Stanislav Korkiainen

IMPROVING PHARMACEUTICAL STORAGE MANAGEMENT IN THE OPERATING AND ANESTHESIA UNIT OF THE KÄTILÖOPISTO MATERNITY HOSPITAL

As the Finnish society struggles under the weight of the cost of the social and health care sector, changes, both big and small, must be made to ensure an equal opportunity for everyone to utilize social and health care services in the future. By taking a concrete step towards cost reduction and efficiency in the pharmaceutical storage management of the Operating and Anesthesia Unit of the Kätilöopisto Maternity Hospital, I will do my small part to help achieve this goal.

The thesis utilizes action research to study the pharmaceutical storage management of the Operating and Anesthesia unit of the Kätilöopisto Maternity Hospital. The study began in the autumn of 2015 with a six-month observation period, where the amount of pharmaceuticals expired in the medicine cabinets was catalogued and the processes of the pharmaceutical storage management were evaluated. During the spring and summer of 2016 the project continued by creating and implementing the improvements to existing processes based on the literature and the results of the first stage of the study.

The result of the thesis was that the pharmaceutical selection was revised and adjustments were made. Also, the pharmaceutical storage management was improved by changing it into a fixed location system utilizing family grouping and special considerations with a clear network of location addresses and SKU identifiers. But there is a limit to how much savings can be achieved this way and the next step, like in many other fields, is digitalization.

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1 Introduction

Finland and Europe are barely recuperating from a recession. In this economic climate it is imperative to take action towards becoming more cost-effective. According to the National Institute for Health and Welfare the cost of Finnish healthcare was 18.5 billion euros in 2013 (THL 2015). Minister Hyssälä states in a bulletin for the Ministry of Social Affairs and Health that the cost of pharmaceutical services is approximately 20% of the whole expenditure of the healthcare sector (STM 2010). That makes the cost of pharmaceuticals in 2013 somewhere around 3.7 billion euros.

As a nurse responsible for the pharmaceuticals in the Operating and Anesthesia Unit of the Kätilöopisto Maternity Hospital, I have noticed that every year pharmaceuticals worth thousands of euros go to waste in our own ward alone. In this context, going to waste means drugs expiring in our medicine cabinets. Most of the pharmaceuticals that expire are used rarely and the necessity of keeping these pharmaceuticals in the assortment must be explored. Some of these drugs are also quite expensive, a single dose can cost over a thousand euros.

Between January and December 2015 the Operating and Anesthesia Unit of the Kätilöopisto Maternity Hospital spent approximately 567 thousand euros on pharmaceuticals (Appendix 3). My intention is to gather information on the amount of wasted money yearly due to expiration. I will log all the pharmaceuticals that expire in the medicine cabinets during a six-month period. Also, the general processes of the pharmaceutical storage management will be evaluated. This stage will take place during the autumn of 2015 and will continue until the spring of 2016. Depending on the results and literature, I will implement new and/or improved processes to reduce the expiration of pharmaceuticals in the medicine cabinets. After the new and/or improved processes are in place, I will monitor the implementation in the autumn of 2016.

Similar projects can be carried out in other units wishing to reduce the monetary cost of pharmaceuticals expiring. Nevertheless, there are limitations on how much savings can be made this way. The next step in pharmaceutical storage management, like in many other fields, is digitalization. Via digitalization, some steps of the process can be removed, personnel can use their time more efficiently elsewhere, and the chance for human error is reduced. All of these improvements help save more money.

2 Theoretical background

In this section I have compiled the necessary theoretical information from the fields of inventory management and lean philosophy to help build my case.

2.1 Inventory

Inventory consists of an organization´s raw materials, work in process, supplies and finished goods. For example, a bottle of cleaning solution in a building´s custodial program can be considered to be inventory. Money, labor, space, damage, deterioration, obsolescence and theft are some of the inventory costs, which are often divided into ordering and holding costs. The value of the items ordered has no effect on the ordering costs, which are considered to be ,for example, wages paid to the employees making the order and the cost of expediting the inventory. Holding costs consist of the cost of funds tied in inventory, rent for storage space, costs caused by handling the stock, including equipment, warehouse staff and stock losses. (Muller, p.1-2)

Good reasons to uphold an inventory are predictability, fluctuations in demand, unreliability in supply, price protection, quantity discounts and lower ordering costs. Predictability enables you to plan and schedule ahead your production by maintaining a large enough inventory. Fluctuations in demand are also a good reason to uphold an inventory, as you need to be able to satisfy a customer on time. Keeping up an inventory is also a good way to protect yourself against an unreliable supplier. You can protect the price by buying at the right time and by doing so you are able to avoid cost inflation. By buying in large quantities you are often able to get a discount on purchase. You can reduce your ordering costs by ordering larger amounts less frequently. (Muller, p. 3-4)

The following criteria must be met to uphold the accuracy of one´s inventory: an overall locator system must be implemented in the whole facility, follow the item´s movement and storage, and uphold timely records of item movement and storage. (Muller, p.47)

2.1.1 Types of inventories

The most common types of inventory are divided into three categories: raw materials, finished product and work-in-process (WIP). Raw material inventory is used to make finished products or partially finished products. Finished product inventory is ready to be sold. It can also be used as a buffer to protect production from expected or unexpected rise in demand. WIP inventory consists of unfinished goods. This inventory should be kept as small as possible. Other inventory categories are functional in nature and can be described as follows: consumables, S&R items (service, repair, replacement and spare items), buffer inventory, anticipation stock and transit inventory. Consumables inventory consists of items like computers, cleaning materials, paint, etc. Consumables are often considered to be like raw materials. S&R items support the existing finished product on the market by providing service, repair and replacement parts. Buffer inventory can be used to protect production from demand and supply uncertainties. Anticipation inventory is accumulated to satisfy a seasonal demand, like, for example, toys for Christmas. Transit inventory means that the stock in question is moving from one location to another. (Muller, p. 4-6)

2.1.2 Obsolete stock

Why should one care about inventory´s monetary value? The answer is quite simple: Inventory equals money (Muller, p. 17). Slow moving or dead stock merely takes much needed storage space. There are three common reasons for keeping obsolete items in stock: the items are already paid for, the items may be used one day and the items may be sold one day. (Muller, p. 37-38)

Difficulties in persuading the people in charge to improve the stock management process are often related to the impact that the disposal of the items would have on the balance sheet and lending. Regardless of the fact that a certain stock may have no value to the customer or the organization, selling it cheap, disposing of it or donating it will have a negative effect on the financial statements due to the write-off. Banks loan to companies

up to 50-60 percent of the inventory´s worth shown on the books. So, some companies may want to keep the dead stock as artificial value to get a better loan. (Muller, p. 38-39)

Good reasons for disposing of dead stock are better use of storage space, the employees and equipment can be used for something more productive and reducing the cost related to inventory just sitting in storage (Muller, p. 40). You can dispose of the dead stock by selling it for a net price, selling it at a discount price, returning it to the seller, donating it, writing it off or auctioning it (Muller, p. 44).

2.1.3 Locator systems

Locator systems enable the creation of procedures, which let you track the item´s movement in the organization. Memory, fixed and random locator systems are the most common systems in use. (Muller, p.50)

When deciding on a locator system, one should choose a locator system that maximizes as many as possible of the following factors: use of space, use of equipment, use of workforce, accessibility to the whole stock, protection from harm, ability to pinpoint an item, flexibility and keeping the administrative costs down. To maximize all of the factors is difficult at best. Which system is the best rests on the following factors: space available, location system, dimensions of the item, shape and weight of the products, item characteristics (toxic, flammable, stackable), storage methods (shelving), workforce availability, equipment and information systems support. (Muller, p.50-51)

Memory system is the most essential of all locator systems (Muller, p. 51). It relies on human memory alone. The basis of the memory system is simplicity, relative freedom from paperwork and maximum use of space. For the memory system to work, the following conditions must be met: limited number of storage places, the size of storage places is limited, items stored are of limited variety, the items are easily visually identifiable, limited number of workers, items making up the inventory are limited to few types and there is little of stock movement. The most complete use of space is achieved using memory systems, as there are no assigned places for the items. (Muller, p.53)

One of the strength of a memory system are that it is simple to understand. There is also not much paperwork to be done. The system´s ability to use the storage space to maximum efficiency is its greatest strength. There is also no need to tie down specific

stocking location to a specific storage keeping unit. And using the memory system requirements for a single item operation can be achieved. Weaknesses of the memory system are that the organization must rely on the memory, health, availability and attitude of a single employee or a small group of employees. Also, any changes in the conditions required for the system to work, which were mentioned earlier, immediately and significantly decrease the accuracy of the system. And as soon as an item is forgotten by the stock keeper, it is also lost to the system. (Muller, p.54-55)

In a pure fixed location system every item has a specifically designated place and no other item can be stored there. Fixed location systems that are less strict permit two or more items to be stored in the same place at the same time. For a fixed location system to work, a lot of space is required. Honeycombing and planning around the biggest quantity of items in storage are the reasons for the considerable space requirements. In this context, honeycombing means that the storage space is not used to the full extent. This phenomenon manifests in both the vertical and horizontal levels, depriving the organization of square meters and cubic space. Planning for the largest possible quantity of all items to be in the storage at the same time means that the storage has to have enough space to house all the items simultaneously. (Muller, p. 55-57)

One of the strengths of the fixed location system is that you know, at all times, where to find something and where to put it. This increases efficiency and productivity, and at the same time reduces errors in the ordering and the stocking process. This system also reduces training time of new and temporary employees. Receiving and replenishment of new items is simpler and faster using the system. The system alsoenables the rotation of the order fillers, sequential product alignment, strong control of individual lots, product placement near the final point-of-use and Item placement based on its characteristics. (Muller, p. 60-61)

Honeycombing is one of the weaknesses of the fixed location system. Another weakness is that space planning must take into consideration the cubic volume of all items likely to be housed in storage during certain period of time. Fixed systems are also a bit rigid. For a system to function a lot of space is needed. (Muller, p. 61)

A zoning system is a variation of a pure fixed locator system. Item´s characteristics are what define zoning. Similar to a fixed system, items with the same characteristics can be placed in the same zone. Items with different characteristics cannot exist in the same zone. The more you control the location of particular items, the more honeycombing will

become an issue, and you will also need to think about your maximum quantities. (Muller, p. 61-63)

One of the strengths of the zoning system is that a stock keeping unit (SKU) can be isolated based on its characteristics. In the zoning system, items can also be moved more easily from one zone to another and new zones can be established with ease. Another strength is that stock keeping units can be added to a zone at any time, unlike in a fixed system, without having to move a lot of items around. The zoning system also allows more flexible planning, as the items are in zones and do not require planning for the 100% of item´s cubic requirements. (Muller, p. 63)

One of the weaknesses of the zoning system is that it may be adding needless administrative complexity to your inventory management. Another weakness is the possibility of honeycombing in the storage unit. Also, updates of inventory movement are necessary. Zoning enables item placement based on the stock keeper's opinion, which is important. (Muller, p. 63-64)

This system enables excellent utilization of storage space at the cost of increased administration. When using a random locator system, no item has a specific home location, but at the same time you know exactly where everything is. A computer database or a manually maintained paper-based file system enables item placement practically anywhere in the warehouse. The use of a computer or paper-based system is the biggest difference between a random locator system and a memory system in which all the knowledge depends on the memory of the stock keeper. (Muller, p. 64)

One of the strengths of the random locator system is its ability to utilize storage space to the maximum. Another strength is the control gained over the whereabouts of the inventory items at all times. (Muller, p. 65)

One of the weaknesses of the random locator system is the constant necessity to update information to be able to track items. Another weakness is that the system may be too complicated for a company that has a small number of stock keeping units. Administration complexity also increases using this system. (Muller, p. 66)

A combination system is a system where the best qualities from fixed and random locator systems are integrated into one system. The beauty of a combination system is that you are able to store the items that need special attention to a specific location, while the rest of the items can be stored randomly. When storing items in a specific location, one needs

to plan around the maximum space requirements of the items. Storing items randomly will require you to plan around average quantities of the items. (Muller, p. 67)

2.1.4 Common item placement theories

Physical control of the inventory is further improved by focusing on the placement of a certain item within the location system. The item placement theories can be generally divided into three categories: inventory stratification, family grouping and special considerations. (Muller, p. 59)

Inventory stratification consists of A-B-C categorization of the SKUs and utilizing a SKUs unloading/loading ratio. The A-B-C categorization approach is based on "Pareto´s law" ("80-20 rule") meaning, for example, that 20% of the items in stock depict 80% of the monetary value of the whole stock or 20% of the items represent 80% of the item usage. To fully exploit this approach, one must place the most popular items closest to the point of use to efficiently control one´s inventory. SKUs are divided into three different categories: A being the most popular and fast moving items, B representing the second most active items and C being the slowest moving items. To actually put A-B-C categorization to work, one must create a matrix that depicts the SKUs in a descending order of importance and the calculation of their value. (Muller, p.60-61)

Greater efficiency can be gained in the A-B-C zones through item placement according to the SKUs unloading/loading ratio. The ratio represents the number of trips needed to bring an item to the storage location in comparison to number of trips necessary to move it from storage to a point-of-use. The closer the unloading-to-loading ratio is to 1:1, the less important it is to place the item as close as possible to the point-of-use. The higher the ratio, the more crucial it becomes to place the item as close as possible to the point-of-use, thereby saving the worker´s time. (Muller, p. 64)

An alternate grouping approach is the family grouping approach, also known as like product approach. In this approach items, similar items are placed together. Similar characteristics should result in a natural grouping of items. The grouping can be based on the similar characteristics of the items, on the fact that the items are often sold together or on the fact that the items are often utilized together. The benefits of using family grouping approach are: storage and retrieval through similar techniques and

equipment is easy, the family groups are easily recognized and a zoning locator system can be implemented easily. However there are also some negative aspects to consider, when thinking about using family grouping: some items are similar enough that they are difficult tell apart, positioning a popular item close to the point-of-use may also bring less popular items with it to take precious storage space from the popular one, popular items may be placed far from the point-of-use if they are grouped together with some less popular items, a product can be utilized in several family groups and family grouping and inventory stratification are both used together. Nevertheless, to achieve efficient item placement, one must utilize both family grouping and inventory stratification. By employing both approaches, the frequently used items are closer to their point-of-use and their less utilized family members can be grouped together farther away. (Muller, p. 64-66)

Some items may require specific storage conditions, if they are, for example, heavy, light, flammable, toxic or frozen. Regardless of the item´s characteristics, inventory stratification and/or family grouping should be utilized when dealing with items requiring special consideration, to enforce efficiency in the inventory layout. (Muller, p. 66)

2.1.5 Location addresses and SKU identifiers

To keep track of one´s inventory, one must establish and uphold a system of location addresses and SKU identifiers. The keys to a successful inventory system are: adequate identification markings on SKUs and bin/slot/floor/rack/drawer/shelf locations, updating information into the system as quickly as possible when the SKUs change locations or have several home bases, and using an easy to read and understand marking system. Putting these ideas into use means decreased labor costs related to searching for the product and storage location, removal of unnecessary orders of products that are in storage but undiscovered and the fullfillment orders of correct SKUs and pack sizes are selected. (Muller, p. 66-68)

2.1.6 Automatic identification

When people are involved in the process of identifying an item, inserting the information into the database and altering the data to keep track of changes in the item´s status, mistakes and time spent increase drastically. Different technologies assisting machines to identify items without any need for people to insert the information, is called automatic identification (Auto ID). Technologies like bar codes, smart cards, voice recognition, different biometric technologies, optical character recognition and radio-frequency identification (RFID) can be used in Auto ID. The most commonly used way for automated inventory identification is one-dimensional, linear bar coding. (Muller, p.75)

Optical character reading (OCR) can be read by both people and machines, but it is slower to read than bar codes, has a higher error rate than bar codes and it is very sensitive to print quality. Machine vision is very precise under the correct light conditions and it is mediocre to read, but the technology is expensive. Magnetic stripe can be read through grease and dirt and the data on it can be altered, but in the reading process a contact reader must be utilized, making high-speed reading of many objects difficult. It is not readable by a human eye. Surface acoustic wave (SAW) can be used in very hazardous environments like acid baths, can be read from over 1.5 meters away, no line of sight is required for reading and it is very durable. Radio-frequency tags can be programmed or coded for life, can be read from over 9 meters away, no line of sight is required and it is very durable. (Muller, p.76-77)

Time and money saved via the elimination of human error often pays for the bar coding system, but the speed of data capture and the accuracy of bar coding are also reasons enough to justify the installation of the system in your business. The code itself, the reading device and the printer are the only things needed to build a bar code system. (Muller, p.75) Universal product code (UPC)/European article numbering system (EAN) is a bar code most commonly used in a point-of-sale environment for product identification. A license is required to utilize the UPC. Code 39, on the other hand, is a bar code most frequently used in a non-retail environment. Most of the software applications used in inventory management can interface with Code 39. There is also Code 128 with its many positive qualities. When considering a bar code system for your

business, one must understand that no system is perfect. One good criteria to base one´s decision on, is to find out, which bar coding system is generally used in the industry in question. If no system is dominating the industry, then it is up to you and the resources available to you. (Muller, p.80-82)

Technology, which utilizes radio waves to identify items or people, is called Radio-frequency identification (RFID). The technology is still lacking universal standards on all fronts. Most commonly, the necessary information like the serial number is stored on a microchip, which is paired with an antenna, and by doing so creating the RFID transponder. The microchip uses the antenna to transmit radio waves to a reader, which transfers the converted data into a computer. (Muller, p. 89)

There are two types of RFID tags: passive and active. A passive tag has no internal battery and works by reacting to the electromagnetic waves emitted from the reader. On the other hand, an active tag has an internal battery and is usually a read/write device. The RFID tags are also divided into five classes: Class 0 is a simple read-only tag with minimal data programmed during manufacturing, Class 1 is a write-once/read-only tag programmed either during manufacturing or by the user only once, Class 2 is a read/write tag, Class 3 is an active read/write with an on-board sensors tag able to record parameters in its tag memory, and Class 4 is a read/write with an integrated transmitter tag able to communicate with each other without any assistance from a reader. (Muller, p. 90-91)

RFID technology possesses many advantages over the traditional bar code technology. For starters, the RFID technology does not require a direct line of sight to read like the bar code technology and it can be read through most obstacles. The reading range is also an issue, as on average the reading range of a bar code is approximately 4.5 meters, whereas the reading range of a RFID tag is up to 90 meters. The reading speed also leans in the RFID´s favor, as it takes a bar code reader about half a second to read the code, whereas a RFID reader reads up to 40 tags a second. Durability is also a winning quality for the RFID, as codes are more prone to be damaged by external forces compromising their readability, whereas RFID tags are more durable and can be placed inside the objects protecting them further from damage. The information on RFID tags can also be altered later, whereas the bar code cannot be. The RFID technology enables specific identification of a certain item, whereas bar code technology merely provides data about the products manufacturer and the product. (Muller, p. 94)

RFID technology has its weaknesses. One major issue is the lack of global standards, which means that companies use internal standards and various technologies to keep track of their items. This leads to a situation, where companies cannot read the tags from the other company. The cost of the RFID system is another issue to be considered. One reader alone costs hundreds of euros and, depending on the size of the company, the amount of readers may rise to hundreds. Also, the RFID tags cost somewhere around 10-20 cents apiece and they must be placed on thousands of items. The issue of system disruption is a potential problem to be tackled, as the RFID system is prone to jamming using energy at the correct frequency. The battery powered tags can also be worn down by interrogating them, causing system disruption as the result. One must be aware of the possibility of a RFID reader collision, which occurs when the signals of multiple readers overlap, resulting in a tag´s inability to respond. Placing an anti-collision protocol enables the tag to alternate in transmitting to different readers. Also, tag collisions can happen when a lot of tags are placed in a small area, all of them trying to communicate with a reader at the same time. The issue is worked on by the RFID companies. Lastly, there is the issue of privacy, security and ethics. RFID tags can be scanned from a short distance away with any RFID reader, making it possible to read tags in a person´s pocket or purse. The durability of the tags makes them very difficult to remove, enabling this issue. RFID tags programmed with unique serial numbers can be connected to the credit card that was used to make the purchase. (Muller, p. 94-96)

2.1.7 Planning and replenishment concepts

As long as an item remains in storage, it increases the carrying cost (K Factor), so it might seem wise to order the item only when you need it. On the other hand, buying f small amounts frequently raises the cost of replenishment (R Factor). This means that every time one places an order, one must take into consideration costs like salaries of the ordering staff, rent and other overhead expenses. In an optimal situation, the company would strive towards a state, where K factor and R factor would be in balance. (Muller, p. 98-99)

The type of inventory management to be utilized depends on the nature of one´s business. The businesses can be divided into two categories: the ones who deal with finished goods (distribution, retailing and replacement parts) and those who deal with

raw materials and unfinished goods (manufacturing). In the world of distribution, the formulae used to calculate inventory need to concentrates on item and quantity, instead of time and place. In the field of manufacturing one is more interested in having the correct item, in the right amount, at the right time, in the right place. The demand for finished items is described as independent and the demand for unfinished goods is described as dependent. Independent demand is affected by conditions out of one´s control, like, for example, market conditions. The demand for one item is not related to other items, so the items are independent of each other. This means that you will need to have the right product and the right amount. Dependent demand is, on the other hand, connected to another item. The demand for the finished product determines the demand for building or creating from raw materials or parts. In this scenario, one will need several different items to create the finished product. Dependent demand dictates that one needs to have the correct items in the right amount at the right time to be able to make the finished product. (Muller, p. 100-101)

To determine an exact reordering point for an item in an independent demand inventory, one must use an order-point formulae. In these calculations, a reordering point (ROP) is determined for each item. The ROP represents the lowest amount of an each item in the inventory before commencing reordering. Each item in the inventory should have working stock, working reserve and safety stock. ROP can be calculated using the following formula: (Usage * Lead Time) + safety stock = ROP. Usage means the monthly use of the item. Lead time is declared as a percentage of a month. For example, 1 week is 0.25 =25%, 2 weeks is 0.5 =50% etc. Safety stock can be calculated as 50% of working reserves. The ROP represents the minimum in the min-max inventory management system. To be able to determine maximum level one must first decide the yearly amount of orders to be placed. This is also called a review cycle. The formula for the review cycle is the following: Total Purchases from a Supplier in Year / Discount Given = Review cycle. The maximum level in min-max inventory management system can be calculated using the following formula: ROP + Usage * the Review Cycle = Maximum. (Muller, p. 102-104)

Dependent inventory management utilizes different kinds of systems. Materials Requirements Planning (MRP) takes into account more than just the item ordered and the quantity, as it also controls the time of arrival via computer systems. (Muller, p. 107) The Just-in-Time (JIT) system takes the MRP even further, as it controls the same things

the MRP does, but it also brings the SKU to the correct place. When utilizing the JIT, the item appears precisely at the right time, not a moment earlier or later. (Muller, p. 111)

2.2 Lean

Lean is a business philosophy instead of a variety of tools and techniques. At the highest levels, lean is an unrelenting hunt for elimination of waste. It is widely used by organizations everywhere, but only a few have actually achieved it. Any organization can apply lean philosophy. It does not matter if the organization is a non-profit one, as all organizations benefit from eradication of waste in their supply chains. (Trent, p. 3-5) The essential purpose of lean is to maximize customer value and minimize waste at the same time. In other words, lean is all about creating more value for the customer with less resources. (Lean enterprise institute 2016)

2.2.1 Principles of Lean

The more recognized principles of lean are flow, pull and striving for excellence. Optimization, standardization and simplification are less traditional principles of lean, but, nevertheless, they also contribute to the elimination of waste. (Trent, p. 5)

The flow principle is about continuously moving the correct material towards the location that requires the material in question. Flow doesn´t have to be material. It can be for example a payment, information, equipment or people flow. It is important to recognize that an interruption to in the flow in any area mentioned can be wasteful. Also, it is good to understand that every organization has some kinds of flow. From the supply chain´s point of view, it is good to keep things flowing to match the demand of the customers. Stopping and restarting adds little value to the customer. The supply chain throughput, supply chain capacity and cycle time are affected by any disruptions in the flow. (Trent, p. 5-6)

A lean supply chain is based more on the pull systems than the push systems. In a pull system, a downstream factor, such as a customer, places an order to an upstream operation. The concept of pull is very essential to lean, as no action is taken by the upstream operator without a downstream demand. In a pull system, mere expectation of a coming order that may never come to pass, is not enough to take action. A push system, on the other hand, operates based on the anticipation of an order or a request.

Only a few organizations use only pull systems, as often both pull and push processes are employed. (Trent, p. 7-8)

Striving for excellence is an integral part of lean. Waste is accumulated when deviation from the target occurs. Waste can be categorized into type I and type II quality control errors. A type I error happens when a call is made to turn down something as non-conforming, when it should have been approved. Type II errors takes place when a call is made to allow something that should have been turned down. In a lean supply chain, there is little room for quality errors, making the chase for no quality abnormalities a crucial one. All errors that work their way through the supply chain should be seen as type II quality errors. To resolve quality issues, one must identify the root cause of the abnormality. Eliminating the root cause should resolve the problem and prevent it from recurring. (Trent, p. 8)

The pursuit of optimization can be commenced in many different fields and areas. Optimization usually results in a decrease of waste. The goal of optimization is to make something more functional and effective; to perfect something as much as possible. (Trent, p.10)

Standardization is another principle of lean. It means that by utilizing models or good examples, one can standardize, for example, processes, practices, policies and procedures across one´s company. If one fails to standardize, this results in wasteful duplication of effort that is not able to advance the best practices. (Trent, p. 10)

Through simplification one tries to reduce the scope or complexity of something without hindering its effectiveness. Process and product design are two fields, which gain the most from simplification. (Trent, p. 11)

2.2.2 Waste and non-value-adding activities

The very essence of a lean supply chain is a ferocious war on waste. In the broader sense of the word, waste means any function, which brings no value from the customer´s point of view or a function, which a customer would not purchase as part of a product or a service. There are three tangible results of waste: it takes too much time to carry out

an activity, there is too much inventory, and costs are too steep compared to the competitors. (Trent, p. 12)

Supply chain activities can be generally divided into three categories: value-adding activities, non-value-adding activities, and wasteful activities. A value-adding activity is something that the customer ordered and is prepared to pay for. A non-value-adding activity is something that must be done to move a product closer or to the customer, but it adds no physical value to the activity. Some level of non-value-adding activities is needed to function in all supply chains. Wasteful activities bring no value nor move items closer to the customer. (Trent, p. 12)

Non-value-adding activities get often mixed up with wasteful activities. One can assume that wasteful activities are always non-value-adding. Waste only accumulates costs, and for that reason, all wasteful activities should be considered for elimination. On the other hand, not all non-value-adding activities should be considered waste. For example, a customer is prepared to pay for the transportation of the ordered product, even though the transportation does not add any physical value to the product. (Trent, p. 12)

There are many different kinds of waste. The more traditional types of waste are defects, excess inventory, excessive processing, unnecessary motion, waiting, overproduction and unnecessary transport. Defects are quality errors, which increase cost. Overbuying, overproduction and bad inventory management all create excess inventory, which is also waste. Excessive processing implies that a process has unnecessary steps or tasks. Any unnecessary motion during movement or processing is categorized as waste. Waiting for additional processing is wasteful. Producing more than currently is required is also waste. Any unnecessary processing and movement within or between places is considered waste. (Trent, p. 13)

But to resolve issues of modern project, one must further develop the concepts of waste. One such concept is digital waste, which includes all kinds of unnecessary data that is gathered, managed, moved or saved for no tactical or strategic gain. Time taken to go through unnecessary data is never free. Duplication of effort is fairly common with bigger organizations, as the organizations let their different operation locations develop own internal processes or work methods instead of enforcing best practices across all operation locations. A lot of waste is created via poor measurement. This concept includes too many measures, too few measures, incorrectly calculated measures and measures that do not advance strategic goals. Another type of waste is the unused

potential of the personnel, which manifests in a form of untapped creative contributions of the employees and lost opportunities. Overdesigning creates waste by providing customers with a product that possesses too many features and functionalities that are not very useful from the customer´s point of view. Also, unnecessary staff produces waste in the form of an excessive overhead. Poor planning, on the other hand, affects the supply chain by keeping the supply and demand off balance. (Trent, p. 13-14)

3 Objectives and Goal

The objectives of this thesis are:

1. To discover how much time and money can be saved by redesigning the processes in the Operating and Anesthesia Unit of the Kätilöopisto Maternity Hospital.
2. To implement new and/or improved processes into the pharmaceutical storage management in the Operating and Anesthesia Unit of the Kätilöopisto Maternity Hospital.

The goal of this thesis is to reduce monetary losses due to expiration of pharmaceuticals in the medicine cabinets in the Operating and Anesthesia Unit of the Kätilöopisto Maternity Hospital.

4 Methods and Materials

This section introduces and explains the process of this thesis. This thesis applies action research as a research method to reduce pharmaceutical costs in the operating and anesthesia unit of the Kätilöopisto Maternity Hospital.

4.1 Methodology and method

In this thesis, data is collected using a quantitative approach, producing numerical data concerning the cost of expired pharmaceuticals. However, the existing processes are studied through observation, which is a qualitative technique.

Research can be considered qualitative as long as the research does not produce findings that have been conceived by statistical or any other quantifiable means. Focus groups, observations and qualitative interviews are the most common techniques for data collection in qualitative research. Quantitative data collection methods apply well in a situation where you want to test out your precise hypothesis or where you expect numerical results from your work. (Kuanda, p.93, 95, 103) Using both qualitative and quantitative methods is referred to as mixed methods. There are five reasons to consider using mixed methods: Triangulation, complementarity, development, initiation and expansion. (Hesse-Biber, p.3-5)

Action research is known by many names: Participatory Action Research (PAR), community-based enquiry and co-operative enquiry to name a few. Healthcare professionals constantly evaluate their own work through their own observations and interactions with other people. What separates action research from a healthcare professional´s daily observations and judgements of his/her work, is that during the action research project, the researcher needs to develop and wield an array of skills to achieve his/her goals. According to Koshy, Koshy and Waterman, such skills are: careful planning, sharpened observation and listening, evaluation and critical reflection. Action research is a tool for those who want to bring change in specific contexts. It helps the researcher to find different ways to enhance the quality of healthcare. It is a method for improving practices. The strength of action research is in its ability to create solutions to

practical problems and to empower its practitioners by engaging them every step of the way from research to implementation. (Koshy, Koshy & Waterman, p. 1-3)

There are several models describing action research. Kemmis and McTaggart consider action research to be a participatory research. They describe it as a spiral of self-reflective cycles, which involve planning, acting and observing, reflecting and then the cycle starts over again. Elliot´s model includes identifying the idea, reconnaissance (analysis), planning action, evaluation, amending the plan and taking a second step, and the cycles go on. O´Leary´s cycles of action research describe action research as a cyclic process, which uses the appearance of knowledge to take shape. O´Leary´s model underlines that the cycles move towards better situational understanding and improved action implementation through the alteration of action and critical reflection. (Koshy, Koshy & Waterman, p. 5-6)

4.2 Research design

Research design is a road map for the gathering, measurement and analysis of data. It is an overall structure under which the research is performed. The following issues must be addressed in the research design: a research problem, means of data gathering, a target of study and methods employed in the management and analysis of data. (Kothari, p. 31-32)
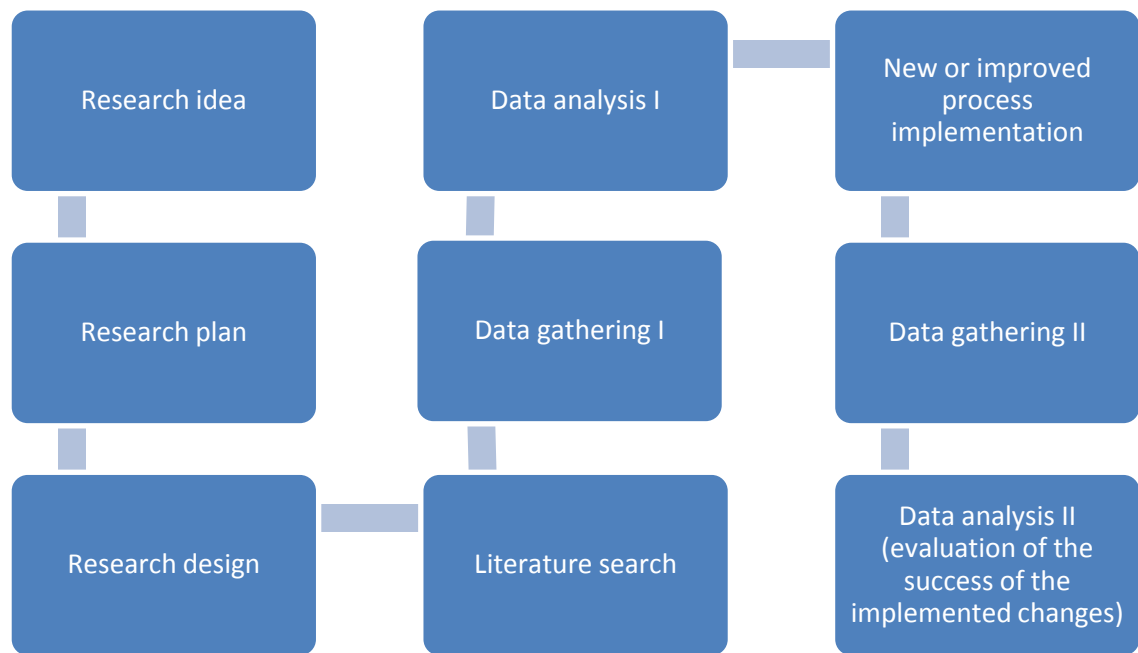
Figure 1. The research design

The research idea for my thesis came to me over time as I noticed that many pharmaceuticals expire or go to waste in the operating and anesthesia unit of Kätilöopisto Maternity Hospital. As I was planning on applying to the HBM master´s program in the spring of 2015, I decided that my thesis will concentrate on reducing the pharmaceutical costs of the unit.

As I was writing my research plan for the entrance exam to apply to Metropolia´s master´s program, the focus of the thesis was to reduce the pharmaceutical expenditure due to expiration. In the autumn of 2015, the studies began and the whole thesis process became clearer. During the first meeting with my thesis adviso,r action research was chosen to be the method used in the thesis. The research design gave the thesis some needed structure and a schedule. A meeting with my thesis advisor in the March of 2016 expanded my thesis subject from reducing the pharmaceutical expenditure due to expiration to pharmaceutical storage management.

I received my research permission from HUS in the autumn of 2015 (Appendix 1). The first data gathering began in September of 2015 and it continued until March of 2016. At the end of every month I removed the expired pharmaceuticals from the medicine cabinets and recorded the monthly losses using Microsoft Excel. The first data analysis using Microsoft Excel followed soon after, revealing expected results.

Literature search also took place in the spring of 2016. Based on the first data analysis and the literature search, the existing processes will be examined and new or improved processes will be implemented in the pharmaceutical storage management of the operating and anesthesia unit of the Kätilöopisto Maternity Hospital. The implementation of new or improved processes took place during the summer of 2016.

After making the changes to the pharmaceutical selection and to the pharmaceutical storage management, I realized that the improvements were useful and welcome. However, to truly improve the pharmaceutical storage management, one should digitize the process as much as possible. Digitalization is the key to lean the pharmaceutical storage management further.

4.3 Data collection and analysis

In the first round, data was collected from September 2015 to March 2016 by doing a monthly inventory of the medicine cabinets to determine the financial loss due to expiration of pharmaceuticals. Microsoft Excel was used to record and analyze the data. In the second round during the late spring and early summer of 2016, literature was revised to improve or create processes in the pharmaceutical storage management. In the third round, I asked some of the staff members for feedback on the improvements implemented. I also observed the new system in action.

Data round	Data type	Data source	Date and Approach	Purpose
Data 1 Current state analysis	Observation	Medicine cabinets on the 6th and 7th floor	September 2015-March 2016, Excel	To determine current financial loss due to expiration
Data 2 Building the proposal	Literature overview	Literature	Spring-summer 2016	Improvement or creation of better processes
Data 3 Validation	Feedback, observation	The staff of the operating and anesthesia unit of the Kätilöopisto Maternity Hospital	Autumn 2016, qualitative	To find out the effect of the implemented changes

Figure 2. Overlook of the research

4.4 Validity and reliability

Validity has two main functions: the first one is the assessment of the relevance and accuracy of the research and the second one is the assessment of the generalization of the research results. To complete these two functions one must test the validity of the construct, the measuring instrument and the internal validity of the results. The generalization of the research results depends on the external validity of the results from the tests mentioned above. (Thietart, p. 196)

Reliability is a way to determine, whether the research can be repeated by someone else or at a later time bearing the same results. It consists of two parts: the reliability of the measuring instrument and the general reliability of the research. (Thietart, p. 196-197)

5 Current State Analysis

In this section, I will introduce my findings on the current state of the pharmaceutical storage management in the operating and anesthesia unit of the Kätilöopisto Maternity hospital. I monitored the expiration of pharmaceuticals in the medicine cabinets from September 2015 to March 2016 and used Microsoft Excel to register the monetary loss during this time.

5.1 The current state of pharmaceutical storage management

At the moment, the operating and anesthesia unit of Kätilöopisto uses over a half a million euros on the pharmaceuticals yearly (Appendix 3). During my six-month observation period, I discovered that pharmaceuticals worth over 10 000 euros expired in the medicine cabinets. The expiration of the most expensive pharmaceuticals change the monthly losses drastically. The monthly losses vary from 18 euros to over 8000 euros. (Figure 4)

 Muller (p.50) states that memory, fixed and random locator systems are the most commonly used systems. The existing locator system was a combination system, which brought together elements from fixed location systems and memory systems. The pharmaceuticals had fixed places in the medicine cabinets, but they were not all alphabetized nor marked inside or outside of the cabinets. This made the system lean heavily on human memory, which was fine as long as the users were accustomed to the system. The existing system became problematic as soon as the personnel from the Women´s Clinic came to work in the same unit, because they were used to a different kind of a locator system.

Inventory stratification, family grouping and special considerations are three item placement theories, which improve the physical control of one´s inventory (Muller, p. 59). The original system implemented all three item placement theories, but inventory stratification was probably the main reason for confusion among the personnel from the Women´s Clinic. The bulk of the pharmaceuticals were divided into two categories: the most commonly used and the rarely used pharmaceuticals. They were separated into two different medicine cabinets. The pharmaceuticals inside these two cabinets were

alphabetized. Family grouping was used among the antibiotics and intravenous fluids. The pharmaceuticals requiring refrigeration are the special considerations group.

Muller (p. 66) also mentions that to keep track of one´s inventory, one must establish and uphold a system of location addresses and SKU identifiers. Our inventory system was missing clear markings outside and inside the cabinets and also general alphabetizing.

I am one of the only two nurses responsible for pharmaceutical storage management, and, therefore, time to manage the pharmaceutical storage is quite limited. We are able to give this responsibility only a fraction of our time due to our primary function as nurse anesthetists. Because of the limited time provided to carry out this responsibility, we are able to do only the bare minimum. This means that we register the pharmaceuticals that are about to expire in the near future, and in the beginning of every month, we dispose of the expired ones.

When it comes to ordering the pharmaceuticals, all of the nurse anesthetists can place an order in our ordering program OSTI. There are upsides and downsides to this. The upside is that there are many nurses, who can place the order, and the ordering process does not depend only on few people. The downside to this is that every nurse orders the pharmaceuticals in a different way, regardless of the fact that some parameters have been set regarding how much of each pharmaceutical we should have in our storage. One nurse may consider that it is crucial to order a large amount of some pharmaceutical, whereas another nurse would order more conservatively.

The ordering program is quite simple. One can search for pharmaceuticals individually or pick from a list of the most commonly used pharmaceuticals. Picking from the list is probably the safer alternative, as the pharmaceuticals are in the correct dose, size and amount. The problems often occur when a person searches for a pharmaceutical individually, because there is the possibility to order the same or similar product of incorrect dose, size or package size.

The anesthesiologists approve the orders after the program sends them a note about the order. This works quite well. The supply chain is rarely disrupted because a doctor forgetting to approve the order. It is more common that the nurse anesthetists forget or do not have the time to make the order, as the time or the person for this activity is rarely clearly allocated.

Generally, the pharmacy sends the correct pharmaceuticals, but sometimes some pharmaceuticals are missing from the load. There have also been some cases, where the pharmacy sends a completely incorrect order. The role of the nurse, who receives the order, is an important one, as he/she must make sure that everything has arrived and the order is actually meant for our unit.

When an order arrives, anyone, who has the time, will unload it. Since any nurse with enough time can unload the order, the best practices are sometimes forgotten. This manifests itself most clearly, when recently arrived pharmaceuticals are stored in the front instead of the back. This disrupts the logical rotation and enables the expiration of the pharmaceuticals remaining in the back.

There has always been a possibility to return the soon-to-expire pharmaceuticals back to the pharmacy. This possibility is rarely used due to lack of time and resources in the pharmaceutical storage management. If a pharmaceutical is sent back to the pharmacy months before the expiration date, and some other unit orders the pharmaceutical in question before the expiration date, a partial refund is paid to our unit. Since the most expensive pharmaceuticals are used rarely, the chances of getting any refund are slim at best.

The whole pharmaceutical assortment is revised once a year. The amount of some pharmaceuticals is predetermined and stated on each medicine cabinet. This has not been revised in a while and the amounts are slightly outdated. Also, the nurses ordering the pharmaceuticals seem to ignore the lists stating the desired amount of each pharmaceutical.
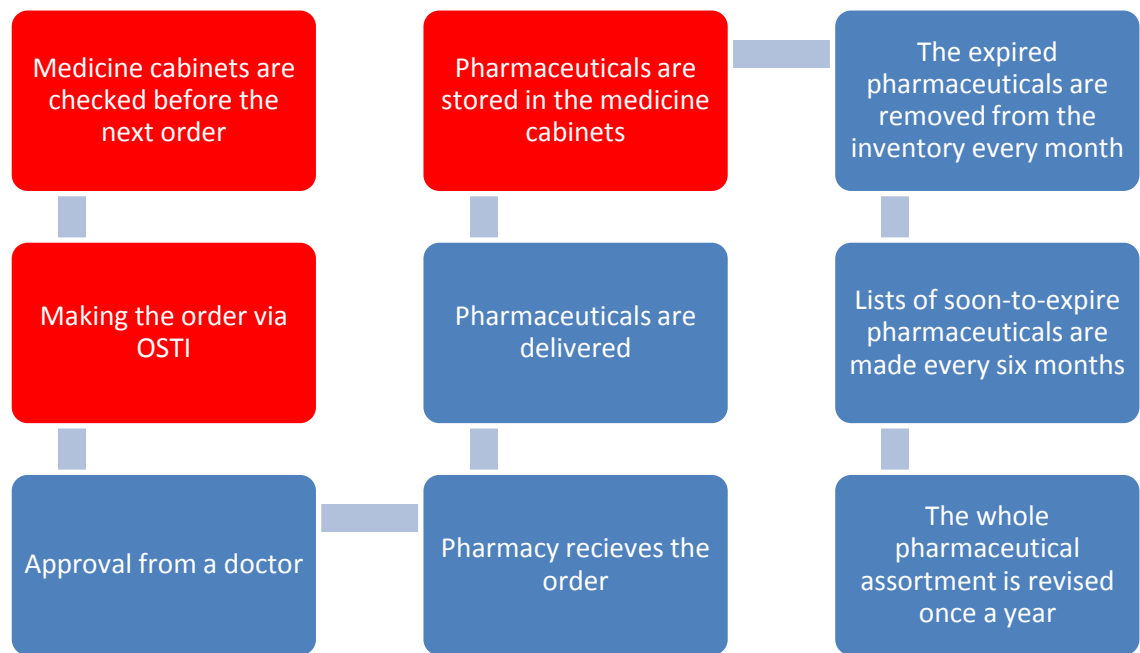
Figure 3. Pharmaceutical ordering and maintaining process

5.2 Key findings

Figure 4. Monetary losses due to expiration

In Figure 4, one can see all of the monetary losses during a six-month period between September 2015 and February 2016. Monthly losses vary drastically from 8335.47 euros to 18.16 euros. This is due to the varying price range of the pharmaceuticals. Figure 5

shows that three pharmaceuticals make up most of the losses (82%) suffered during the observation period.

The observation period revealed that coagulation factors are the biggest single group causing financial losses due to their expiration. In Figure 5, one can see that Atenativ and Novoseven together create more than half of the overall losses (56%), which are due to their expiration.
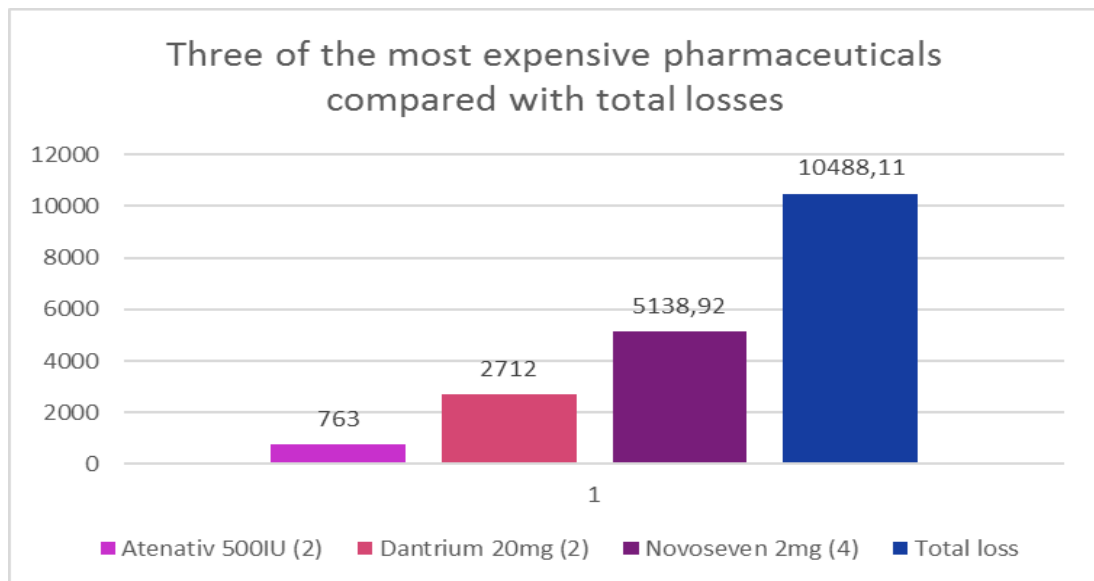
Figure 5. Three of the most expensive pharmaceuticals compared with total losses

By looking at Figure 6, which is a list depicting all the expired pharmaceuticals, one can see that most of the pharmaceuticals on the list do not come even close in the monetary sense, when compared to the expired pharmaceuticals shown in Figure 6. Besides the coagulation factors few other groups are represented in Figure 6. One of these groups is antibiotics, which includes: Abbocitin, A-PEN, Cefuroxime, Clindamycin and Meropenem. The monetary losses caused by this group are quite modest at only 180.22 euros, which is 1.7% of the overall losses. Another group that is clearly represented in Figure 6, are the often or fairly often used pharmaceuticals. Atarax, Atropin, Cefuroxime, Clindamycin, Dynastat, Labetol, Lidocain and Litalgin are part of this group. Once again the financial losses caused by this group are relatively small at 625.48 euros, which is 6% of the overall losses.

There are 36 different pharmaceuticals shown in Figure 3. By adding together the five most expensive pharmaceuticals one gets 9550.66 euros, which is 91% of all losses, meaning that 31 pharmaceuticals make up only 9% of all losses.

All the expired pharmaceuticals

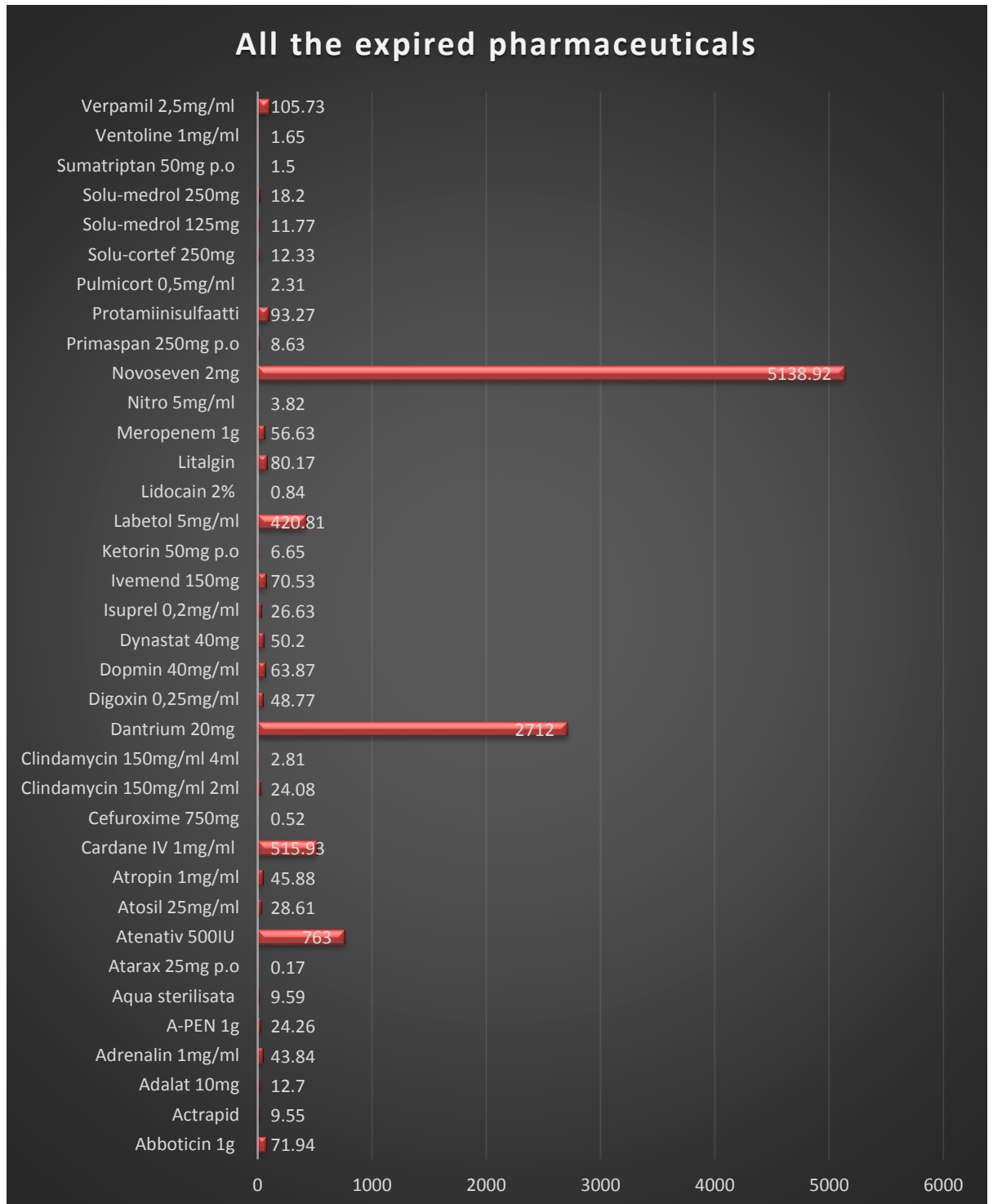| Pharmaceutical	Value
Verpamil 2,5mg/ml	105.73
Ventoline 1mg/ml	1.65
Sumatriptan 50mg p.o	1.5
Solu-medrol 250mg	18.2
Solu-medrol 125mg	11.77
Solu-cortef 250mg	12.33
Pulmicort 0,5mg/ml	2.31
Protamiinisulfaatti	93.27
Primaspan 250mg p.o	8.63
Novoseven 2mg	5138.92
Nitro 5mg/ml	3.82
Meropenem 1g	56.63
Litalgin	80.17
Lidocain 2%	0.84
Labetol 5mg/ml	420.81
Ketorin 50mg p.o	6.65
Ivemend 150mg	70.53
Isuprel 0,2mg/ml	26.63
Dynastat 40mg	50.2
Dopmin 40mg/ml	63.87
Digoxin 0,25mg/ml	48.77
Dantrium 20mg	2712
Clindamycin 150mg/ml 4ml	2.81
Clindamycin 150mg/ml 2ml	24.08
Cefuroxime 750mg	0.52
Cardane IV 1mg/ml	515.93
Atropin 1mg/ml	45.88
Atosil 25mg/ml	28.61
Atenativ 500IU	763
Atarax 25mg p.o	0.17
Aqua sterilisata	9.59
A-PEN 1g	24.26
Adrenalin 1mg/ml	43.84
Adalat 10mg	12.7
Actrapid	9.55
Abboticin 1g	71.94

Figure 6. All the expired pharmaceuticals

In Figure 7, the pharmaceuticals are divided into groups. Coagulation factors are clearly the largest group. The second biggest group is Dantrium taking up 26% of the share. Dantrium could be a part of the Others group, but it would blow the Others group out of proportion. The Others group has a 10% share. Antibiotics and Often or fairly often used pharmaceuticals have combined a share of 8%
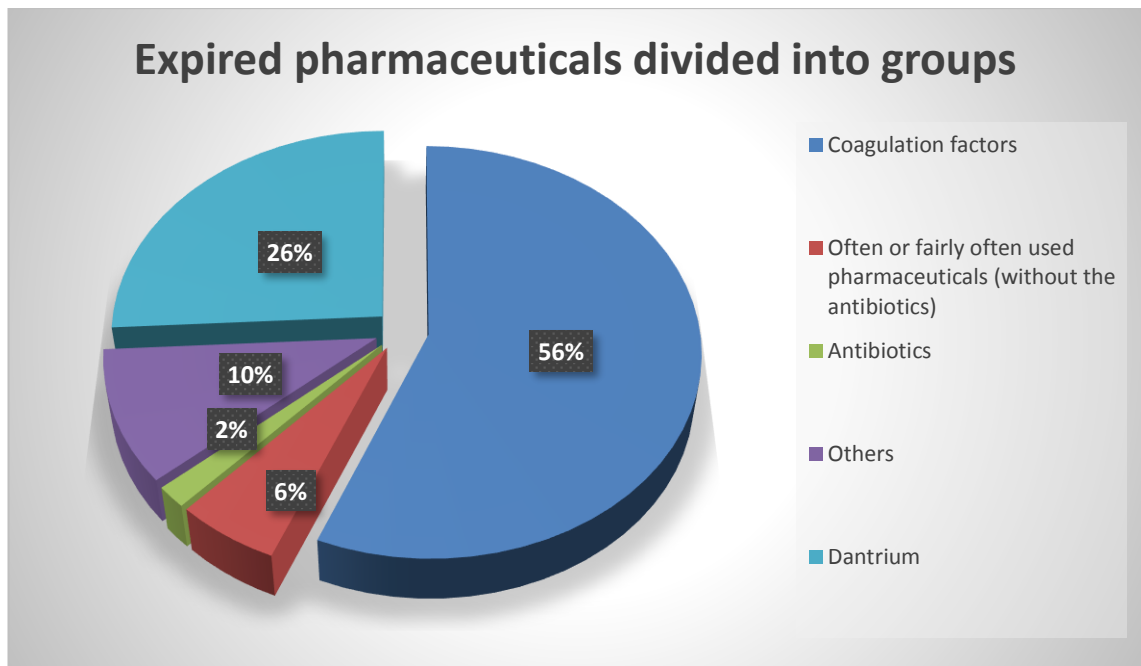
.

Figure 7. Expired pharmaceuticals divided into groups

6 Improved Pharmaceutical Storage Management System

In this section, I will present the improvements I have implemented into the pharmaceutical storage management system in the operating and anesthesia unit of the Kätilöopisto Maternity hospital during 2016. I will also present my future vision for the pharmaceutical storage management. The lean philosophy was an essential force guiding my decision-making throughout the whole project.

6.1 The improvements implemented

According to Trent, the best known principles of lean are flow, pull and striving for excellence. Optimization, standardization and simplification are also principles of lean, but they are less known. (Trent, p.5) Lean thinking as a whole is present throughout my project, but the principles of flow, optimization and simplification are the cornerstones of my work.

In 2015, the operating and anesthesia unit of the Kätilöopisto Maternity Hospital spent 566 987 euros on pharmaceuticals (Appendix 3). This figure is taken straight from the OSTI-program. During my initial six-month observation period, I discovered that pharmaceuticals worth 10 488.11 euros expired in the medicine cabinets (Chart 4), which makes the yearly losses somewhere around 21 000 euros. Muller presents three common reasons for keeping obsolete items in stock: the items are already paid for, the items may be used one day and the items may be sold one day (p. 37-38). Their potential future usefulness is probably why many of the rarely used pharmaceuticals have survived in the inventory to this day. Muller also gives the following fair reasons for disposing of dead stock: better use of storage space, the employees and equipment can be used for something more productive, and reducing the cost related to inventory just sitting in storage (p. 40). The first reason is definitely the most important one, as storage space is very limited in our unit. If one compared the total losses to the sum used on the pharmaceuticals yearly, one would discover that the losses due to expiration only amount to 3.7% of the total sum used on the pharmaceuticals yearly. I consider a 3.7% loss very acceptable, but this number can be reduced.

Nevertheless, inventory is a must. According to Muller, good reasons to uphold an inventory are predictability, fluctuations in demand, unreliability in supply, price protection, quantity discounts and lower ordering costs (p. 3). In our case, the main reasons to keep a comprehensive inventory are predictability and maybe the fluctuations in demand, but every year there´re also occasions when heavily used product is not available for some time. Many of the pharmaceuticals are kept in the inventory just in case. Getting some of the rarer pharmaceuticals outside office hours would take too long, as they would have to be ordered from the pharmacy. This is not as simple as it sounds, as one must first contact the on-call pharmacist, who is home, to go to the pharmacy and send you the drug via taxi. This is quite time-consuming and unacceptable if the need for the pharmaceutical is urgent, as it can be in some cases.

The data analysis revealed that more than half of the expiration losses came from the coagulant agents. One could say that around 82% of the financial losses were generated by only three pharmaceuticals (Novoseven, Dantrium and Atenativ), meaning that the bulk of the expired pharmaceuticals amount to only 18% of the overall losses. (Chart 5.) These revelations led me to discuss the issue with the chief of anesthesiology. I suggested that we would remove some of the most expensive and rarely used pharmaceuticals on the list. Of the three most expensive pharmaceuticals that expire regularly, only Novoseven was removed. However, the quantity of many expensive coagulant factors was reduced to a minimum, which means that the rarely used coagulants cause less financial losses than before.

Besides taking the obvious steps and removing some of the most expensive pharmaceuticals, I started thinking about the existing processes and practices in the pharmaceutical inventory management in my unit. According to Muller (p.50), a locator system should maximize as many as possible of the following factors: use of space, use of equipment, use of workforce, accessibility to the whole stock, protection from harm, ability to pinpoint an item, flexibility and keeping the administrative costs down. The existing locator system was a combination system consisting of a fixed location system and a memory system. It utilized all three of the item placement theories, meaning that item stratification, family grouping and special considerations were employed. Our pharmaceutical inventory management system was missing a system of location addresses and SKU identifiers. After we received a lot of new employees from the Women´s Clinic, the problematic areas started to manifest themselves. The combination system, which was relying heavily on a memory system, had to be changed towards a

fixed location system. This was made possible by alphabetizing the pharmaceuticals and employing a clear system of location addresses and SKU identifiers. Mostly it meant alphabetizing and putting clear markings inside and outside the cabinets to indicate which pharmaceuticals resided where. Alphabetizing removed the problematic issue of item stratification, as the division into two categories, often used and rarely used, ended. Also, from the perspective of lean philosophy, flow was improved via alphabetizing. As the storage of pharmaceuticals became more logical, the employees found the needed pharmaceuticals more quickly, thus reducing waste in terms of wasted time. As a part of establishing the system of location addresses and SKU identifiers, clear quantities were determined for all the pharmaceuticals and posted inside or outside medicine cabinets. After the changes made, the pharmaceutical system became a fixed location system utilizing family grouping and special considerations with a clear network of location addresses and SKU identifiers.

As a part of this project, I also went through our whole pharmaceutical arsenal proposing adjustments to the selection and quantity of pharmaceuticals. We adjusted the pharmaceutical selection by removing some unnecessary pharmaceuticals and by decreasing the number of other pharmaceuticals stored in our medicine cabinets. The alphabetized pharmaceuticals and the lists of the correct quantities of the pharmaceuticals were installed not only to serve as a system of location addresses and SKU identifiers, but also to reduce search time and to help nurses order the right quantities of the correct pharmaceuticals. These actions should reduce the amount of expired pharmaceuticals and the overall financial losses. The lean philosophy plays a part here too, as optimization is implemented to the system. Also, the principle of simplification can be seen present in the simplification of the ordering process. The reforms were done in the main pharmaceutical storage on the 6th floor, in the recovery room on the 6th floor and in the recovery room on the 7th floor.

After implementing these improvements in the summer of 2016, I observed the situation and asked for feedback from my colleagues. Many of them colleagues were happy with the implementation of the improvements. Some had preferred the previous system, but were fine with the new one. The most surprising problem was the difficulty, inability or lack of interest to keep the pharmaceutical storages alphabetized. This is an issue especially in the recovery rooms. Although they are mostly alphabetized, there are clearly much more errors compared to the main pharmaceutical storage. I also have observed and gotten feedback that many of the nurses do not use the lists installed in

the medicine cabinets, but instead order the pharmaceuticals as they see fit. This often leads to the situation, where there are shortages of some most commonly used pharmaceuticals and, at times, there are too many of the some more rarely used pharmaceuticals.

6.2 The future of pharmaceutical storage management

There is a lot of change going on in my unit at the moment. For example, all of the gynecological surgeries are being moved to the Women´s Clinic at the beginning of March 2017. This means also big changes to the pharmaceutical storage management and to the Women´s Clinic, as all the new innovative changes will be implemented there.

In my vision for the future, digitalization plays a big role. At the moment, we use a program called OSTI to order pharmaceuticals. When placing an order, every pharmaceutical must be picked from either a list of most commonly ordered pharmaceuticals or typed into the program individually. Then, usually, a doctor must confirm the order before it goes to the pharmacy. When placing the order, there is also a chance of human error, as the nurse making the order may accidentally order a wrong pharmaceutical, a pharmaceutical of wrong concentration, a rarely used pharmaceutical in bulk or the ordering is forgotten altogether. An answer to these problems could in digitizing and automating the ordering process further.

According to Muller (p. 75), not only time and money saved via elimination of human error, but also the speed of data capture and the accuracy of bar coding are reasons enough to justify the installation of the system in your business. The bar coding system itself requires only the code, the reading device and the printer to operate (Muller, p.75). As the pharmaceutical selection and the accurate number of each pharmaceutical is known, these variables could be fed into the ordering program. Then every time a pharmaceutical would be removed from the main pharmaceutical storage area, the nurse removing it would use a barcode reader on the product and the information of its removal would go straight to the ordering software. Another option could be a scanner, possibly a barcode reader, in the doorway of the pharmaceutical storage scanning the pharmaceuticals leaving the main storage area. A doorway scanner would remove the possibility to forget to read the barcode on the pharmaceutical and could act as a security and tracking system to keep a close eye on the movement and use of pharmaceuticals.

As every product removed from the main pharmaceutical storage area would be entered into the ordering software, the pharmacy then would see in real time the missing pharmaceuticals. As the pharmaceutical selection and the quantity of each pharmaceutical is known, the pharmacy would simply send the accurate number of each pharmaceutical missing from the main pharmaceutical storage area on the predetermined days every week.

This system would mostly eliminate human error in the units making the order, but the possibility for human error remains on the pharmacy´s side. No one could order too little or too much of anything and the pharmaceuticals should be of the correct concentration. There is the possibility that someone could forget to read the barcode on the pharmaceutical after removing it or that there could be a hardware malfunction, but no system is completely without flaws . Also, no one could forget to place the order, as it would be placed automatically and in real-time based on the variables entered into the ordering software. The system could be programmed to warn in advance about upcoming expiration of a pharmaceutical. This system would free up time for the nurses to do actual patient work. The doctor in charge of the pharmaceutical issues would get weekly or monthly reports from the ordering software to check the pharmaceutical consumption and see if there are any deviations in the ordering trends. The optimized pharmaceutical selection and the automated ordering system would also reduce the amount of pharmaceuticals expiring in the medicine cabinets, meaning that there would be also less financial losses.

In terms of lean, digitization would improve flow, striving for excellence, optimization and simplification to the pharmaceutical storage management. Flow would be better, as the possibility to forget to make the order would be eliminated, and the medicine would arrive based on the predetermined variables entered into the system. The quality errors associated with the expiration of pharmaceuticals in the medicine cabinets could be also removed by entering specific variables into the system, which would warn the staff months before upcoming expiration, giving them plenty of time to either dispose of the pharmaceuticals or send them back to the pharmacy. Optimization and simplification go hand in hand. By automating the system as much as possible, it becomes simpler and more optimal, removing unnecessary processes and freeing up personnel for other work. If this kind of system was found functional and successful, standardization on the organizational level could commence.

7 Discussion and Conclusions

In this section I am pondering on the thesis process in general and bring this thesis project to the finish line.

7.1 Summary

The objective of my thesis was to improve the pharmaceutical management system in the operating and anesthesia unit of the Kätilöopisto Maternity Hospital. My starting point to this was my realization that a fairly large amount of the pharmaceuticals expire in the medicine cabinets costing my unit money. Motivated by this realization, I started a six-month observation period cataloguing every single pharmaceutical expiring in the medicine cabinets. After analyzing the data, I discussed the findings and provided the chief of anesthesiology with suggestions on how to proceed. The storage system was updated by alphabetizing the pharmaceuticals, the whole selection was revised and some pharmaceuticals were removed, and specific parameters were set for ordering the pharmaceuticals. The reception for the implemented changes was mostly positive. Unfortunately, some of the staff do not take the changes into account and continue doing things as they have always done them. This was to be expected, as employees used to their routines can be quite resistant to change.

7.2 Practical implications

The starting point for my thesis was my own work as the nurse responsible for the pharmaceuticals in my unit. In my work, I noticed that fairly often expensive pharmaceuticals expire in the medicine cabinets and I wanted to reduce this. My six-month observation period confirmed that this actually was the case. The observation period also revealed that there were many different pharmaceuticals expiring in the medicine cabinets. The bulk of the financial losses are made by a few pharmaceuticals. Although most of the expired pharmaceuticals do not actually cost that much, they do take precious storage space, which is already very limited. All in all, it was quite satisfying to finally verify the issue I had noticed over the years and have the results in black and white.

As a result of the findings, I started to analyze the whole pharmaceutical storage management system and the processes it involved. First, I examined the assortment of pharmaceuticals, in use in the unit. Changes were implemented to the assortment based on the observations made and discussions with the chief of anesthesiology. The biggest change made was that a specific amount was determined for every pharmaceutical in the selection. Other changes consist of removing some pharmaceuticals from the selection, reducing the amount of some pharmaceuticals kept in storage and increasing the amount of some other pharmaceuticals kept in storage. It was clearly easier to suggest and make the adjustments to the pharmaceutical selection than before, as I had research materials to back up my arguments. During the analyzing process of the data, it quickly became very clear that it was not only enough to remove some pharmaceuticals from the selection, but it was necessary to define a clear amount for every pharmaceutical in stock. People tend to order pharmaceuticals based on their gut feeling, which quickly leads to a situation, where we have a lot of pharmaceuticals we do not need. Eventually, this type of an ordering habit leads to pharmaceuticals expiring in the medicine cabinet. Also, the medicine cabinets were alphabetized to help the staff find the pharmaceuticals more quickly and to make the pharmaceutical storage system more efficient. This pharmaceutical storage system improvement project can be also seen as part of the ongoing LEAN project sweeping the whole unit in both hospitals, as this thesis has been all about removing wasteful practices and making the pharmaceutical storage system more efficient.

7.3 Outcome versus objective

The objective of my thesis was to reduce the expiration of pharmaceuticals in the medicine cabinets and minimize the financial losses connected to the expiration of pharmaceuticals by improving the existing processes in the pharmaceutical storage system or by implementing completely new processes.

After the six-month observation period I got verification for my original hypothesis that a fairly large amount of pharmaceuticals expires in the medicine cabinets, especially expensive coagulation factors. Based on the results of the observation period, modifications were made to the pharmaceutical selection by removing, reducing or increasing certain pharmaceuticals. Also, the exact amount of every pharmaceutical was

defined and listed in every medicine cabinet. Then the pharmaceuticals were alphabetized, as some pharmaceuticals need specific conditions for storage and some pharmaceuticals are so great in number that they need separate storage cabinets. These cabinets are marked based on the purpose of use of the pharmaceuticals stored there.

As my objective was to reduce the number of pharmaceuticals expiring in the medicine cabinets and by doing so also reducing the financial losses connected with the expiring pharmaceuticals, I am fairly certain that the changes implemented will reduce the number of pharmaceuticals expiring in the medicine cabinets and the removal or reduction of some of the most expensive pharmaceuticals from the selection alone guarantees a significant reduction to the financial losses due to expiration in the future. Actual verification of this would require another observation period. Even if I undertook such an endeavor, the results would not be comparable, as the nature of the unit is changing in March of 2017 and with it the pharmaceutical selection. Regardless of the coming changes, the implemented adjustments stand. The pharmaceutical selection and the quantities simply must be adjusted to better serve the changed need of the unit.

7.4 Reflection and afterword

In general, I think succeeded in my thesis project relatively well if one takes into consideration the challenging circumstances the project was completed in. By the circumstances I refer to the changes my unit has undergone during the last year and a half and continues to undergo. Also, balancing work, different courses at school and the thesis project has been quite difficult and at times the thesis project has had to take the backseat in the greater scheme of things. These are also the reasons I was not able to complete the thesis according to the original schedule and had to ask for an extension on the research permit (Appendix 2).

In the thesis process, I was satisfied with my six-month data gathering phase. The results were more or less what I had predicted. Perhaps a longer data gathering phase could have given a more accurate picture of the situation, but even the shorter observation period more or less confirms my original hypothesis. The implementation of the changes and the improved processes were successful and the changes implemented received more positive feedback than negative. Keeping up the implemented changes has proven, not surprisingly, challenging, as the rest of the staff does not adhere the implemented

changes very enthusiastically, even though they appreciate them. This is difficult, because my normal responsibilities take up most of my time and upholding the changes would require more attention than I can spare at the moment.

The writing process itself has been periodic at best, as the courses during the three semesters took all of my time. The writing took place between the semesters, but the bulk of the writing was done after I had finished all the courses. For future reference, I hope that the course load will not be so punishing and that the studies will enable actually working on the thesis also during the semesters. 90 credits compressed into year and a half of studies means an overwhelming amount of work, especially for those working full-time at the same time. I would have appreciated to be able to write my thesis throughout the whole length of my studies instead of writing it between the semesters and after the actual studies. This would have made my thesis process more cohesive and effective. This also would have enabled me to turn in my thesis earlier.

The changes and the improved processes implemented are unique and personalized for my unit and cannot be repeated in other units in this form, as every unit must first examine their own pharmaceutical storage management systems to improve it in the future. Some of the solutions and the changes made can be used elsewhere, if they serve the need revealed by their initial examinations.

Like in many other fields, digitalization is the future in this case as well. Reducing the possibility of human error and making some current work stages obsolete is possible by implementing digitized solutions. Digitizing could free up staff to perform their actual work duties and enable the unit to maintain a minimal pharmaceutical selection and by doing so save money. This, of course, is only speculation, as proving this would require further studies. Since digitalization of these functions would require investments from the Hospital District of Helsinki and Uusimaa (HUS), this could be a formidable area for future studies.

To sum it up, my thesis work improved the pharmaceutical storage system in my unit. The adjustment of the pharmaceutical selection removed unnecessary pharmaceuticals and will reduce the monetary losses due to expiration in the future. Alphabetizing and labeling the pharmaceuticals in the medicine cabinets will help the staff to find the needed pharmaceuticals and increase efficiency. Also, defining the exact number of every pharmaceutical in storage will maximize the use of the storage space and reduce the monetary losses due to expiration. Maintaining the system is challenging, but with

time and by winning the hearts and minds of the rest of the staff, the new pharmaceutical storage management system will prevail. Or would have prevailed, but as the Kätilöopisto Maternity Hospital closes in the autumn of 2017, the improvements implemented are a short-lived triumph. In the end, the best result of this thesis is the concept of the next step in the evolution of pharmaceutical storage management.

References

HESSE-BIBER, S. Mixed Methods Research. (2014) [Online] Available from: http://www.proquest.com [Accessed: 5th May 2016]

HUS. *Operating and Anesthesia Unit.* [Online] Available from: http://www.hus.fi/en/medical-care/hospitals/katiloopisto-maternity-hospital/wards/Operating-and-Anesthesia-Unit/Pages/default.aspx [Accessed: 13th may 2015].

KOSHY, E., KOSHY, V & WATERMAN, H. (2011) Action Research in Healthcare. London: Sage Publications Ltd.

KOTHARI, C. (2004) Research Methodology: Methods and Techniques. [Online] Available from: http://www.proquest.com [Accessed: 30th April 2016]

KUANDA, J. Research Methodology: A Project Guide for University Students. (2012) [Online] Available from: http://www.proquest.com [Accessed: 5th May 2016]

LEAN ENTERPRISE INSTITUTE. (2016) [Online] Available from: http://www.lean.org/ [Accessed: 12th July 2015]

MULLER, M. Essentials of Inventory Management. (2011) [Online] Available from: http://www.proquest.com [Accessed: 21st May 2016]

SOSIAALI- JA TERVEYSMINISTERIÖ. (2010) *Ministeri Hyssälä: lääkehoidon kustannuksia ja tuloksia arvioitava kokonaisuutena.* [Online] Available from: http://www.stm.fi/tiedotteet/tiedote/-/view/1488667 [Accessed: 7th may 2015].

TERVEYDEN JA HYVINVOINNIN LAITOS. (2013) *Terveydenhuollon menot ja rahoitus 2013.* [Online] Available from: https://www.thl.fi/fi/tilastot/tilastot-aiheittain/sosiaali-ja-terveydenhuollon-talous/terveydenhuollon-menot-ja-rahoitus [Accessed: 7th may 2015].

THIETART, R-A. (2001) Doing a Management Research: A Comprehensive Guide. [Online] Available from: http://www.proquest.com [Accessed: 30th April 2016]

TRENT. R. (2007) End-to-End Lean Management. [Online] Available from: http://www.proquest.com [Accessed: 12th July 2016]

VALVIRA. *Professional practice rights*. [Online] Available from:
http://www.valvira.fi/en/licensing/professional_practice_rights [Accessed: 13th May
2015].

VERÄJÄNKORVA, O., HUUPPONEN, R., HUUPPONEN, U., KAUKKILA, H-S &
TORNIAINEN, K. (2006*) Lääkehoito Hoitotyössä.* Helsinki: WSOY oppimateriaalit Oy.

Appendices for client´s use only