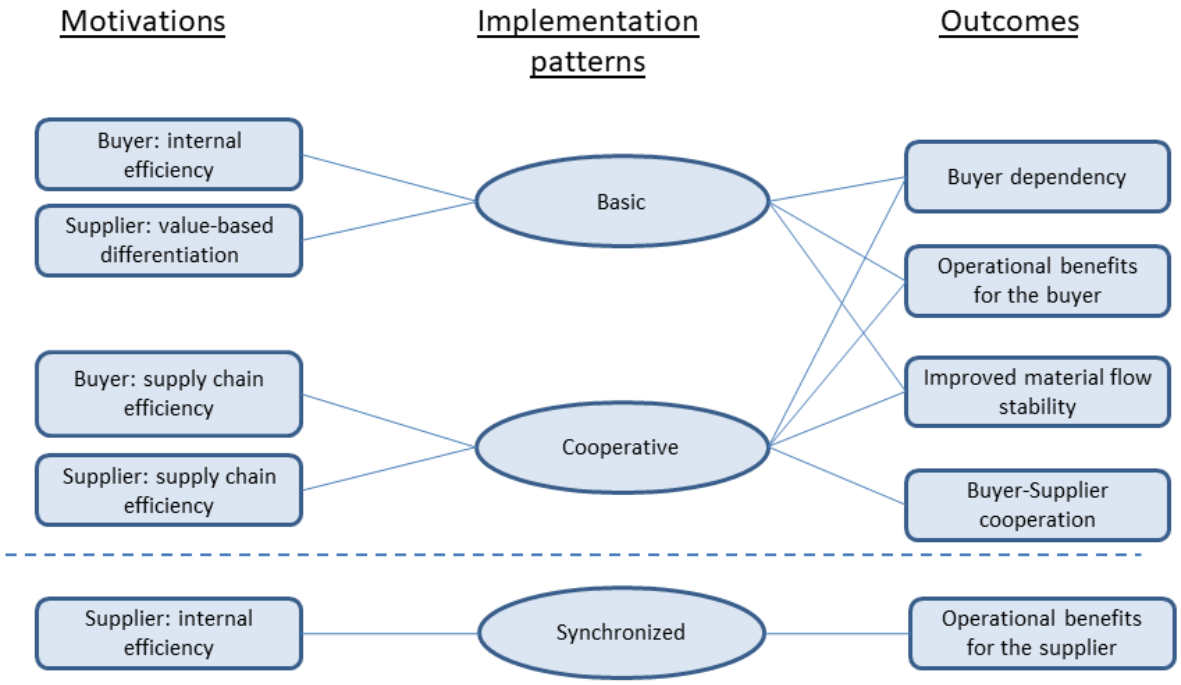

Figure 4 Patterns of vendor managed invetory (adapted from Kauremaa et al. 2009)

In basic VMI implementation, VMI is used at its basic level of shifting the responsibility of replenishment to the supplier in tandem with increasing need of information to carry out the responsibility. Basic VMI is characterized by one-sided but supplementary ambitions. The buyer's objectives in basic VMI are ease of supply and superior operational efficiency. On the other hand, the supplier pursues to maintain or improve its commercial position in the market. This is achieved via the inter-organizational system, which can be seen as a structural relationship-marketing program. This translates into value-based differentiation. The buyer's goals are met in basic VMI if the purchasing operations are made lighter, more effective and more efficient as the ordering process is removed from the equation. Material availability will increase and inventory levels will decrease. The supplier's goal is achieved if the VMI service is implemented successfully. (Kauremaa et al. 2009)

In cooperative VMI the interests of the two parties are mutual and the aim is to improve the whole supply chain. Both the buyer and supplier aspire to operational efficiency. Moreover, what is unique for the cooperative VMI is the alignment of end-goals and collective actions. Whereas in basic VMI the supplier's focus was in product availability, in cooperative VMI the target has shifted more towards the end-customer and its needs. The cooperative VMI process enables more transparent and visible needs and material resources for the two parties working together to achieve minimum inventory and maximum availability. As a by-product, cooperative VMI creates an inter-organizational atmosphere where collective development ventures and open and sup-

portive dialogue regarding non-VMI subjects can be had. To conclude, in comparison to basic VMI, cooperative VMI can be viewed as more intricate way of improving connecting more interdependent organizations within a vertical supply chain. (Kauremaa et al. 2009)

The third mode of VMI implementation is synchronized VMI. Synchronized VMI can be viewed as an improvement over the former two VMI patterns, basic and cooperative VMIs. In synchronized VMI, the supplier thrives to integrate the inter-organizational program with the use of downstream information in its decision making as well as in seek of operational effectiveness. For synchronized VMI to succeed, it requires the distinct intent from supplier's part to have the VMI in the center of its internal operations and planning. Although synchronized VMI is one possible implementation model, Kauremaa et al. (2009) noted that it is hard for the suppliers to harness all the benefits of the inter-organizational visibility created by VMI and thus harder to implement. (Kauremaa et al. 2009)

2.3.2 Benefits and risks of VMI

VMI aims to reduce lower inventory level and, at the same time, improve service levels. For this to be possible there needs to be good visibility and communication between supply chain members. Kim (2005) found out that health care organizations which had adopted VMI could see up to 30 % stock reductions in pharmaceuticals, as well as other benefits. With VMI, the flow of information and materials becomes more harmonious, service levels improve, transportation and inventory costs decrease and the supply chain as a whole is more coordinated. Traditionally, the lowering of inventory levels and simultaneous improvement of service level has been seen contradictory but through VMI this can be achieved. Table 2 gives an overview of the various risks and benefits which retailers and vendors face by entering in a VMI program. (Guimaraes et al. 2013).

Table 2 Benefits and risks of VMI (adapted from Guimaraes et al. 2013)

Retailer		**Vendor**	
VMI Benefits	*VMI Risks*	*VMI Benefits*	*VMI Risks*
Reduce inventory and cost	Information visibility allows opportunistic behavior	Increase inventory flexibility	Order process is not abandoned by customer
Fewer stock outs	Dependency on vendor	Reduce lead time variability	Initial technology investment
Increase service levels/product availability	Switching costs	Consistent ordering pattern	Difficulties in technology integration
Fill rates improvement		Reduce transportation costs	
Increse inventory turns		Optimize physical distribution	
Reduce transactional costs		Warehouse efficiency	
Reduce ordering and planning costs		Real time access to information	
		Competitive advantage relationship	

According to Guimaraes et al. (2013), there are two main drivers for VMI: information sharing and decision making. Out of these two, information sharing is the force that creates all the performance benefits (fill rate improvements, reduction of transactional costs, reduction of stock outs etc.). The vendor can enjoy these perks only if it begins to use collaborative information sharing technologies and programs. It has also been acknowledged, that more simple information systems in VMI yield better results regarding effectiveness than complex information systems. Claassen et al. (2008) concluded in their study that the quality of information systems is a strong enabler for VMI implementation success and it provides the following:

- information availability and visibility
- decisions based on total information within the supply chain
- collaboration between parties in the supply chain
- single point of contact for data.

It is important to note that disregarding the risks associated with VMI prevents both parties from benefiting from the arrangement; this is where one needs to consider the decision-making component.

Dong and Xu (2002) claim that retailer is the main beneficiary in VMI arrangements only if the relationship is short term. Conversely, long term arrangements benefit the vendor more as they will be able to better predict future demand. Overall, even though

both parties benefit from VMI systems, vendor can be interpreted to enjoy more benefits from the arrangement.

2.3.3 VMI systems in hospitals

Traditionally, the problem with inventory management in hospitals has been the fact that the actual inventory levels reflect the desired inventory levels of the medical staff rather than the needed inventory levels. Furthermore, the decisions regarding inventory are oftentimes politically driven and experienced based instead of data-driven decisions. This might cause overstocking and create waste in the supply chain. (Nicholson et al., 2004)

Despite the willingness to improve supply chain management within health care organizations, the health care industry as a whole has its unique ways of implementing the best practices in SCM. Some limitations regarding implementation of best practices are misaligned or conflicted interests, limited education, inconsistencies in relationships between purchasing organizations and supply chain partners and lack of executive support. Even if the best practices are implemented, there still remains hindering aspects regarding efficiency in the supply chain. Such hindering aspects can be health care professionals' preferences, limited information sharing, evolving technologies, lack of standardized codes and lack of SCM knowledge and skills. Overall, the unwillingness to implement VMI systems in health care environment stems from the lack of information about the benefits and shortage of sufficient training. (Guimaraes et al., 2013)

Pan and Pokharel (2007) discovered in their study that VMI can be utilized in hospitals to decrease stock levels and reduce logistics costs. For VMI to be effective, hospitals need to have functioning information systems which support electronic commerce and the suppliers need to be from local area in order to secure the uninterrupted flow of materials (Pan & Pokharel, 2007). In VMI programs, with the assistance of integrated VMI software, it will become easier to predict future demand of medical supplies and pharmaceuticals in hospital settings. Orders are created based on automated economic ordering quantity calculations taking into consideration lead time, safety stock, exceptional demand and seasonality. Electronic data interchange (EDI) controls the information flows and lowers the costs of communication and collection of data. By transferring the purchase order creation activity to distributors, hospitals are able to reduce errors in procurement process as well as manual labor by the health care professionals which ties up resources from their actual work. (Guimaraes et al., 2013)

Guimaraes et al (2013) determined it to be easier to implement VMI programs to pharmaceuticals. This is to some extent due to the ability and knowledge of the pharmaceutical companies over SCM best practices and information systems involved. It can

be even stated that pharmaceutical companies have positioned themselves strategically to be able to provide VMI and other IT solutions regarding SCM.

In their study, Guimaraes et al (2013) found out VMI to be a lean solution for hospital material management. Despite the aforementioned implementation barriers of the health care sector, VMI provides multiple benefits such as increased replenishment efficiency, reduction of waste, streamlining of the material and information flows via visibility throughout the supply chain, lowered inventory costs and improved quality of care due to the freed resources from the purchasing activities. It is imperative to understand that, as in any lean solution, VMI requires continuous improvement and attention in order to provide desired results.

2.4 Collaboration in planning, forecasting and replenishment CPFR

2.4.1 CPFR model and contingent factors

Collaborative planning, forecasting and replenishment, later on referred to just CPFR, can be defined as *"... collaboration where two or more parties in the supply chain jointly plan a number of promotional activities and work out synchronized forecasts, on the basis of which the production and replenishment processes are determined"* (Larsen et al, 2003, p.532).

As is evident from the definition, CPFR has three sub-processes; planning, forecasting and replenishment. These three can be further divided into nine steps. These steps are presented in figure 5. The main focus of CPFR is to pursue to complete and evolve the previous supply chain management methods, such as vendor managed inventory, just-in-time logistics or continuous replenishment. CPFR can be seen as a broader variation when compared to other collaborative models. (Danese, 2007)

According to Larsen et al (2003), CPFR can take many forms depending on the level of implementation. The authors classify CPFR in three tiers; basic, developed and advanced. The level of implementation is dependent on two factors: scope of the collaboration; how many business processes are involved and depth of the collaboration; indicating the integration of business processes. Danese (2007) extends that CPFR is modular model in a sense that it is not mandatory to implement all nine steps of the model in order to gain benefits.

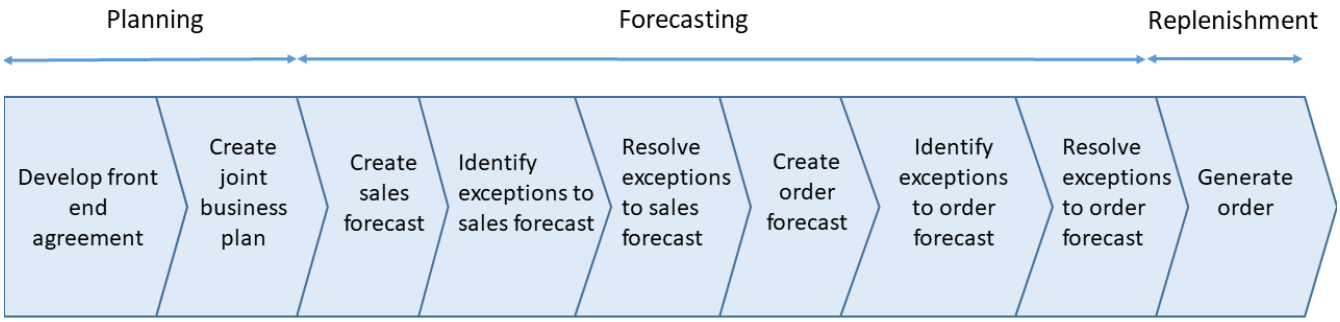

Figure 5 CPFR activities (adapted from Danese, 2007)

The first step in CPFR is for the parties involved to agree to commit to a program of collaboration in demand forecasting. This includes also determining the key metrics and sponsors within all organizations. The second step is to create a joint plan addressing item management profiles, which include lead times, promotions, minimum order quantities and reorder frequencies. Next, the collaborating parties create a sales forecast aligned with the joint business plan based on actual consumption data collected from all parties. Steps four and five concentrate on identifying and resolving issues and exceptions with the sales forecast. These can be, for example, inaccuracies in forecasts, execution problems or over/under stocking. All these variables force the parties to readjust their initial joint sales forecast. In conjunction with steps one to five, the parties are now able to combine the information and planning into a more accurate order forecast. This enables the seller/distributor to prepare production schedules according to demand while simultaneously minimizing safety stock. Steps seven and eight are similar to steps four and five where deviations and exceptions to order forecast are identified and resolved. Finally, by accruing all the collaborative planning and information gathered throughout the process, a replenishment plan can be established by turning the order forecast into a binding order. (Danese, 2007)

According to Danese (2007), the different types of CPFR arrangements are contingent on five factors: CPFR goals, CPFR development stage, supply network's relational/physical structure and characteristics of products and their markets. Investigating these five factors will allow better understanding of the depth of collaboration between parties and also clarifies the number of interacting units and processes in the collaboration setting.

Danese (2007) determined in her research that companies engage in CPFR for two main reasons: reducing costs and transforming the supply network more agile. In the former, the aim is to reduce costs, e.g. investments in inventory, while maintaining the same service level. This could be characterized as "strategy of efficiency". The latter focuses in adapting the supply chain to fluctuations in demand, making it more responsive. Hence, this can be characterized as "strategy of responsiveness". Danese (2007)

also discovered that for companies aiming to achieve efficiency through CPFR, the level of collaboration required was low. Communication of data was enough for the arrangement to reap benefits. Communications can be seen as exchange of data on sales plans, stock data or order forecasts. On the other hand, if companies sought to be more responsive to changes in demand, it required much deeper collaboration between involved parties. Alongside exchange of data, companies need to jointly manage their expectations and synchronize their plans.

The depth of collaboration is contingent on supply chain network's physical structure and product/market characteristics. Product and market characteristics in question are elasticity of demand, spatial complexity (geographical distance between collaborators) and homogeneity of products. If product has high elasticity of demand, significant changes in shelf prices, e.g. promotions, may affect the demand greatly. In the case of high elasticity of demand, collaborating parties need to have high level of collaboration in order to response to fluctuations in demand and create more accurate demand forecasts and plans. For high level of collaboration, it is also required that supply chain network's physical structure has low spatial complexity. If the geographical distance between collaborating parties is high, it limits the collaborations. Furthermore, the homogeneity of products determines the level of collaboration in relations with demand elasticity and spatial complexity. While collaborating parties market and sell similar products, it is easier for them to collaborate on a deeper level. If all parties are familiar with the marketplace, they are able to better assess demand fluctuations and better collaborate in creating demand forecasts and plans. Different products always limit the depth of collaboration but even though parties have similar products, this does not necessarily create a good environment for high level collaboration if the spatial complexity is high and/or demand elasticity is low. (Danese, 2007)

The nature of relationships within a supply chain network's relational structure has great effect on the number of interacting units. As in many other SCM practices, also in CPFR trust and good relationships are important factors when choosing a supplier or a partner to cooperate with. Also, existing supply chain integrations affect the decision to do cooperation with other organization; if some parts of the supply chain are already integrated, it lowers the threshold to commit in collaboration. Reflecting on the nature of relationships, collaborating parties may evaluate the number of potential partners. Danese (2007) discovered in her study that if the number of potential partners is low, then also the number of interacting units is low. In turn, if the number of potential partners is high, this may enable more interacting units. Another determining factor for the number of interacting units is the development stage of CPFR. If CPFR is still in initial stage, it typically limits the number of interacting units. On the other hand, if CPFR is in advanced stage, this permits for more interacting units. To summarize, for high number of interacting units in a CPFR setting, it is required that the amount of potential CPFR

partners is high and an advanced stage of CPFR has been established. Furthermore, if CPFR is still in its initial stages or the number of potential CPFR partners is low, the number of interacting units is low. Figure 6 demonstrates the different modes and paths a CPFR can take.

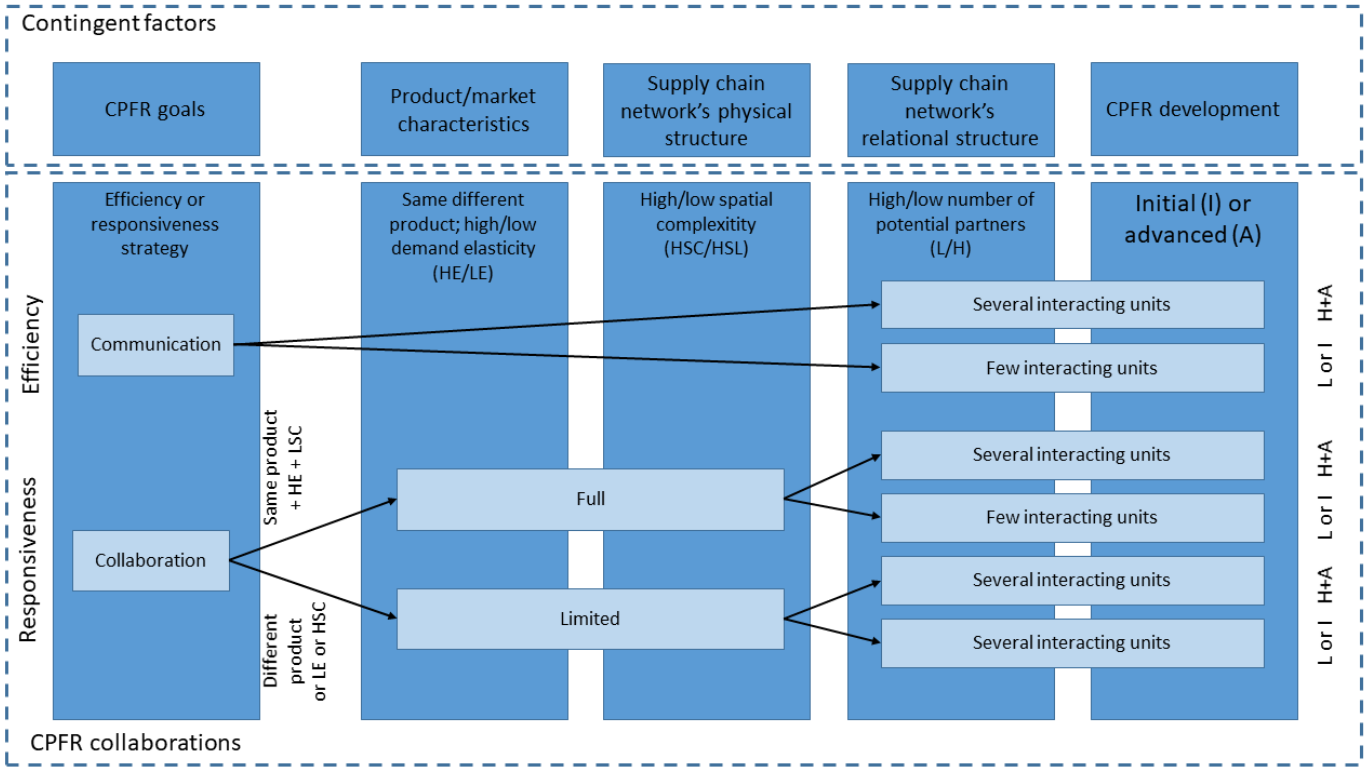

Figure 6 Relationships between contingent factors & CPFR collaborations (adapted from Danese, 2007)

2.4.2 CPFR in hospitals

Lin and Ho (2014) performed 13 interviews with medical experts in 11 Taiwanese hospitals in order to better understand the implications and possibilities of CPFR implementation in health care environment. The interviewees had varying range of experience between 5 to 30 years and were mainly responsible for procurement of pharmaceuticals. The study showed that 90 % of the Taiwanese hospitals did not utilize integrated information systems with suppliers and approximately 80 % of the hospitals were concerned with asymmetric information flows with their pharmaceutical suppliers. The lack of communication and information sharing between the two parties resulted in frequent overstocking and stock-outs. Furthermore, 9 out of 11 hospitals also were not content with their existing e-procurement systems. In conclusion, Lin and Ho (2014) determined that the current pharmaceutical procurement processes in most of the hospitals were highly manual labour extensive and were characterized by waste of employee resources.

According to Lin and Ho (2014) CPFR could be a viable solution for hospitals in battling with issues in pharmaceutical procurement process. In their study, they categorized the benefits of CPFR implementation in hospitals in three classes: quality, cost and time. The benefits are presented in table 3. It is important to note that the different type of benefits apply to different kind of hospitals in varying degrees. As a rule of thumb; the larger the hospital, the larger the benefits.

Table 3 CPFR benefit analysis (adapted from Lin and Ho, 2014)

Class	Benefit (%)
Cost	1. Reduce stock cost (20-40) 2. Save stock space (3-10) 3. Save labor cost (30) 4. Reduce shipping fee (5-15) 5. Save paper usage (90-99)
Time	1. Save purchase time (40) 2. Reduce delivery time (1-2 days)
Quality	1. Promote service quality (1-5) 2. Rise forecast accuracy (10-20) 3. Reduce shortage rate (2-10) 4. Reduce urgent order rate (5-20)

As in any endeavor to enhance the supply chain, the main goal is to reduce costs and improve operational effectiveness. Table 3 shows that CPFR can reduce stock costs up to 40 % and save labor costs up to 30 %. Also, lead time can be reduced and effectively enhance service quality and limit shortages. This is increasingly important in a health care context where the costs of shortages can amount to lost human lives.

Bhakoo et al (2012) refined the five contingent factors of CPFR arrangements by Danese (2007) to better fit in a health care setting and illustrated that they can also be applied. The five contingent factors are:

1. Spatial complexity
2. Regulatory environment
3. Product characteristics
4. Physical characteristics
5. Degree of goal congruence.

Spatial complexity can be high or low and Bhakoo et al. (2012) suggest that if a supply chain partner has high spatial complexity, the inventory should be managed via internal control methods. In the case of low spatial complexity, it is possible to manage inventory with methods that take advantage of collaborative arrangements with supply chain partners.

Regulatory environment can be high or low. Bhakoo et al. (2012) propose that if the regulatory environment is low, it is feasible to manage inventory via methods that use collaborative arrangements with trading partners. On the other hand, if the regulatory environment is high, the inventory should be managed with methods using internal controls.

Product characteristics are divided into functional or innovative; internal controls work better for innovative products as an inventory management method. Functional products can be managed with methods that incorporate collaborative arrangements with suppliers. (Bhakoo et al. 2012)

Physical characteristics are either limited or abundant. Abundant physical characteristics refer to larger hospitals with well utilized, advanced IT infrastructures and adequate storage possibilities. At the same time, limited physical characteristics denotes to smaller hospitals with elemental utilization of IT infrastructure and limited storage capabilities. According to Bhakoo et al. (2012), internal control methods are better suited for limited physical characteristics. On the other hand, organizations with abundant physical characteristics are able to utilize collaborative arrangements with suppliers.

The degree of goal congruence can be high or low. In the case of aligned goals where the congruence is high, the suited method of inventory management incorporates collaborative arrangements with suppliers. If the goals of the supply chain partners are not aligned and the congruence is low, it is beneficial to manage inventory via methods of internal controls. Figure 7 summarises these aforementioned contingent factors. (Bhakoo et al. 2012)

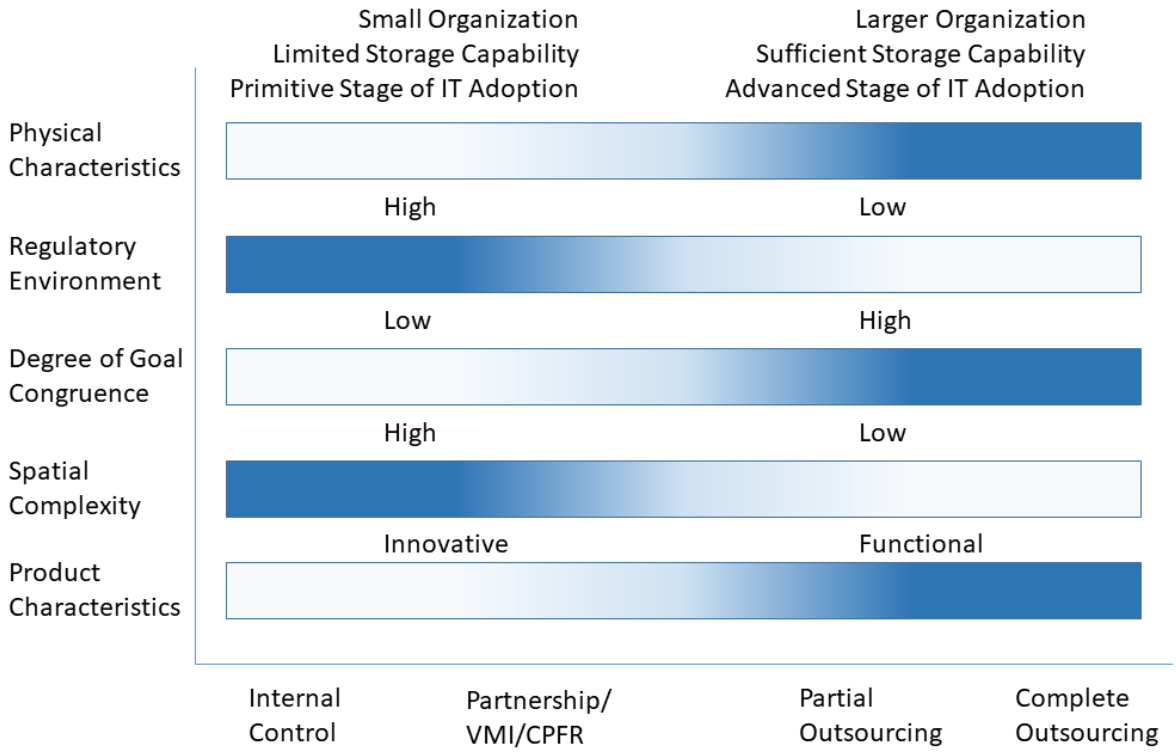

Figure 7 Contingent factors affecting the development of collaborative relationships across the health care/hospital supply chains (adapted from Bhakoo et al. 2012)

Figure 7 shows that the ideal conditions for collaboration for health care organizations are in a low spatial complexity setting where the products are functional (high demand and high supply elasticity) and there is low level of regulations. The larger and more developed health care organizations benefit more and are more capable of collaboration. With high degree of goal congruence, the parties in a supply chain are more inclined to collaborate than when the parties had conflicting aspirations.

In their study, Bhakoo et al (2012) also recognized multiple challenges the hospitals and pharmacy departments faced while seeking collaboration with suppliers. *Trust issues* between suppliers and hospitals was the most prominent obstacle in creating collaborative arrangements. While large multinational pharmaceutical companies' main goal is to maximize profits to its shareholders, the public hospitals are non-profit and this leads to lack of confidence between supply chain partners and lesser degree of information sharing.

The second challenge Bhakoo et al (2012) noticed was aforementioned *divergent goals* between the pharmacy departments in the hospitals and the pharmaceutical companies. The hospitals recognize that collaborative arrangements with profit maximizing entity open up growing dependencies, which might lead to opportunistic behaviour. Other cause of goal incongruity, according to the study, stems from the pharmacy departments objective to secure patient safety and uneasiness to hand over the control of

pharmaceutical inventory management to a third-party supplier. Related to inventory management, pharmacy departments emphasize the importance of ensuring that required stock levels are maintained at the supplier prior to establising a VMI process as stock-outs can have mortal consequences.

Physical and technical infrastructure was also mentioned as an obstacle for collaborative VMI arrangements. Based on the interviews with hospital pharmacists, the concern was that the hospitals would not have adequate physical infrastructure to support necessary storing of items. This was particularly apparent in larger and heavier products such as intravenous fluids. The literature emphazises the significance of information sharing and information systems in collaborative arrangements, i.e. VMI. Large portion of pharmacists in hospitals were not convinced that satisfactory systems could be implemented without major problems and economically. (Bhakoo et al. 2012)

For collaboration between hospitals and suppliers to be successful and financially feasible, Bhakoo et al (2012) determined the *size of the hospital* to be a critical factor. Larger bed count correlates with greater requirement for medicines and consequently larger storage facilities. This in turn enables greater cost reductions if collaborative VMI arrangements are utilized.

The last barrier, according to Bhakoo et al (2012), for entering in collaborative arrangements with pharmaceutical suppliers is *cultural inertia*. The fear of losing control over important clinical functions, i.e. investigating the latest drugs on the market or looking for more inexpensive alternatives, lead the directors of hospital pharmacies to be sceptical of collaboration with suppliers. Furthermore, the pharmacists envisioned that they would not be able to follow the trends of medicine consumption and the reasons behind the fluctuations. Ultimately, Bhakoo et al (2012) construed this as a fear of becoming useless on the part of the hospital pharmacists.

3 RESEARCH FRAMEWORK

The research framework for this study will expand on the literature reviewed and attempt to fit the previously discussed themes into the context of Finnish health care, more specifically the procurement of pharmaceuticals in Finland. The Finnish health care system has been hailed as one of the best in the world and its regulation on pharmaceuticals has multiple unique characteristics (Sitra, 2009). This necessitates creation of a completely new framework in studying the possibility of collaborative arrangements within the pharmaceutical supply chain of hospital pharmacies in Finland.

3.1 Unique characteristics of pharmaceutical industry in Finland

3.1.1 Mandatory reserve supplies

In the context of this study, we will be discussing only about the regulations and characteristics connected with the hospital pharmacies. The unique characteristics of Finnish pharmaceutical regulations are mandatory reserve supplies and single channel system. We will be examining these two characteristics in more detail.

Finland is geographically disadvantageously located in regard to medicine supply. It is mainly surrounded by water in logistically relatively challenging location in the northern parts of the world. Alongside the logistic challenges, substantial seasonal changes in temperatures create difficulties for medical transportation. Furthermore, Finland only has one pharmaceutical factory compared to 15 factories from 20 years ago and infusion liquids are not manufactured in Finland, at all. Adding to the already peculiar circumstances, is the fact that Finland does not possess any original molecules used in pharmaceutical manufacturing; all the molecules are imported from other countries. (Interview with head pharmacist, 20.4.2016; STM 2018)

To ensure the availability of medicines in a catastrophic event, the Finnish government introduced The Act on Mandatory Reserve Supplies (979/2008) which aims to *"ensure the availability of medicines in circumstances in which such availability is restricted or prevented as a result of suspension of deliveries, a serious crisis or other equivalent reason."* The act was first introduced in 1984 and has been since revisited multiple times. Basically, pharmaceutical companies, importers, health care units and the National Institute of Health and Welfare are required to stock certain medicines based on the average consumption of said medicines. The requirements vary between parties; health care units are required to stock quantities, which correspond with the average consumption during the first 9 months of the previous year. Pharmaceuticals are

divided into three medicine groups and each group is assigned a mandatory stock requirement based on the average consumption of either 2 weeks, 3 months or 6 months. All the parties, to which the Decree concerns, are required to report to the Finnish Medicines Agency, FIMEA. (fimea.fi)

FIMEA will revisit and confirm the list of items to be stocked as mandatory reserve supplies yearly. The list includes *"products which have a critical medical significance and which have active pharmaceutical ingredients listed in the Decree of Mandatory Reserve Supplies of Medicines (1114/2008). Supplies also include excipients and additives and packaging materials used in the manufacturing of medicinal, if the party subject to maintaining the mandatory reserve supplies, storages active pharmaceutical ingredients instead of medicinal products." (fimea.fi)*

In formulating the research framework, the mandatory reserve supplies must be taken into consideration. For pharmaceuticals with short expiration periods, it is not plausible to eliminate waste entirely due to the mandatory reserve supplies. The mandatory reserve supplies also create pressure for the supplier and ties up storage space in a collaborative VMI arrangement.

3.1.2 Single-channel system

Single channel system is the other unique characteristic of Finnish pharmaceutical market. Single channel system refers to a system where a wholesaler has exclusive rights to distribute medicines of a certain manufacturer. In the EU area, the only other country to have a single channel system is Sweden. Typically, in single channel countries, the number of wholesalers is limited. In Finland, there are three main wholesalers of which two are significantly larger. There are also some smaller suppliers but the amount of medicines ordered is negligible.

The single channel system has its weaknesses and strengths; it effectively prevents counterfeit pharmaceuticals entering the legal supply chain. Alongside with other regulation, it has been shown that in the single channel system, the wholesale prices, and in conjunction the retail prices, are among the lowest in Europe (Kanavos et al. 2011). On the other hand, the single channel system is susceptible to disruptions in the distribution chain. This was extremely evident in autumn 2017 when the other large wholesaler, Oriola with some 40 % market share, rolled out its new ERP system unsuccessfully. The failed implementation caused a five-week disruption in the pharmaceutical deliveries and cost the company estimated 5 million euros (tivi.fi, 2017). While in a multi-channel system, the hospital pharmacies could have adapted to the supply chain disruptions by ordering the same product from a different supplier, in the single channel system, the hospital pharmacy was reliant on deliveries from the single provider.

Hospital pharmacies in Finland are public entities and thus they are tied to the current legislation on public procurement and tenders. The prices are fixed throughout the two- to three-year agreement period. (STM, 2018)

The single channel system affects directly collaborative supply chain arrangements and thus, it is important to take it into account in the research framework. Next, we will be discussing the research framework.

3.2 The framework

Adapting from Danese (2007) and Bhakoo et al (2012), the research framework will be combining the contingent factors with the unique charachteristics of Finnish pharmaceutical industry, which affect the viability of CPFR and VMI arrangements. The purpose of the framework is to guide the empirical research and attempt to establish the pain spots where medical waste might occur in the upstream pharmaceutical logistics process within hospitals.

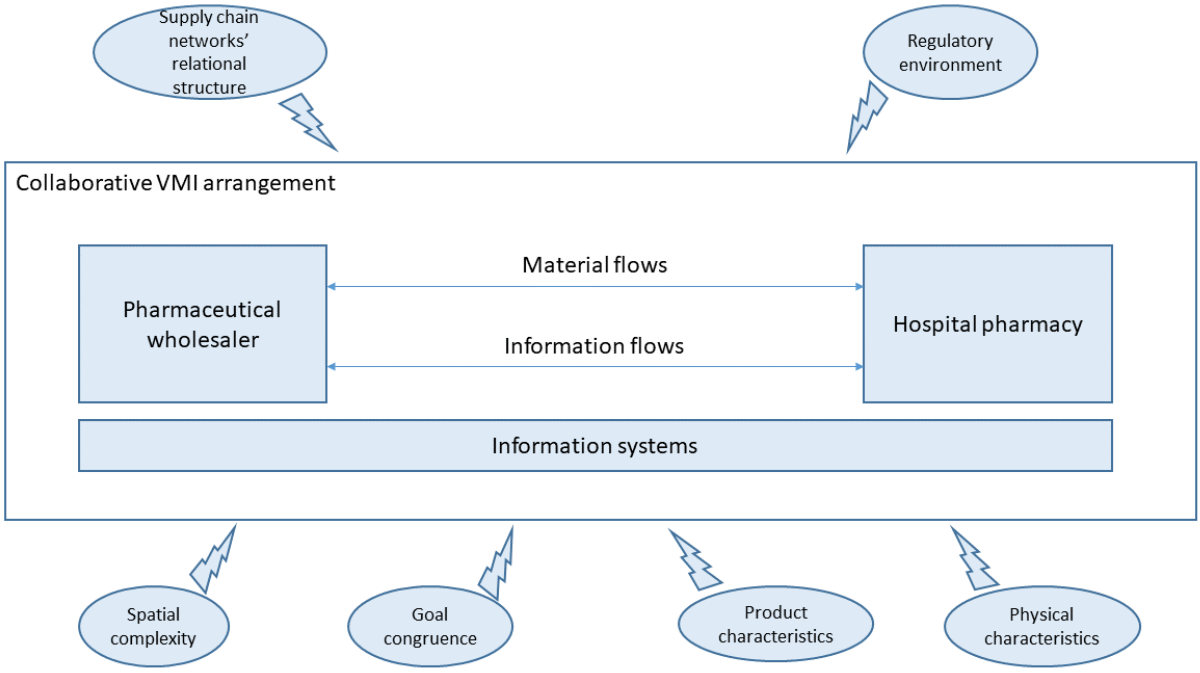

Figure 8 The research framework

The framework suggests that CPFR and VMI arrangements would be a good instrument in reducing waste and costs within the upstream logistics process for pharmaceuticals in Finnish health care setting. It describes how the unique characteristics of Finnish pharmaceutical industry could make it a good fit for CPFR and VMI arrangements. Figure 8 demonstrates the contingent factors affecting the success of CPFR and VMI arrangements.

The research framework consists of six different contingent factors; supply chain networks' relational structure, regulatory environment, spatial complexity, goal congruence, product characteristics and physical characteristics. The information system can be seen as key enabler that ties everything together.

4 EMPIRICAL RESEARCH

First, this chapter will outline the research methodology used for this study, describe the data collection and analysis methods and discuss the reliability of the research. Afterwards the results of the study will be presented.

4.1 Research methods

4.1.1 Case study methodology

In this study, a case study methodology will be employed. Case study is the preferred research strategy when the questions are presented as to "why" and "how", when the events are not in the control of the researcher and when the focal point is on a contemporary occurrence within some real-life context (Yin 2003, 1). The subject of this study is a process to which there is little to no control over the events. Additionally, the subject is a contemporary phenomenon with real-life context. Gerring (2004) extends this and describes a case study as "*an intensive study of a single unit for the purpose of understanding a larger class of (similar) units".* In the context of this study, the University hospital of Turku and its hospital pharmacy represent accurately the setup for all five University hospitals located in Finland. In addition, all the related external factors such as regulations and suppliers apply explicitly to all the units. Therefore, a case study methodology can be seen as a suitable method for the research purposes.

"*A research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study"* (Yin 2003, 19). That is to say, it defines the way of performing a research and outlines the frame of the research. A qualitative study is chosen for this research as it supports the research purposes. The use of case study methodology enables a comprehensive analysis of the subject through interviews with interviewees possessing different knowledge and perspective of the study subject.

Yin (2003, 39) identifies four different types of designs for case studies; single-case (holistic), single-case (embedded), multi-case (holistic) and multi-case (embedded). These four differing types of case studies create a two by two matrix (figure 9). The common denominator for every type of design is the aspiration to analyze the case relative to the contextual factors. As can be interpreted from the matrix, the lines between the case and the context are not solid and reflect the ambiguous nature of the two.

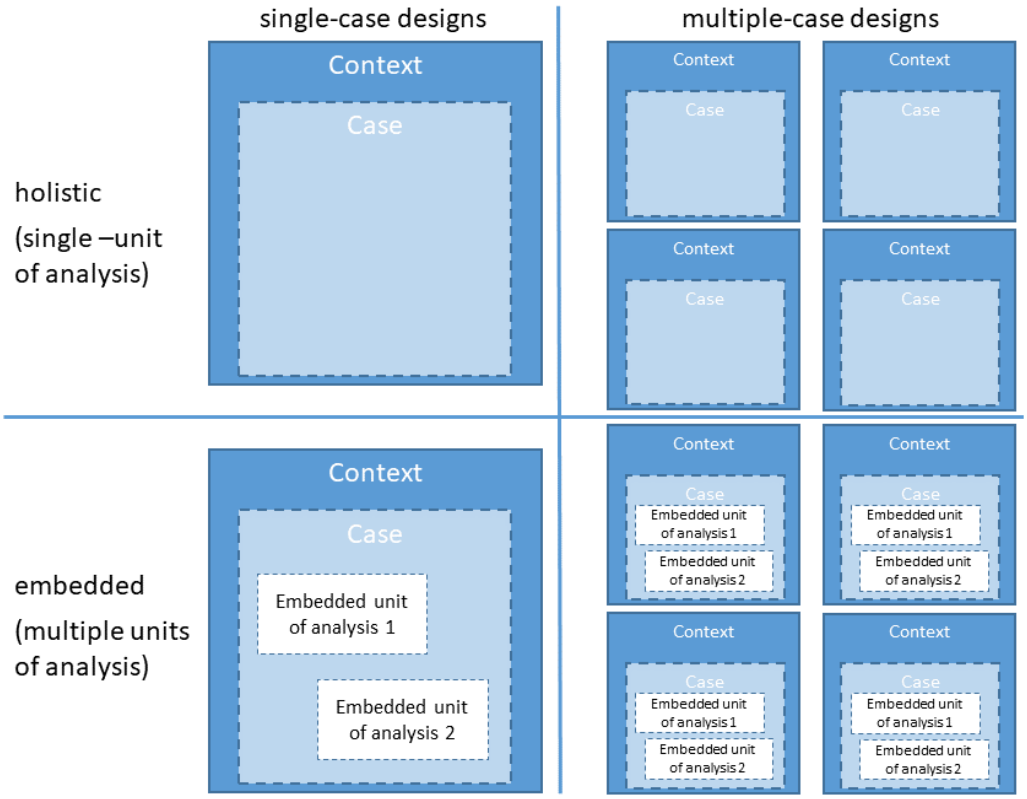

Figure 9 Case study design types (adapted from Yin, 2003)

It can be further recognized from the matrix that single- and multiple-case studies portray two distinct design circumstances and that within these two variations, there may be a single unit (holistic) or many units (embedded) of analysis (Yin 2003, 39).

Before entering the data collection phase of a research, there needs to be a decision made regarding the primary distinction in designing case studies; single-case study or multiple-case study.

4.1.2 Single-case design

For a single-case design to be appropriate study method, Yin (2003, 39-42) presents five rationales. Additionally, to reinforce the point, Yin compares a single case study to a single experiment as many of the same conditions apply equally. The five rationales are:

- Critical case
- Extreme or unique case
- Representative or typical case
- Revelatory case
- Longitudinal case.

Critical case denotes a single case, which is the most relevant case in testing a clearly formulated and specified theory. The theory has distinct set of presuppositions, and in conjunction, a set of conditions within which those presuppositions are assumed to be factual. If a single case meets all the required circumstances, it may be able to challenge, extend or confirm the theory in question. With all the required circumstances met, the single case may be used to conclude whether the presuppositions are indeed appropriate or whether some other factors might be more suitable. (Yin 2003, 40)

Regards to *extreme or unique case,* Yin (2003, 40-41) gives an illustrative example from a common occurrence in clinical psychology. Certain dysfunctions might be so uncommon and exceptional that even a singular case can be worth researching and documenting. In this case, a single-case study design is appropriate.

Inversely, for a *representative or typical case,* a single-case study can be a valid research design. In representative or typical case, the case portrays the conditions and circumstances of a typical or general occurrence. For example, a hospital might be representative of an archetypical hospital among similar hospitals or a marketing agency might represent a typical marketing agency in the industry. The findings from representative or typical cases can be presumed to be illustrative about the experiences of the ordinary organization or individual. (Yin 2003, 41).

With *revelatory case* Yin (2003, 42) refers to a single case, where there is a possibility to research and investigate formerly inaccessible phenomenon. Yin cites Liebow's (1967) renowned case study of unemployed men in USA as a prime example. Liebow had the opportunity to observe unemployed men in their day-to-day life and discover commonplace problems around the whole country.

Conversely, a study of the same case at different points of time (two or more) may warrant a single-case research design. In this *longitudinal case*, it is possible to reveal how circumstances and conditions might have changed in the course of time and if there has been any progress or regress in relation to certain conditions. (Yin 2003, 42)

However, a single-case study does not come without its caveats. Yin (2003, 42) states that before employing the single-case study method, it must be vigorously investigated in order to minimize the possibility that the case is misrepresentative and maximize the access to evidences.

4.1.3 Multiple-case design

Yin (2003, 46) states that across some fields of study, multiple-case design is seen as a separate methodology from single-case design altogether. Yin, however, considers them to be within the same methodological framework and thus variants of each other. As is evident from figure 9 and the definition, multiple-case design uses many cases within a

study. Multiple-case design can be seen as more rigorous and broad study due to the evidence consist of multiple cases. In multiple-case design, every case should be carefully chosen as they should all serve a distinct purpose relative to the study and context. Again, Yin draws parallels with multiple experiments and multiple cases.

As a rationale for multiple-case study design, Yin (2003, 52) concisely describes it *"...derives directly from your understanding of literal and theoretical replications. The simplest multiple-case design would be a selection of two or more cases that are believed to be literal replications, such as a set of cases with exemplary outcomes in relation to some evaluation theory."* As described by Yin, the main rationale for using multiple-case study is *replication.* The replication logic either requires the cases to be chosen in a way that it predicts opposing results but for foreseeable reason (*a theoretical replication)* or predicts the same outcome (*a literal replication)*. Additionally, Yin emphasizes the importance of not confusing replication with sampling logic.

As it is with a single-case design, multiple-case design is not without its downsides alike. Inherently, multiple-case design is more time and resource consuming than a single-case design (Yin 2003, 47). In addition, it is easy for the researcher to lose sight of the uniformity of the study.

4.1.4 Holistic vs embedded

In regard to single-case design, the same case study can consist of more than one unit of analysis. This approach is called *embedded* case study in which within one case, also a subunit or subunits are taken into consideration. Yin (2003, 42) demonstrates an embedded single-case with an example of a hospital, a single organization, where the research incorporates results from multiple sources with various points of views within the organization. On the other hand, a *holistic* case study would analyze solely the general or global characteristics of a project or an organization. The holistic design is better suited for cases without logical subunits and for situations where the fundamental theory central for the case is of holistic nature. The embedded design is oftentimes seen to be adding meaningful insights and extending the analysis to a more robust study.

The multitude of cases in multiple-case design does not remove the holistic and embedded variations. That is to say, a multiple-case study can be comprised of many embedded cases or many holistic cases.

4.1.5 Embedded single-case study

An embedded single-case study method will be chosen for the purpose of this study. As stated earlier, it is believed that Turku University hospital and its hospital pharmacy represent accurately the setup for all five University hospitals located in Finland. Hence, a case study is chosen. Furthermore, according to Yin (2003, 39-42), a single-case design is appropriate when the case is representative or typical. Thus, a single-case design will be used. Yin extends that an embedded single-case design may add significantly to a single-case study and therefore an embedded design will be utilized.

4.2 Data collection and analysis

Yin (2003, 83) identifies six different sources of evidence for case studies: direct observation, participant-observation, physical artifacts, documents, interviews and archival documents. Moreover, Yin (2003, 89) states that interviews are one of the most significant sources of information in case studies.

4.2.1 Interviews

Interviews were selected to be the main method of data collection for this research. Additionally, documents acquired from the interviewees were utilized to bolster the interviews. Data was collected through half-structured theme interviews with open-ended nature. The interviewees were pharmacists with differing job descriptions working in the hospital pharmacy in the University hospital of Turku. Pharmacists with different positions were chosen in order for the research to be more thorough. The job descriptions for pharmacists interviewed included the head pharmacist, a pharmacist responsible for the information systems, a pharmacist responsible for logistics operation, and two pharmacists responsible for procurement. The two procurement pharmacists also had somewhat differing roles. One procurement pharmacist was mainly responsible for the preparation of the tendering process for suppliers and the other was more responsible for the operational day-to-day procurement process.

The interviews started with a brief discussion of the responsibilities of each interviewee and their background. Afterwards, a discussion was sparked with the goal of identifying areas in which medical waste was created within the upstream supply chain and procurement process. To guide the conversation towards this goal, a frame of six themes were discussed. The discussed themes were *procurement process, pharmaceutical waste, expiration of pharmaceuticals, collaboration with suppliers, information sys-*

tems used in the procurement process and development initiatives. Each of these themes had a set of aiding questions, which are presented in appendix 1. The interviews took place in April and June of 2016. Summary of interviews is presented in table 4.

Table 4 Summary of interviews

Date	Position	Location
20.4.2016	Head pharmacist	Turku
20.4.2016	Logistics pharmacist	Turku
20.4.2016	IT system pharmacist	Turku
2.6.2016	Procurement pharmacist	Turku
10.6.2016	Procurement pharmacist	Turku

The interviews were not recorded due to the lack of consent from interviewees and therefore notes were taken instead.

4.2.2 Analysis of empirical data

Yin (2003, 109) defines data analysis to be composed of categorizing, tabulating, combining, testing and examining data. Yin extends that analysis of case study evidence is particularly challenging due to fact that analysis strategies and techniques relative to case studies have not been well outlined. The aim of analyzing the evidences is to address the initial propositions of the study.

In his study, Yin (2003, 111-115) proposes three main strategies for case study evidence analysis. The main strategies are relying on theoretical propositions, developing case descriptions and setting up a framework based on rival expectations. Alongside the three main strategies, Yin (2003, 109) offers five analysis techniques to be used; time-series analysis, logic models, cross-case synthesis, explanation building and pattern matching.

This study will be employing the most commonly used analysis framework, the strategy of *relying on theoretical propositions.* It indicates that the design and goals of the study are based on present propositions, which consequently correlate with the set of research questions, existing perception of the literature, and ultimately new propositions (Yin 2003, 112). The research framework created for this study (figure 8) will incorporate the previously discussed literature and the unique characteristics of the case study setting in attempt to discover answers to the research questions.

For the purpose of this study, *logic model* -analysis method is chosen. A logic model seeks to describe intricate action sequences over time in a chronological, recurring, cause-effect-cause-effect pattern (Yin 2003, 127). In logic modelling, both empirically

noted events and theoretically anticipated events are combined and used (Yin 2003, 127). Logic models can be seen as good ways of recognizing patterns within a process. The notes based on the interviews will be analyzed by creating a logic model of the up-stream logistics process in attempt to identify the underlying reasons in the process which lead to medical waste.

4.3 Reliability and validity

For research design to be reliable and of high quality, it needs to provide answers to certain logical tests, which are built upon the concepts of credibility, confirmability, data dependability and trustworthiness. Yin (2003, 33-39) presents four different logical tests for quality assurance purposes: *construct validity, internal-* and *external validity* and *reliablity.*

Construct validity represents the correct operational measures for the concepts of the study. Yin (2003, 35) recognizes this to be particularly problematic logical test in relation to case study research. Case studies are susceptible to the subjective judgement of the researcher in the data collection. This may be alleviated by using multiple sources of data, establishing the chain of evidence. Albeit this study is mainly constructed based on the interviews, also documents will be reviewed. Furthermore, multiple interviews are conducted in order to further enhance the construct validity of this study. Additionally, the chain of evidence will be established by producing the interview framework as well as the key findings and the analysis leading up to them.

According to Yin (2003, 37) external validity refers to the ability of the case study to be generalized past that specific case. Single cases are often deemed to be insufficient for generalization purposes. However, frequently the critics mistakenly draw parallels with survey research, which depends on statistical generalization instead of theoretical generalization used in case studies. As stated previously, the conditions and circumstances apply similarly to all the University hospitals in Finland. Internal validity is not relevant in the context of this study as it is only applicable for causal studies.

Reliability is presumably the most commonly acknowledged logical test. It aims to minimize the biases and flaws of a study. Essentially, a researcher should be able to replicate the exact same case study and come to the same conclusion in respect to the findings. The research framework and the interview frame have been documented and clearly described formerly to improve the reliability of this study.

4.4 Results

In this section, the results of the research will be presented. First, the subject of the case study, Turku University hospital and its hospital pharmacy, will be briefly introduced. After this, the current procurement process will be described as well as the tools and information systems used in the process. This will be followed by an evaluation of the current process using the formulated framework detailed in figure 8. Finally, a proposal for a future procurement process will be presented and discussed.

4.4.1 Turku University hospital and its hospital pharmacy

Turku University hospital (TYKS) is one of five Finnish university hospitals, which offer specialized medical treatment. The other ones being located in Helsinki, Tampere, Oulu and Kuopio. According to reports from the Finnish National Institute of Health and Welfare, Turku University hospital is the second largest hospital in Finland measured by utilization, only after Helsinki university hospital (thl.fi, retrieved 2019). It is part of hospital district of Southwest Finland and provides health care services for some 470 000 people in 28 municipalities (VSSHP.fi, retrieved 2019).

At the end of 2017, Turku University hospital and its public utilities employed 1 020 members of staff and during the fiscal year 2017 its operating expenses were 163,1 million euros (3 % increase compared to year 2016). Out of the total operating expenses 68,8 million euros or 42 % resulted from material purchases with an increase of 6,3 % to year 2016. Material expenditure in Turku University hospital echoes the notion made by Poulin (2003) that hospitals may spend on average 30 to 40 % in logistical activities of their overall operating costs. The largest share of the operating expenses by far comes from the medical service area's pharmaceutical material purchases. In 2017, the pharmaceutical material purchases accounted for 78 % of the total material purchases or 53,9 million euros. Pharmaceutical material purchases have been in a steady ascent in the 2010s as can be seen from Figure 10.

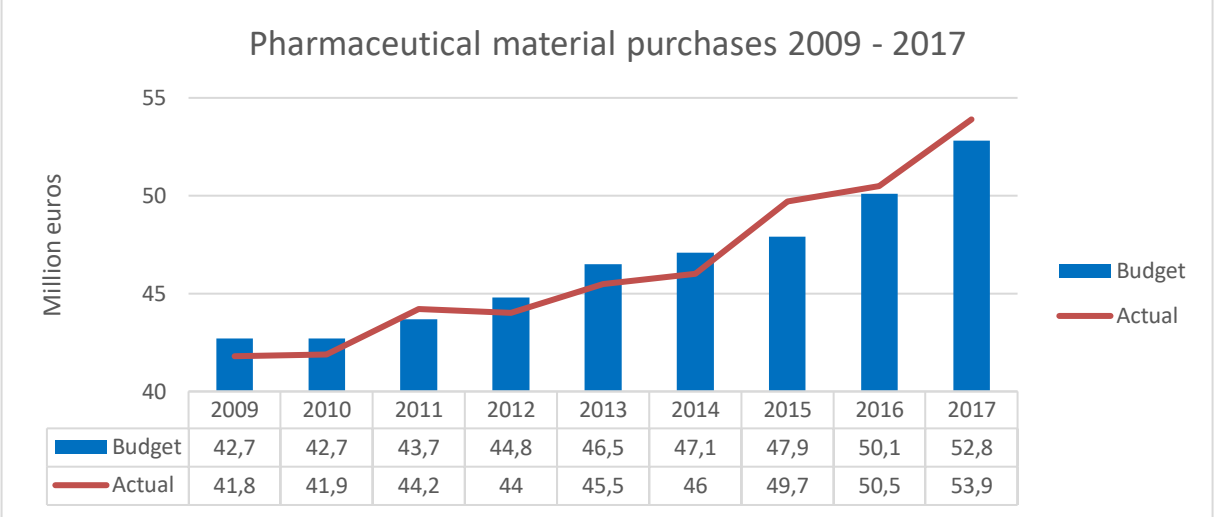

Figure 10 Pharmaceutical material purchases 2009 – 2017 in Turku University hospital (VSSHP annual report 2017)

The rising trend depicted in figure 10 clearly illustrates the need to examine and evaluate the current procurement processes and whether there are possibilities to improve the process.

Hospital pharmacy in Turku University hospital is responsible for supplying pharmaceuticals for all the departments within the entire hospital. Head pharmacist who oversees the organization and its operations leads the hospital pharmacy. Under the head pharmacist, there are licensed pharmacists each responsible for their own operational area. In total, the organization consist of 88 staff members of which roughly half are trained pharmacists.

The hospital pharmacy operates in a two-echelon system where the hospital pharmacy alone is responsible for procurement of medicines for the whole hospital (LaPierre and Ruiz, 2007). A purchasing unit procures other materials. The pharmaceuticals are delivered to requesting departments using periodic replenishment model, which Lapierre and Ruiz (2007) suggest to be more suitable for health care organizations than models basing the replenishment on reorder point. It was commonly acknowledged within the hospital that the majority of the medical waste was created in the requesting departments. However, due to the lack of supporting information systems the medical waste was not reported and monitored accurately.

The hospital pharmacy has two inventories. The larger, main inventory is managed by a state of the art inventory robot, which is capable of performing a full inventory check within three hours. The automatized inventory frees human resources for more demanding, pharmaceutical procedures, which can be seen as the most important advantage. Other benefits for the automated inventory management are reduction of human errors (while working correctly, practically error-free), itemization of products and traceability, uptime outside of regular working hours and efficient utilization of warehouse space. It also has its limitations; the network of multiple information systems and

interfaces are more susceptible for malfunctions, there are surprisingly large number of packages that are unsuitable for the robot, electronic prescriptions contain many errors and the robot is not as flexible towards the customers as humans could be. The robot manages up to 90 large boxes filled with pharmaceutical packages a day of which still roughly 10 are unloaded and checked manually for quality assurance purposes. Currently the automated inventory sustains some 70 000 packages (Interview with logistics pharmacist, 20.4.2016; documentation)

The other warehouse is an open-shelfed over-the-night storage for abrupt medicine demands from the departments outside of working hours of the hospital pharmacy and during weekends. The over-the-night storage is not directly connected to any information system and is still managed via an old-fashioned order book. Medical staff will submit their orders in the order book and independently collect the needed pharmaceuticals from the open shelves. According to the logistics pharmacist (20.4.2016), a large portion of medical waste created within the hospital pharmacy is generated in the over-the-night storage. Oftentimes, the medical staff are in a haste and order unnecessary items. Unused items should be returned to the storage and recorded in the order book but in reality, this does not happen frequently. (Interview with logistics pharmacist, 20.4.2016; documentation)

4.4.2 Current procurement process

The current procurement process can be divided into two different sub-processes: bi-annual tendering of pharmaceuticals and actual purchasing of pharmaceuticals. The tendering process is basically an on-going process. When the tendering has been concluded for two-year period, the preparations for the next cycle begins. One of the most time-consuming part of the tendering is maintaining the basic pharmaceutical offering. Decree 6/2012 by Finnish Medicine Agency (Fimea) stipulates that the basic pharmaceutical offering must guarantee safe, appropriate and economical medication. The basic pharmaceutical offering seeks to harmonize and direct the use and procurement of pharmaceuticals. The offering is guided by current national treatment practices and relies fundamentally in scientific evidence. (Interview with head pharmacist, 20.4.2016; STM, 2018)

The tendering process involves personnel from nearly all departments of the hospital pharmacy. It is extremely important to conduct the tendering with utmost care. For example, the tendering period of 2016-2017 comprised of approximately 143 million euros worth of medicines and the tendering process was carried out in co-operation with four other hospital districts. The tender itself can contain up to 15 000 individual pharmaceutical bids. Forecasting of the consumption is also key in the tendering process and

requires input and insight from professional pharmacists. The tendering process also contributes to medical waste. When the basic pharmaceutical offering changes due to the new contract period, some of the old medicines might be left unused. (Interview with head pharmacist, 20.4.2016; STM, 2018)

In special circumstances, the hospital pharmacy may import special medicines independently when those medicines are not available from the regular suppliers. In the need of independent importing, the logistics pharmacist will contact European wholesalers/suppliers via email and order directly from them. However, the hospital pharmacy actively attempts to avoid independent importing. Furthermore, the hospital pharmacy will never initiate independent importing on cost basis. (Interviews)

Three rotating procurement pharmacists manage the day-to-day purchasing process in two-week cycles. One reason mentioned for having three changing procurement pharmacists in charge of purchasing instead of just one dedicated, was the reluctance to take responsibility alone of the medical waste. Additionally, the rotation makes the work more diverse and pleasant. (Interview with IT pharmacist, 20.4.2016; interview with procurement pharmacist, 2.6.2016)

Generally, the daily purchasing process begins with an alert and a purchasing suggestion from the enterprise resource planning (ERP) system, webMarela. The system prepares individual purchasing suggestions per supplier based on an alert point manually entered into the system and one procurement pharmacist reviews the list of medicines to be ordered. The purchasing suggestions may contain hundreds of lines. The interviews revealed that there were misconceptions within the organization about the amount of work resources tied up in the purchasing process. The logistics pharmacist was under the impression that only 10 % of suggested orders were reviewed manually when in reality, all the automatically suggested orders had to be reviewed one line at a time by the procurement pharmacists. Large portion of creating the order is based on the professional judgement of the pharmacist. Furthermore, orders with expiration date within six months of the delivery require additional approval. (Interview with IT pharmacist, 20.4.2016; Interview with logistics pharmacist, 20.4.2016; interview with procurement pharmacist, 10.6.2016)

After the review and possible changes made, the orders are confirmed. For the two largest suppliers, the orders can be directly made in webMarela via integrated interface. For the third, smaller, main supplier, the order needs to be made first in supplier's web portal and then again in webMarela, essentially doubling the workload. For the smaller suppliers, the orders are placed via email. Afterwards, an order confirmation is received from the suppliers and the orders are usually fulfilled with one to two days of lead-time. Figure 11 portrays the current procurement process on a high level and systems and interfaces between parties. (Interview with IT pharmacist, 20.4.2016; interview with procurement pharmacist, 10.6.2016)

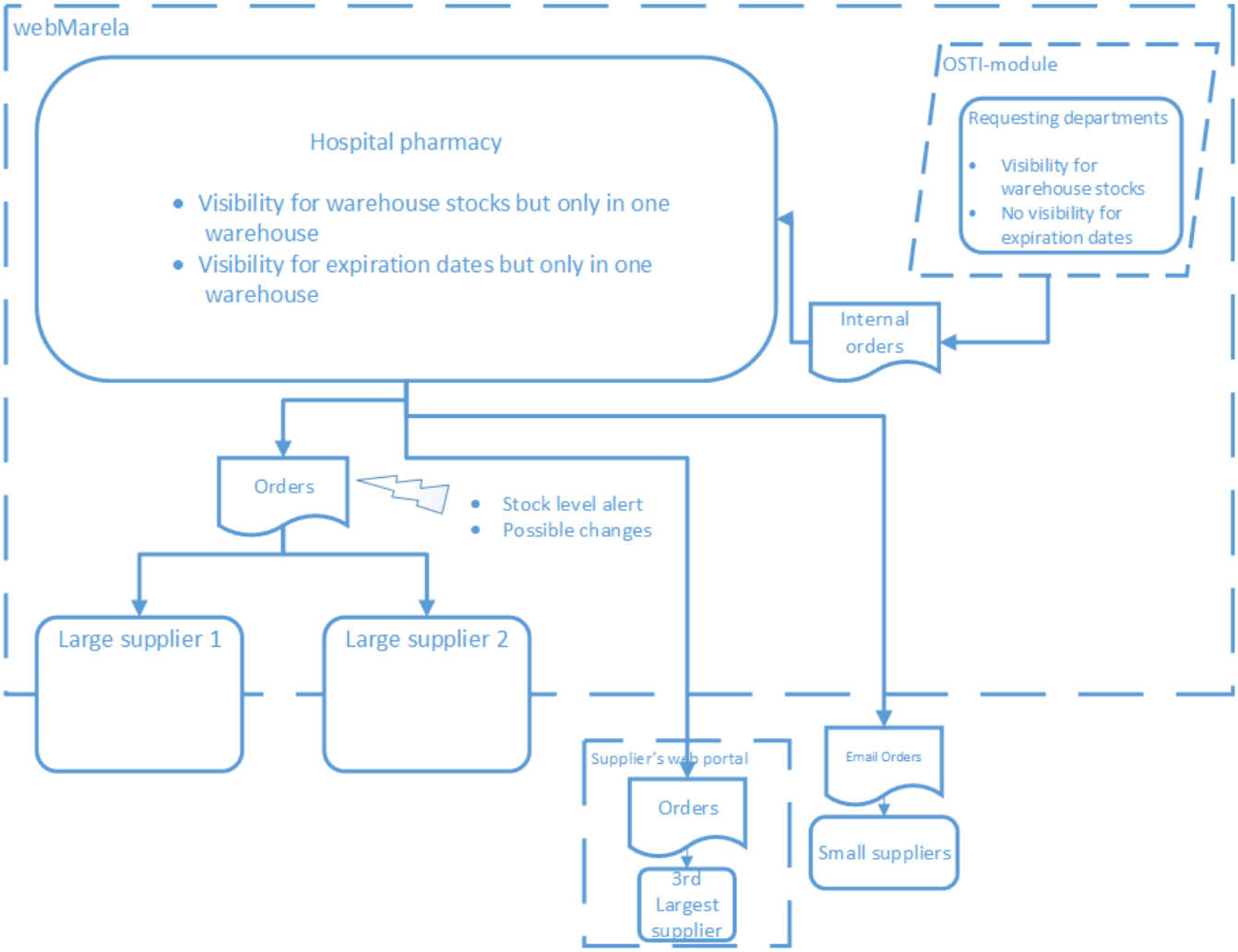

Figure 11 Purchasing process and information system interfaces

4.4.3 Information systems in hospital pharmacy

The main information system used in the hospital pharmacy is its ERP, webMarela. It is used for inventory management, ordering, receiving and provisioning. As it was first implemented some ten years ago, it can be seen as a relatively old system. However, it is developed and updated continuously to improve the reliability and functionality of the system. In the hospital pharmacy, there is an IT pharmacist responsible for the maintenance and development of the system. IT pharmacist also works as an intermediary between the hospital pharmacy and the system service provider and offers immediate support for other pharmacists using the system. (Interview with IT pharmacist 20.4.2016)

WebMarela is also used in the requesting departments. However, it is used through separate OSTI-module. As shown in figure 11, the requesting departments are able to see the stock balance of each pharmaceutical item from OSTI. The problems concerning medical waste arise from the fact that the requesting departments are not able to see the

expiration details of each medicine. This creates information asymmetry and the requesting departments may order large quantities of medicines with short expiry dates. The hospital pharmacy has tried to remedy this problem with the employment of trained pharmacists at the requesting departments. These department pharmacists have access to the regular interface of webMarela and thus are able to see the expiration dates of medicines. The results in reducing medical waste and unnecessary orders have been promising albeit expensive. All orders placed by the requesting departments are visible in the stock balances in real-time. (Interview with IT pharmacist, 20.4.2016; interview with procurement pharmacist, 10.6.2016)

WebMarela has integrated interfaces with the two largest suppliers, which constitute over 95 % of the placed orders. The orders can be directly placed within the system and the order confirmation is received automatically in webMarela. In webMarela, the procurement pharmacists are able to see the stock balances and the expiry dates of the medicines. However, if an individual item is stored in two separate warehouse locations, the system only shows the expiry of just the other. This again creates information asymmetry and the hospital pharmacists may order products with the assumption of long expiry dates. In these circumstances, the supplier has incentive to ship the goods with shorter expiry dates, which again leads to unnecessary returns. An important development initiative that arose from the interviews was the ability to see the expiry dates of all the supplier's warehouse locations. In conjunction with that, also an upgrade in OSTI to be able to see the expiry dates in hospital pharmacy was high on the list of development ideas. (Interview with IT pharmacist, 20.4.2016; interview with procurement pharmacist, 10.6.2016)

As can be seen from figure 11, the third largest supplier does not have an integrated interface with webMarela and the orders need to be double-booked first in webMarela and then in the supplier's web portal. According to the interviews, there would be need for integration since this would reduce the workload and make the process less time consuming. The amount of orders placed to the smaller suppliers is negligible and there was a consensus among the interviewees that there is no need for integration for smaller suppliers. (Interview with procurement pharmacist, 10.6.2016)

The interviewees were of an opinion that the functionality and usability of webMarela were on a good level. Nonetheless, the aforementioned development initiatives in system integrations were emphasized. The development of the system is performed in collaboration with the system service provider and the initiatives are communicated by the IT pharmacist. In the IT pharmacist's view, the hospital pharmacy lacked the resources and required knowledge in order for the development to be swifter. Furthermore, in the event of a version upgrade, the IT pharmacist felt that the hospital pharmacy had inadequate resources for the testing. The interviews also revealed that occasionally the system can be slow and unstable due to the constraints in IT infrastructure.

However, this was not seen as a huge hindrance regarding the procurement process. If webMarela was down, the procurement pharmacists have always the option to make the needed orders directly in the supplier's web portal. This was considered a good fail-safe. (Interview with IT pharmacist, 20.4.2016; interview with procurement pharmacist, 10.6.2016)

A sub-optimal use of webMarela's functionalities was exposed during the interviews. This was acknowledged by the IT pharmacist but it was also recognized that more optimal use would require better know-how and resources. The sub-optimal use of webMarela was the most evident in the system parametrization of the medical items, especially regarding the alerts, which initiate order suggestions. Currently, in most cases, the suggested orders need to be altered by the procurement pharmacist. This could be remedied by better parametrization. It needs to be noted that going through all the parameters for all the items is a massive effort but even the re-parametrization on the item group level could improve the situation by a large margin. (Interview with IT pharmacist, 20.4.2016; interview with procurement pharmacist, 10.6.2016)

4.4.4 Medical waste in the hospital pharmacy

It was generally accepted, even by the requesting departments themselves, that most of the medical waste was created in the requesting departments (Interview with head pharmacist, 20.4.2016; Peltoniemi, 2019). This can also be seen from the figure 12. However, the upstream logistics process also creates substantial medical waste. The main reason for this, the mandatory reserve supplies, was echoed by reports and interviews alike (Interview with procurement pharmacist, 2.6.2016; STM report, 2018).

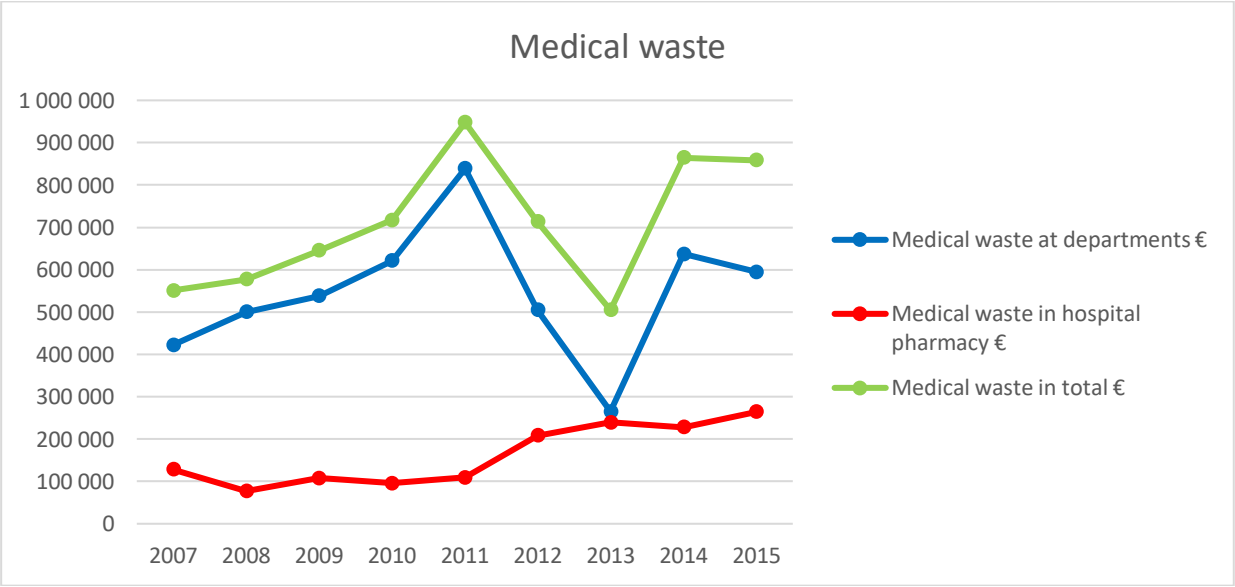

Figure 12 Medical waste in TYKS (Peltoniemi, 2019)

The red line lowest in figure 12 is indicative of the rising trend in medical waste that needs attention. Other noted contributing factors were the over-the-night warehouse, ordering habits of the requesting departments and constraints in the information system integrations to suppliers. As mentioned earlier, the over-the-night warehouse and its old-fashioned and informal order booking method enables medical waste creation. The ordering process for the requesting departments is expensive and time consuming and thus they order large quantities in longer intervals. This in turn makes the forecasting of the total consumption harder and more complex. Although the information systems have relatively high level of integration, there is still room for improvement. WebMarela does not show the expiry information for all the suppliers' warehouses and occasionally the ordered pharmaceuticals might have shorter expiry dates than initially supposed. This creates a hard decision concerning returning the products; the medicines might be needed immediately but a large portion of it might go to waste due to the short expiration. (Interviews with procurement pharmacists, 2.6.2016 and 10.6.2016)

Due to the constraints of the mandatory reserve supplies, it is practically impossible to reduce the medical waste entirely but an attempt has to be made. Next, we will be looking into the possibility to battle medical waste within the upstream logistics process using a framework formulated in this research. The purpose of the framework is to evaluate the suitability of collaborative VMI arrangements in the context of Finnish hospital pharmacy. The framework consists of six contingent factors: supply chain networks' relational structure, regulatory environment, spatial complexity, goal congruence, product characteristics and physical characteristics. We will be discussing each of these in more detail.

4.4.5 Supply chain network's relational structure

In the case of hospital pharmacy and its pharmaceutical wholesalers, the supply chain network's relational structure can be construed as simple. There are only three large suppliers of which two constitute over 95 % of the volume. This would enable the hospital pharmacy to engage in collaborative VMI arrangements easier as the collaborations have only few participants. Furthermore, the single-channel system increasingly simplifies the collaborations, as there would be no need for the competing wholesalers to collaborate. Only one specific pharmaceutical can be ordered from one wholesaler and thus the only collaboration required would be between the hospital pharmacy and the wholesaler in question.

As stated by Danese (2007), the level of existing supply chain integrations has an effect on the collaborations. In this case, the integration can be seen to be on a relatively high level. There is already existing information system integration between the two

largest suppliers and the hospital pharmacy. This exhibits the capability of parties in entering into more collaborative arrangements and further developing the information system integrations. Currently, the information system integrations are only one-way, as the suppliers do not have access to the information generated in webMarela. A prerequisite for collaborative VMI arrangements would be a two-way information system integration. The suppliers would need the access to the information regarding the stock balances in the hospital pharmacy's inventory and regarding the actual consumption of the medicines. Consequently, the suppliers would be able to adjust their deliveries based on the actual stock levels and well-formulated demand forecasts.

At present, the other form of integration and collaboration between the suppliers and the hospital pharmacy is rather limited. The parties convene only once a year to discuss development and assess the as-is situation. Otherwise, the communication extends only to email exchange and occasional feedback questionnaires from the suppliers. Willingness to increase the level of collaboration emerged from the interviews. (Interviews)

4.4.6 Regulatory environment

The regulatory environment creates multiple challenges for collaborative VMI arrangements. Bhakoo et al (2012) concluded that in highly regulatory settings, it is better for the partners in supply chain to manage inventories using internal control methods. As has been presented earlier, the pharmaceutical industry in Finland is highly regulated. Additionally, there are multiple legislative requirements for the hospital pharmacies, which further complicates the state of affairs. For example, the Decree on medicines (1987/693) outlines the responsibilities and requirements for hospital pharmacies and the medicine law (1987/395) gives the broader guidelines regarding medical supply and manufacturing (fimea.fi). Furthermore, the mandatory reserve supplies creates a seemingly insurmountable obstacle regarding medical waste. However, the fact that the mandatory reserve supplies also extends to the wholesalers, reduce the negative effect on collaborative VMI arrangements.

Again, the single-channel system can be seen as creating a beneficial regulatory environment for the collaborative VMI arrangement to succeed. It allows for more simple and straightforward collaborations. The rigid system with high entry barrier also ensures that the collaborations can be projected long to the future. However, it also requires to be acknowledged that the single-channel system is not without its flaws. This was evident from the failed ERP implementation at one of the larger suppliers which caused extensive problems in medical supply across the country.

4.4.7 Spatial complexity

Spatial complexity has an effect on the possibility to enter into collaborative VMI arrangements. If the spatial complexity is low, collaborative VMI arrangements are more viable option. Turku University hospital pharmacy is located in southwest Finland some 150 kilometers from Finnish capital, Helsinki. According to the report prepared for the Finnish social- and health ministry, the branches of pharmaceutical wholesalers are mainly located in the southern Finland (STM, 2018). Hence, the spatial complexity between the parties involved in the collaboration would be low. Bhakoo et al. (2012) determined that a supply chain partner with low spatial complexity is able to utilize collaborative arrangements as an inventory management method.

Although the spatial complexity in this specific instance is low, it should be noted that, in general, Finland is a country of long distances. This concern was also brought up in the report prepared for Finnish social- and health ministry (STM, 2018).

The low spatial complexity allows for more frequent deliveries and thus requires smaller inventory space in the hospital pharmacy. The shorter transport distances also increase the reliability of the cold chain for pharmaceuticals requiring it and thus reduce the medical waste generated in the instance of broken cold chain.

4.4.8 Goal congruence

Danese (2007) concluded that the goals of collaboration determine the level of collaboration. If the goal is efficiency, the level of collaboration is often limited to data exchange. If the objective is to improve responsiveness, the likelihood of deeper collaboration is higher. Bhakoo et al. (2012) elaborate that the degree of commitment and trust between supply chain partners is indicative of the chances of the parties entering into collaborative arrangements.

Although efficiency can always be seen as an important goal in supply chain management, the mandatory reserve supplies will always limit the efficiency aspect of medical supply in hospital pharmacies. Thus, it would be beneficial for both the suppliers and hospital pharmacy to allocate their resources into improving responsiveness. Collaborative VMI arrangements would be a great tool to achieve this.

Ombaka (2009) noted that it is paramount within hospital supply chains to deliver medicines in the right places, at the right time and in correct quantities. A collaborative VMI arrangement where the wholesaler would handle the supply of pharmaceuticals in conjunction with collaborative forecasts could be a potential remedy for generation of unnecessary medical waste. For example, the wholesaler would have better knowledge of lead-times between its warehouses and thus, would be able to better design the re-

plenishment patterns. This would eliminate the problem of not receiving medicines with the wished expiration dates. Lin and Ho (2014) summarized the benefits of collaborative arrangements shown in table 3. Reflecting the interviews with the benefits, reduction in shortages, creation of urgent orders and the time relieved from the purchasing activities were seen as key benefits.

For the suppliers to enter in such collaborative arrangements there should also be incentives and benefits for them. Currently, the agreements allow the hospital pharmacy to return deliveries for products with bad expiry dates (Interviews). This ties up resources and creates logistics costs for the supplier. The wholesalers would have innate incentive to reduce logistics costs and deliver products with preferable expiry dates.

Other tangible benefits for the wholesalers would be the potential reduction in deliveries. As the wholesaler would have the whole picture of the total demand and the inventory balances, they would be potentially able to better answer the demand with fewer deliveries.

Bhakoo et al. (2012) noted in their research that hospitals were reluctant to relinquish the control over pharmaceutical procurement. They stressed the paramount importance of trust between supply chain partners. Trust, in business relationships in particular, is built during the course of a longer period. The long history of association with the suppliers in Finland permits for good trust and the interviews strengthen this evaluation.

4.4.9 Product characteristics

Both Danese (2007) and Bhakoo et al. (2012) state that product characteristics have an impact on collaborative VMI arrangements. Danese (2007) notes that items with high demand and supply elasticity are more likely to be included in collaborative VMI arrangements. Bhakoo et al. (2012) extend the interpretation in hospital environments to functional and innovative products. The interviews revealed that many of the products in the basic pharmaceutical offering have fairly constant demand and thus the consumption is more easily forecasted.

The collaboration in forecasting is also important for products with high seasonality. For instance, flu vaccinations are required mostly during the flu season but the timing of the flu season can vary. The wholesalers might not have the best information available and thus they would need to collaborate with medical professionals to formulate an accurate forecast.

The interviews revealed that some pharmaceutical groups are more vulnerable for medical waste than others are. Medicines, which can be placed in the ‘innovative’ -category (Bhakoo et al., 2012) were more prone to generate medical waste than the medicines in the ‘functional’ –category. Furthermore, the innovative medicines also

have an inclination to be more expensive than the functional medicines. The collaborative VMI arrangements could be implemented on a pharmaceutical group basis. If the hospital pharmacy is not comfortable to relieve all control over the whole pharmaceutical offering, a possible solution could be to choose specific groups under the supplier's control. It would also be reasonable to pilot the VMI arrangement with one pharmaceutical group before embarking in a full collaborative VMI arrangement.

Products requiring cool storage and uninterrupted logistical cold chain create problems in the current upstream logistical process. One procurement pharmacist noted that at present, they were not able to order cold products on Mondays, which in turn creates a huge spike in logistics on Tuesdays. This spike in logistics could be resolved by using collaborative VMI arrangements. The supplier would be able to see the stock balances in real-time and supply cold products on Mondays accordingly. (Interviews)

4.4.10 Physical characteristics

Physical attributes such as availability of warehouse area, stage of IT adaptation and the size of the health care organization are all drivers that factor in the possibility to enter into collaborative VMI programs (Bhakoo et al., 2012). Larger hospitals are able to take advantage of economies of scale. Furthermore, larger hospitals generally have bigger storage facilities, which enables the supply chain partners for more flexible inventory management. The IT adaptation is also a prominent factor in collaborative VMI arrangements as formerly described.

Turku University hospital can be interpreted to tick all the boxes in physical characteristics that support collaborative VMI arrangements. The hospital pharmacy has implemented an inventory robot, which can independently receive and store pharmaceutical products. The possibility of round-the-clock receiving allows the suppliers to do more flexible deliveries. Additionally, it is integrated with the hospital pharmacy's ERP and automatically shows the stock balances of items in real-time and it is able to receive products at any given time. Furthermore, the IT adaptation can be determined to be on good level considering the interfaces with suppliers and the inventory robot. In the mid-2010s, the hospital pharmacy relocated to brand new facilities with ample storage space. The inventory robot also permits for better inventory space utilization than a regular shelf-storage.

5 DISCUSSION AND CONCLUSIONS

It has been established that medical waste in pharmaceuticals is a problem on a nation-wide scale in Finland and moreover, globally. The increasing trend in pharmaceutical purchases indicate that the problem will only grow unless a cure to minimize the waste can be found. This section will lay out the summary of findings and discuss the research.

5.1 Summary of findings

This research set out to explore pain points that generate medical waste in the upstream logistics process and possible solutions for them. The goal of this thesis was to answer three questions; what are the best practices in medical supply chain management, what is the current state of pharmaceutical procurement processes and information systems in Turku University hospital and what are the future prospects of integration in hospital procurement processes and information systems? The interview results were analyzed in regard to the research framework formulated based on the literature reviewed.

The study revealed that a collaborative VMI arrangement with pharmaceutical suppliers could be a possible solution in battling the medical waste in upstream logistics process in hospital pharmacies. The unique characteristics of Finnish pharmaceutical industry both enable and complicate the implementation of VMI programs. On the other hand, the mandatory reserve supplies creates inevitable medical waste while at the same time, the single-channel system can be seen as an excellent fit towards VMI programs. The single-channel system creates a simplified supply chain -network structure where specific pharmaceutical products may be procured only from a certain wholesaler. The fact that there are only three larger pharmaceutical wholesalers in Finland creates an even more advantageous supply chain -network structure. The already existing integration of IT systems with the two largest pharmaceutical wholesalers further bolsters the case for collaborative VMI arrangements.

It was also evident from the research that the spatial complexity in the case of Turku University hospital is low, which in turn permits VMI programs. Moreover, both the suppliers and hospital pharmacy would benefit from a collaborative VMI program as their goals would be aligned and thus the possibility of success in collaboration would increase. The physical characteristics of Turku University hospital are also suitable for VMI arrangements.

The current procurement process in the Turku University hospital is manual and resource consuming. A collaborative VMI arrangement would relieve the pharmacists from the labor extensive manual procurement process and enable them to concentrate on

tasks requiring more medical expertise. WebMarela, the ERP used in the hospital pharmacy, is seen as a well-functioning information system, although improvements could be made. Information visibility in the system throughout the whole supply chain could be increased and the integrations to suppliers could be made two-way. Currently the wholesalers do not have visibility to stock levels or demand in webMarela. This is also a requirement for collaborative VMI program.

5.2 Discussion

The on-going social security and health care reform has been a hot topic for the past decade and mostly not in a positive light. Furthermore, the infamous Apotti –venture has added to the discussions and has received plenty of criticism both from the academics and the taxpayers. This shows that there is still a lot of room for improvement in the health care industry. There seems to be a consensus that the health care sector lags behind other industries in IT adaptation and application of best practices in supply chain management (Chen et al, 2013; de Vries and Huijsman, 2011). Although the root cause for medical waste within the upstream supply chain in hospital pharmacies cannot be entirely attributed to the lack of IT adaptation and best practices, improving these might help in the battle against medical waste.

This study reinforces the notion that the procurement processes and IT systems involved in the process could be developed further. Currently, the procurement process for pharmaceuticals appears to be manual and labor extensive. The interviews revealed that there were misconceptions about the procurement process even within a small organization in the hospital pharmacy. Additionally, the procurement pharmacists were not able to view the expiration dates for the pharmaceutical products in all the warehouses at the wholesalers, which in turn resulted in either bad expiry medicines or returns. Neither of these options is good for the efficiency in the supply chain or medical waste.

It has to be acknowledged that the reduction in medical waste is not an easy task by any means, especially in the upstream logistics processes. The mandatory reserve supply will inevitably result in medical waste. However, there are possibilities to improve the current processes and information systems and through that eliminate unnecessary medical waste.

5.3 Limitations and future research suggestions

When reading through this study and interpreting its results, it is necessary to understand that there are also limitations to this study. First, this study was performed from the point of view of the hospital pharmacy without consideration to the point of view of the pharmaceutical wholesalers. Interviews with the other participants in the collaborative VMI program would have given a more comprehensive and pragmatic overview. The pharmaceutical wholesalers might have different ideas and views on the problems within the processes.

Furthermore, the study was conducted as a single-case study, which has its own limitations. A multiple-case study with other university hospitals could have been employed. Again, this would have given a broader view of the problems and possible solutions to them.

For future research to build on this research, it would be interesting to include the supplier aspect in the equation. Moreover, it would be interesting to perform a study on medical waste as a quantitative instead of qualitative. This could strengthen or disprove the conception that the pharmaceutical staff has regarding the medical waste and its origins. One additional future research possibility would be to extend the research to a similar university hospital in Sweden as they have equivalent single-channel system in pharmaceuticals.

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APPENDIX 1

Theme interview:

1) Procurement process
    - What triggers an order?
    - What defines the quantity of the order?
    - Are there differences in the procurement process between suppliers?
2) Pharmaceutical waste
    - In what part of the supply chain the medical waste is thought to be generated?
    - Is procurement process involved in the generation of medical waste?
3) Expiration of pharmaceuticals
    - How accurate are the pharmaceutical expiration information in suppliers' systems?
    - How often the ordered expiration dates match with received expiration dates of products?
4) Collaboration with suppliers
    - Is there any collaboration?
    - What kind of collaboration?
    - Should the collaboration be further developer and how?
5) Information system used in the procurement process
    - Functionality?
    - Integrations to suppliers' systems?
6) Development initiatives
    - Development ideas for the system?
    - Additional functionalities?
    - Development ideas for the process?