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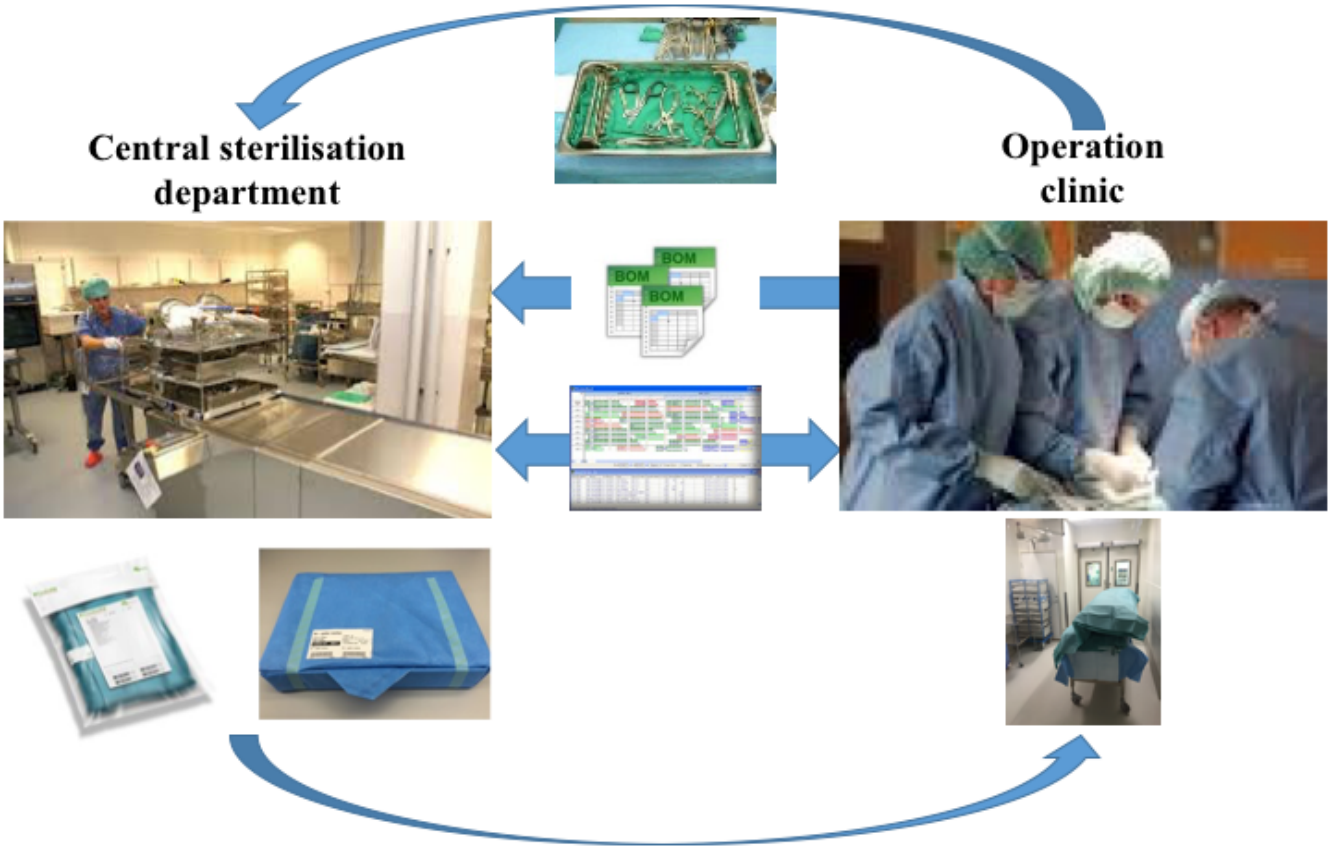

Reduction of Changeover Time between Surgeries

Design and evaluation of a materials supply process of surgical material to operation theatres

Master's Thesis in Quality and Operations Management

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Cover:
Graphical illustration of the proposed and evaluated materials supply process.

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Abstract

This study, is a result of a collaboration between Uddevalla hospital, Västra Götalandsregionen, and Chalmers University of Technology. The purpose of the study is to designing a new materials supply process of surgical material for the operation clinic at Uddevalla hospital which enables for decreased changeover time between surgeries.

The study is conducted at Uddevalla hospital, a hospital which provides elective patient care. The flow of surgical material towards the part of the operation clinic that performs hip surgery is investigated. In order to map out the flow of surgical material towards the operation clinic, the project team follows the material from contamination during surgery, to it being back in the operation clinic storage, sterilised and packed. Data is collected through literature search, and a combination of structured observations and semi-structured interviews at Uddevalla hospital, NÄL hospital, and Mölndal hospital.

During the data collection and the description of the current situation at Uddevalla hospital, it is made clear that material handling activities take place at the operation clinic which could be performed elsewhere by other personnel. Further, handling of separate disposable articles is identified as time consuming, and the operation table setting is appointed as the activity that effect the changeover time the most.

A new materials supply process is suggested in which the activities operation cart packing and disinfection are externalised from the changeover process at the operation clinic to the central sterilisation department. Further, the project team recommends the introduction of operation table setting rooms. The project team also suggests the introduction of procedure packs, which are packages in which all disposable material needed for a type of surgery are combined in a single package.

The new materials supply process, through externalisation of material handling activities, frees-up time for the operation clinic personnel, and enables for more patient care, hence reduced changeover time between surgeries. The operation table setting rooms allow the operation table setting to be performed during ongoing surgery. The procedure packs simplify the cart packing by reducing the number of articles to collect, and they speed-up the operation table setting since fewer packages have to be opened.

The externalisation of the disinfection process and the operation cart packing require a new IT-system in which orders can be placed and information sharing between the central sterilisation department and the operation clinic is enabled. To further improve the communication between the two units, it would be beneficial if they could be located on the same floor, which requires a new operation building.

Keywords: changeover time, hospital logistics, materials supply, surgical instruments, disposable material

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1 Introduction

In this chapter, background information regarding hygienically surgical material handling is presented along with an introduction of surgical logistics within Västra Götalandsregionen (VGR), including a description of the surgical units at Uddevalla hospital. Further, the purpose and scope of the study, are presented.

1.1 Background

The background provides an introduction of hygiene within surgical material handling, and its importance for patient safety. Following from the introduction of hygiene, the problem at VGR is introduced, the changeover time between surgeries and resource utilisation. The section introduces surgical logistics within VGR, and its connection to changeover time. The organisation's wishes with the study is presented and the surgical units at Uddevalla hospital is introduced.

1.1.1 Introduction to hygiene within surgical procedures

The awareness of the effect of hygiene in surgical contexts was put into practice by Joseph Lister, in terms of disinfected skin, wound and suture material, in the end of the 1800 (Lindholm & Barkenfelt, 2015). The reason for the introduction was the inspiration from the chemist and biologist Louis Pasteur who had been studying the way bacteria cause decomposition and infections. The introduction of these disinfection procedures made the mortality for amputations decrease from 43% (1864-1866) to 15% (1867-1869). The next revolutionary step within hygienically procedures within surgery, introduced by George Emerson Brewer, was the sterilisation of surgical equipment which decreased the infection risks for patients from 39% (1895-1896) to 3,2% (1898-1899) (ibid.).

To ensure high quality and safety within healthcare, and surgical clinics, emphasis is put on preventing infections. Infections can be dangerous for the patient and costly for entire societies (Socialstyrelsen, 2006). Today, the knowledge of infection risks in connection to surgery is on wuthering heights in comparison to the 19th century. Nowadays it is common knowledge that microorganisms from the patient's own flora or the surrounding may cause infections to the patient. Naturally, procedures are aligned with this knowledge. Just to mention a few hygiene rules, that the project team has been introduced to during this study, instruments used are washed and sterilised and their sealed packages are opened just before operation. Furthermore, operation clinic personnel are wearing operation clothes in materials that do not shed and doors are opened only if absolutely necessary, not to cause any unnecessary flow of air that might bring in unwanted particles that may cause infections.

Supporting backstage procedures, such as processing of instruments and material handling, is not typically the first thing that gets into one's mind when hearing the word surgery, but they are crucial processes that in truth mean the differences between sickness and health, and maybe even life and death. This study focuses on the materials supply processes, which is a chain of activities that carry surgical material, both disposable material and instruments, to the operation theatre, where surgery takes place.

1.1.2 Introduction to surgical logistics within VGR

VGR includes 17 hospitals in the western region of Sweden, which account for approximately 19% of all medical care in Sweden (Västra Götalandsregionen, 2016). A large variety of operations are performed within the different hospitals, and many operations are performed on a daily basis. Hospitals within VGR are demanded to perform a certain amount of operations every year. For VGR it is of high interest to increase the amount of operations performed every year, and, thereby, to decrease the waiting times for their patients. Regionservice constitute a part of VGR and is providing logistical support to enable efficient resource utilisation within the different hospitals within VGR.

In times when resources are getting more scarce, it puts pressure on hospitals, in general, and so in turn the operation clinics to use those resources wisely. Vårdförbundet, a Swedish trade union for health professionals, has stated that there is an alarming lack of operation room nurses in all regions of Sweden (Vårdförbundet, 2013), why VGR wants to make sure that these employees are spending their time on accurate tasks connected to medical work that others do not have neither experience nor education to perform. It has been stresses that too much material handling activities, today, are performed by operation room nurses, and other operation clinic personnel, such as disinfection, packing and storage activities.

One way to decrease the time spent on materials handling for the operation clinic personnel and enable for an increased number of performed operations, that VGR firmly believes in, is to move materials handling activities upstream the supply chain. That means to prepare as much as possible of the material outside the operation clinic, and have it delivered shortly before operation. The collection of prepared material will in the future be referred to as a kit. Preparation of kits, consisting of both surgical instruments and disposable material allows for the proportion of time spent on patient care to increase compared to the changeover time. In this way, the scarcest resources are utilised more wisely and the possibility of performing more operations increases. Changeover time, in a surgical context, is the period required for the process to change from finished operation to the start of another.

VGR wants the space at the operation clinic to be used in the most cost effective way. VGR means that there exists improvement potential in the space utilisation at the operation clinic, that today holds high volumes of stock. High volumes of stock at the operation clinic causes high cost of capital, and it signifies occupation of expensive space that could be used for patient treatment instead.

The processes that turn the contaminated surgical instruments usable, and packed together with disposable material, will in this study be referred to as the materials supply process. The definition of the term 'usable' is that the instruments and material are sterile, set on the operation table, and ready for use. VGR believes that there is great improvement potential in the supporting materials supply process to become more time efficient, space efficient and, hence, cost efficient, and more patient safe.

According to Poulin (2013) the budget expenses for a hospital is not only made up of direct patient care, but that logistics accounts for a big portion. Studies have shown that 30-46%[1] of hospital expenses are invested in different logistical activities. This gives an indication of the role that logistics play within hospitals and the significant gains that could be achieved through investments in improvement activities.

In order to improve a process, it is crucial to understand the elements that it is composed of and how they interact (George et al., 2005). Operation clinic personnel, such as operation room nurses and assistant nurses, are through collaboration with the surgeon and the anaesthesia doctor managing the process of performing safe and successful surgery. In order for the process to be effective, the operation clinic personnel must be given the best possible working conditions. Figure 1.1 shows that to be able to perform surgery, people, facilities, equipment, and material, need to be put in place, and work together.

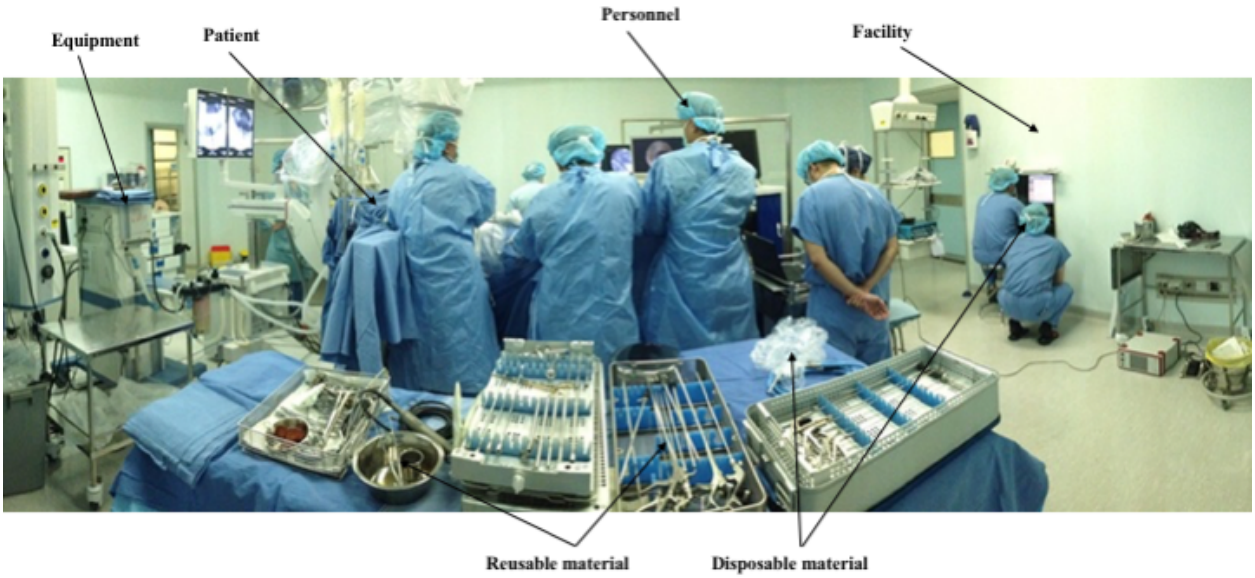

Figure 1.1. A photo illustrating an ongoing surgery, which shows the complexity of the needed personnel, instruments, disposable material and equipment. Picture taken from internal presentation at VGR.

[1] Including support services such as purchasing, stores, the pharmacy but also health care services such as patient care units and operating rooms.

1.1.3 Introduction to operation clinics at Uddevalla hospital

Uddevalla hospital, since 2015, only performs elective health care, i.e., planned health care. Uddevalla hospital contain four clinics that performs surgery; the outpatient surgery clinic, the orthopaedic clinic, the surgery clinic and the operation clinic. At the outpatient surgery clinic, minor surgical procedures are performed. This type of surgery does not require overnight hospital stay. At the surgery clinic, inguinal hernia, tumour, and urology surgery is performed. At the orthopaedic clinic, orthopaedic care is performed. The operation clinic is a shared resource for the different clinics at Uddevalla hospital. The operation clinic provides the other operation clinics with operation facilities, material, and personnel, except for the surgeon that belongs to one of the other clinics. One area of the operation clinic is mainly focusing on hip and knee replacements, and shoulder and back surgery, and consist of four operation theatres. This part of the operation clinic will be referred to as the operation clinic throughout this study. Out of all the clinics that are involved in surgery, the operation clinic is the one that uses the most resources when it comes to material handling, as its surgical procedures require the greatest amount of instruments.

Uddevalla hospital includes one central sterilisation department which is responsible for providing the hospital's different operation clinics with sterile surgical material, both instruments and disposable material. In the near future, there will be a decision about building a new operation building which will include a new central sterilisation department and a new operation clinic. It is therefore important that the design of the logistics process is considered before the start of construction.

A functional materials supply process is a requirement for performing surgery, and the current process in Uddevalla hospital could be more efficient if the right activities were performed by the right people in the accurate place.

1.2 Purpose

The purpose of the study is to designing a new materials supply process of surgical material for the operation clinic at Uddevalla hospital which enables for decreased changeover time between surgeries.

The new materials supply process shall free-up time for the operation clinic personnel from material handling activities, and hence enable for a higher utilisation of the operation clinic personnel, in terms of patient care. The new materials supply process will be evaluated with respect to the following measures: time, quality, and cost. Time refers to changeover time, quality is linked to patient safety, and cost is capital cost in terms of storage of material. Changeover time and patient safety will be of highest priority when evaluating the materials supply process, while cost will be considered as a secondary measure. In this study, cost is a secondary measure, since the aim of the study is not to directly to decrease cost, but to decrease changeover time. However, it is an important measure to include since money is something that people in general can understand and relate to.

Additionally, the study aims to present prerequisites needed for implementing the new materials supply process and provide further input to the implementation phase. Finally, the aim is to present the results of the study in such a way that it serves as input when building the new operation building at Uddevalla hospital.

1.3 Scope

This section presents the focus of the study, meaning subjects and areas that will be investigated. It also describes the reason why these particular areas have been chosen, and are relevant to study in terms of feasibility and possible gains.

In order to maintain the study focused, the project team has chosen to study the materials supply process for planned surgery, i.e., elective care, but not for emergency surgery. More precisely, the project will focus on the materials supply process for two specific types of operations, namely hip replacement surgery and hip revision surgery. A hip replacement means that the patient will get a new hip prosthesis while a revision surgery means that an existing prosthesis is repaired. The reason for the choice of operations is that these types of surgeries are performed frequently at Uddevalla hospital. It is considered more relevant to study high frequency operations, rather than low frequency operations, since improvements here have greater impact on personnel's' everyday work. Additionally, these operations are considered appropriate to study since they require a considerable amount of material, and hence their materials supply process has a greater impact on the changeover time between surgeries than operations that require smaller volumes of material. Further, the reason why two kinds of operations will be studied is that it increases the amount of available data and enables for more general conclusions.

Patient safety will be considered in the report, but only in connection to the materials supply process for the operation clinic. The project team will not bring up subjects concerning how surgical procedures and medical treatments are performed. The reason for this is, naturally, the project team's lack of knowledge in that field. Further, the study has, from the start, been pinpointed to focus on the materials supply process, i.e., material flows and not patient flows. The materials supply process will in this study be defined as the processes that carry both the disposable material and the surgical instruments forward. For the disposable material, the scope of the materials flow is from receiving the material at the hospital to it being utilised in the operation theatre. For the instruments, the materials supply process is viewed as a cyclic process, from it being used to it being set on the operation table, ready to be used again.

The study will be focused on Uddevalla Hospital. The reason is that there are plans of building a new operation building to replace the already existing one at Uddevalla hospital. Due to the need for input when planning for the construction of the new operation building, it was requested by the hospital that a study was performed on how work is conducted today, including current areas of improvement. Uddevalla hospital is representative for hospitals in general within VGR, in terms of size, why studying this particular hospital enables for relevant future comparisons and generalisations.

2 Frame of reference

This chapter aims to present findings from relevant literature that is connected to this study. The content is serving as input regarding how to analyse today's materials supply process and to be able to analyse the new materials supply process proposal. The chapter presents research done in the area of operation efficiency, such as changeover time reduction and introduction of procedure packs.

2.1 Process improvement

The supply of surgical material towards the operation clinic at Uddevalla is considered to be a process. Since the project team seeks to improve this surgical materials supply, theory about process improvement is presented.

Harrington (1991) divides processes into production processes and business processes. According to Harrington (1991, p. 9), the definition of a production process is: "any process that comes into physical contact with the hardware or software that will be delivered to an external customer, up to the point the product is packaged, excluding shipping- and distribution processes." A business process, on the other hand, is a supporting process to the production process. According to Harrington (1991, p. 9) a business process can be any type of service process, and it "consists of a group of logically related tasks that uses the resources of the organization to provide defined results in support of the organization's objectives."

Once the type of process is classified, it is possible to bring forward the accurate tools for improvement. The materials supply process, investigated in this study, is considered to be a business process, and the total process of providing surgery, in which materials supply is included, is the production process. To map out the process helps and enables for a thorough analysis of the process. When the process is identified and visualised Harrington (1991, p. 132) has put together twelve tools for streamlining a business process. The purpose of the tools, presented in table 2.1, is to trim waste, with the goal to improve performance and quality.

Table 2.1. Twelve tools for streamlining a business process according to Harrington (1991).

Nr.	**Tool**	**Nr.**	**Tool**
1.	Bureaucracy elimination	7.	Upgrading
2.	Duplication elimination	8.	Simple language
3.	Value-added assessment	9.	Standardisation
4.	Simplification	10.	Supplier partnership
5.	Process cycle-time reduction	11.	Big picture improvement
6.	Error proofing	12.	Automation and/or mechanization

According to Harrington (1991), to perform the same activity at different stages of the process, adds to the overall cost of the process. Further, duplication could generate conflicting data that unbalance the process, since data gathered for the same procedure in different parts of the process, might mismatch. Hence, elimination of duplicative work, provides opportunity to improve the overall organisation's effectiveness.

2.2 Process flow and Just-In-Time production

Theory about Just-In-Time production is relevant in the creation of the new materials supply process and analysis of today's process at Uddevalla hospital, as the project team seeks possibilities to better utilise space and decrease inventory related activities for the operation clinic personnel, why deliveries of the required material in the right time is interesting to take into account. Just-In-Time, continuous flow and pull systems are usually associated with industrial production system. The project team believe that they are transferable and applicable in a hospital setting since the aim is to move towards surgery initiated material orders.

Just-In-Time refers to a system in which products or services are delivered at the right time, in the right quantity, with the right quality, to the right place, and right price (Womack, Jones & Roos, 1990). Just-In-Time production requires flexible resources, high quality, no machine breakdowns, reliable suppliers and quick machine set-ups, since there is little back-up in terms of stock.

Striving towards a one-piece flow is the goal for a production process (Liker & Meier, 2006). In a one-piece flow, only material for the next operation is built up, it is the perfection of a continuous flow. When sustaining a continuous flow, problems are surfaced that inhibit the flow, while the alternative is overproduction which is considered to be the worst of wastes (Liker & Meier, 2006).

Pull is a concept that is often used interchangeably with flow (Liker & Meier, 2006). Flow defines that state of material as it moves from process to process. Pull is a type of flow in which material is moved accordingly to request. The following criteria need to be in place to enable a continuous flow:

Table 2.2. Key criteria for achieving flow, taken from Liker and Meier (2006, p.91).

1.	"Ensure consistent capability, which is the primary intent of the stability phase. At the very least, the level of capability should be on a daily basis. During each day the operation must be capable of fulfilling the requirements of the customer."
2.	"Consistent capability requires consistent application and availability of resources-people, materials, and equipment. The inconsistent availability of these resources is the primary reason that flow is unsuccessful. Methods must be put in place to ensure availability of resources (not by simply adding resources, which is added cost)."
3.	"Reliability of processes and equipment is imperative. Initially this would encompass the larger issues such as downtime, or changeover, but as the process is refined it would include lesser issues such as ease and simplicity of use."
4.	"Operation cycle times must be balanced (equal) to the takt time. Uneven work times will create waiting time and overproduction."

2.3 Changeover time

The project team seeks to decrease the changeover time between orthopaedic operations at Uddevalla hospital, why theory about how this can be done will be presented. Further, an example of how changeover time can be analysed in a case of orthopaedic operations is given, along with information about how changeover time can be divided into different phases.

Changeover is a term that is normally used when talking about manufacturing processes. According to Henry (2013) the definition of "changeover is the total process of converting a machine, line, or process from running one product to another." Changeover time can be reduced by elimination, simplification, externalisation, and execution. Elimination is considered to be the most important approach of changeover time reduction, since it is double waste to try to improve an activity that is not value-adding in the first place.

Single-minute exchange of die (SMED), developed by Shiego Shingo, is a method for reducing waste in a manufacturing process. Explained by Henry (2013), the concept of converting changeover tasks from internal to external was the greatest contribution of SMED. Internal tasks, takes place when the production line is stopped. Externalisation means to do those internal tasks without disturbing the production, when the production line is running. Externalisation does not necessarily mean that tasks are eliminated or that labour hours are saved, in some cases labour hours may increase because of parallel work. However, it might still make sense if labour hours increase, if the cost of stopping the main manufacturing process is very high. Shingo (1985), uses SMED to eliminate waste by firstly separating internal setup from external setup to make sure that operations can be conducted as external setup. Secondly the internal setup is converted to external setup, and finally all aspects of the setup operation are streamlined.

In this case, the theories developed by Shiego Shingo can be applied to the surgical process at Uddevalla hospital. The main manufacturing process is then when the surgery takes place and the changeover is the conversion between the operations. The materials supply process is considered to be the major part of the changeover since it is that process that enables a new operation to start.

2.3.1 Changeover time between surgeries

In figure 2.1 a process map is presented, illustrating typical activities that constitute the changeover between orthopaedic surgeries. The process map is taken from a study of changeover activities for orthopaedic operations performed by Meredith et al. (2011).

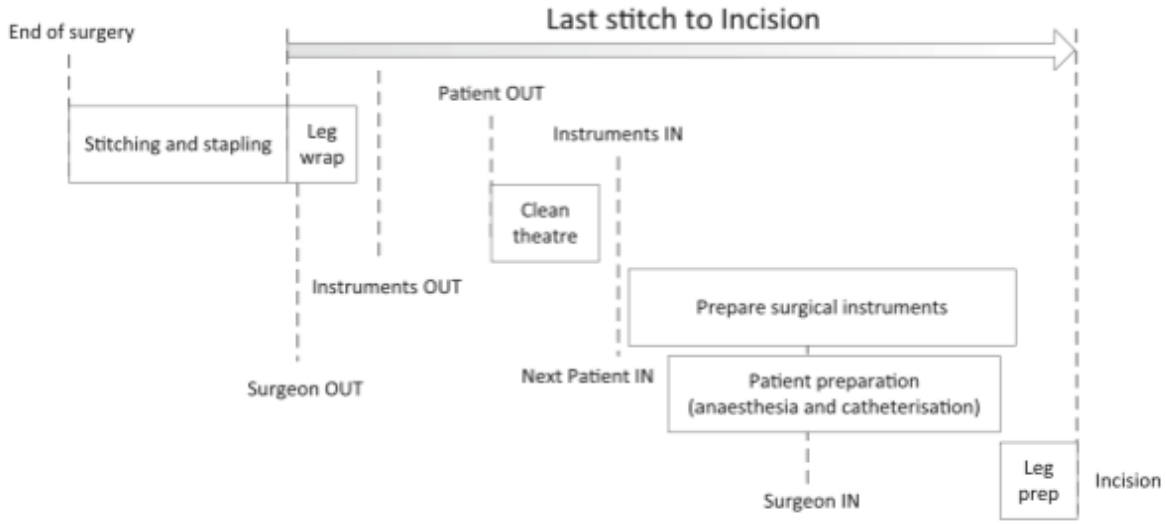

Figure 2.1. A process map illustrating the changeover activities between orthopaedic surgeries, taken from Meredith et al. (2011).

Further, Meredith et al. (2011), developed a model, figure 2.2, for orthopaedic surgery changeovers, where the changeover process is divided into three phases. The three different phases are essential to analyse and examine, as standardisation of these phases can serve as help when reducing changeover time. In this study, operation preparation, regarding the materials supply process, will be the main focus.

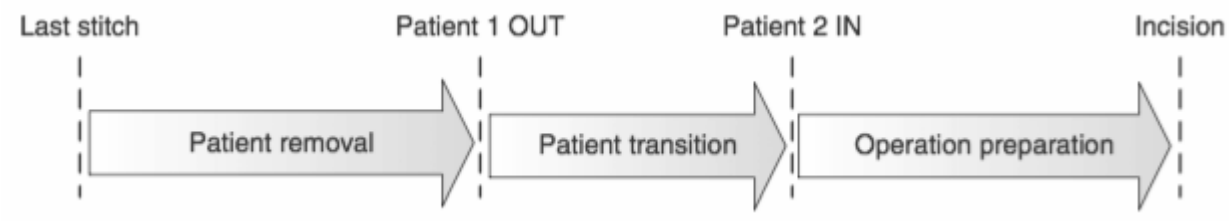

Figure 2.2. An illustration of how orthopaedic surgery changeovers can be divided into different phases according to Meredith et al. (2011).

Meredith et al. (2011) have applied operations management methods to analyse elective orthopaedic surgery and describe the issues that affect operation theatres' productivity. The authors conclude that concurrent process design, meaning a process design that enables for performance of work activities in parallel, requires less time than a serial process design. A concurrent process design, of the changeover process, results in shorter changeovers and hence increases the possibility of broaden the number of performed operations. The rest of their findings, of what speeds up changeovers, are presented in table 2.3.

Table 2.3. Summary of what speeds up and slows down changeovers of orthopaedic surgeries, taken from Meredith et al. (2011).

	Faster	Slower
Process archetype	Patient preparation and instrument preparation concurrently	Patient preparation and instrument preparation in series
First case setup timing	Long first case setup	Short first case setup
Prepare surgical instruments	Two stage preparation, start of day and during changeover	Complete preparation during changeover
Surgeon availability	Surgeon in theatre during changeover	Surgeon arrives after patient is ready for operation
Theatre layout	Set up room adjacent to theatre for patient preparation	No set up room—all processes occur in theatre

Time is a crucial measure for efficiency, but also patient safety, and so in turn it is an important measure for quality. It is crucial that operation times are kept as short as possible since the longer the broken skin is open, the greater is the infection risk (Klundert, Muls & Schadd, 2008). Reduced changeover time could contribute to decreased waiting time for a patient who is about to get surgery. A patient that is waiting to get surgery does not eat during the day, which causes the body temperature to decrease. A cold patient is at greater risk of getting infections during an operation, why keeping surgeries on time is of outmost importance for the patient's safety.

2.4 Standardisation

In this theory section, standardisation is presented from an industrial point of view to enable an analysis of the standardisation degree of material handling activities at Uddevalla hospital. The standardisation analysis will be linked to the quality aspect as low degrees of standardisation could mean that the same procedures are being performed differently. Literature about prerequisites for standardised work is presented below, as this will be a part of the analysis. Further, standardisation will be analysed in terms of the hospital's vulnerability to unforeseen events, why theory about robust design is presented in this section.

The purpose of standardised work is to serve as a foundation for continuous improvement (Liker & Meier, 2006). If the work is different from time to time, there is no basis for evaluation. Prerequisites of standardised work can be found in table 2.4 below.

Table 2.4. Prerequisites of standardised work, taken from Liker and Meier (2006, p. 125).

1.	"The work must be repeatable. If the work is described in "If...then" terms, it will not be possible to standardize. For example, if the task is described by saying, "If A happens, then do B, but if C happens, do D," and so on, it is not possible to standardize unless these are just a few very simple rules."
2.	"The line and equipment must be reliable, and downtime should be minimal. It is not possible to standardize if the work is constantly interrupted and the worker is sidetracked."
3.	"Quality issues must be minimal. The product must have minimal defects and be consistent in its key parameters. If the worker is constantly correcting defects or struggling with the effects of poor product uniformity-such as size variation that affects the fit of the part, and thus the time required-it is not possible to see the true picture of the work."

2.4.1 Robust design

A powerful tool for reducing cost and increase quality, in both products and processes, is robust design (Bergman & Klefsjö, 2010). Robust design focuses on improving the function of the product or the process, taking noise factors, environmental variation, into account. This strategy enables for flexible products and processes that are not vulnerable to unavoidable conditions. In order to maintain an organisation that is functional no matter unforeseen events such as absent personnel, requires standardisation.

2.5 Waste reduction

Waste will be considered when evaluating the current and the future materials supply process, even if the aspects that are analysed are not necessarily addressed as waste. The types of waste that will be focused on are wait time, transportation, processing, inventory, and defects.

There are many aspects of cost found in the supply of surgical material. This section of the theory will present cost from a waste reduction perspective. Cost is reduced by the elimination of waste (M. Winroth, lecture, 8 September, 2014, Liker & Meier, 2006). Waste ("muda" in Japanese) is 'anything other than the minimum amount of equipment, materials, parts, space, and worker's time, which are absolutely essential to add value to the product.' (Shoichiro Toyoda Founder, Toyota). There are seven types of waste, namely: over-production, wait time, transportation, processing, inventory, motion, and defects.

2.6 Procedure packs in a surgical setting

Utilisation of procedure packs will be taken into account when analysing possibilities of implementing the new materials supply process at Uddevalla hospital, why literature on the subject will be presented in the following section. Apart from describing the meaning, and giving an example of a procedure pack, cases in which introduction of procedure packs lead to significant gains will be presented.

A procedure pack is a pre-packed package containing disposable material such as drapes, gowns and other items that are going to be used during an operation (Boyd, 2004). At Regina QuÁppelle Health Region, a healthcare organisation in Canada, procedure packs were introduced for the first time year 1997. The content of their first basic procedure pack is presented in table 2.5.

Table 2.5. Content of the first basic procedure pack in Regina QuÁppelle Health Region (Boyd, 2004).

Nr.	**Item**
1.	The back table cover.
2.	The drapes suitable for the position of the patient.
3.	The prep dish and components
4.	Gowns for the nurse, surgeon and assistant.
5.	A variety of other items such as dressings, needle board, cautery and scalpel blades.

This procedure pack was meant for cardiovascular surgery, heart and blood vessels surgery, but later more types were introduced for other types of surgeries (Boyd, 2004). One of the benefits achieved through use of procedure packs is standardisation; the surgeons had to agree on the content of the packs, and hence method of the procedure. The effect of that was that material handling became less confusing and time consuming for the operation clinic personnel. Boyd (2004) states that the nurses estimate that they save approximately 10-15 minutes in setup time for each surgical procedure due to the introduction of the procedure pack. Another gain noted from the introduction of procedure packs is decrease in the stress level for the material processing staff due to reduction of work elements. The operation clinic personnel did also notice an improved quality level since the procedure packs minimised the delivery of wrong articles.

Significant time savings for the materials supply for open heart surgeries have been possible due to the introduction of procedure packs according to Kinney and Lutjens (1986). The greatest time savings were recorded during the collection of disposable material and the un-wrapping of single-use products during the setting of the operation table. Before the procedure packs were introduced, 170 packages were used to provide 110 separate articles. After the introduction only four packages were necessary and the mean turnover time was reduced from 328 minutes to 90.5 minutes, where the turnover time was defined as the elapsed time from the patient left the operation theatre until the room was ready for the next procedure. Further, Kinney and Lutjens (1986) states that the combined effort from nurses, physicians, and the materials supply company representatives, was the key behind the success of the composition, introduction, and usage of the procedure packs.

2.7 Throughput time

The recorded throughput times of materials supply activities from Skaraborgs hospital, presented in the following section, will serve as complementary input to the observations of the materials supply process at Uddevalla hospital. Further, it will serve as input when determining required capacity level at the central sterilisation department at Uddevalla hospital to enable deliveries according to material demands of the operation clinic.

Lindholm and Barkenfelt (2015) have performed a study of the processing time of transforming contaminated surgical instruments to usable packaged and sterilised instruments in Skaraborgs hospital, comparable in size to Uddevalla hospital. Lindholm and Barkenfelt (2015) studied the processing time for a surgical net which included 48 articles and concluded that the average total time for processing this net is 3.4 hours. The studied activities, including the average recorded time for each process, can be found in table 2.6.

Table 2.6. Processing times for a net containing 48 articles at Skaraborgs hospital, recorded by Lindholm and Barkenfelt (2015).

Nr.	**Activity**	**Time (min)**
1.	Loading of the net into the washing machine	3.5
2.	Disinfection	55.4
3.	Cooling after disinfection	15.5
4.	Inspection and packing of net, including wrapping	11.8
5.	Sterilisation in autoclave	66.2
6.	Cooling after sterilisation	49.4
	Total	201.8

2.8 Change management

One of the aims of the study is to provide input to the implementation phase. The following section contains strategies for aligning the team that the change concerns, making them working in accordance to change.

To succeed in business today is hard; competition is intense, customer expectations are high, and government deregulations have to be taken into account (Nadler & Tushman, 1997). The source of truly sustainable competitive advantage lies in organisational capabilities, including the capability to change strategy, method, and even alignment when needed. Once it has been decided to change an inefficient, or even non functional way of working, and a new proposition has been designed, change doesn't happen overnight and seldom is it welcome. Nadler and Tushman (1997) argue that design problems, are usually problems of implementation, meaning that it is not necessarily a poorly designed proposition that makes the change unsuccessful, rather a poorly executed implementation phase.

Nadler and Tushman (1997) mention three main problem areas related to change, and how to tackle them. To begin with, the problem of power, is the challenge of shaping political dynamics associated to change. To handle this problem, one must receive the support of key power groups such as stakeholders. Strategies for building this support could be participation and bargaining. Further, it is important to demonstrate leadership in support of change, articulating a vision of the future state, providing enough support and resources, and remove roadblocks. Moreover, the use of symbols such as graphics, symbolic acts, etc. can be powerful when communicating. Additionally, to build in stability in the change phase, one must allow time to prepare for change, send consistent messages, and communicate what will not change, to reduce defensive actions and conflicts. Second, is the problem of anxiety. Anxiety is created when people have to replace old habits and working methods with new one's. In order to decrease anxiety and instead motivate constructive behaviour in response to change one can create dissatisfaction with the current state and reward desired behaviour in transition to the future state. Thirdly, and lastly, is the problem of organisational control, which is the objection to managing the transition state. By communicating repeatedly, through multiple channels, a clear vision of the future state and a description of how things will operate, the process is kept on track. Further, it is beneficial to continuously evaluate the success of the transition state in accordance to, the transition plan.

2.9 Analytical framework

Based on the theory presented in chapter 2, 'Frame of reference', this section aims to describe what data that needs to be collected to be able to conduct the analysis of today's situation and the new materials supply process with respect to time, quality, and cost.

2.9.1 Time and process improvement

The main part of the analysis consists of how the materials supply process could be streamlined to make it more efficient, described by Harrington (1991). One part of streamlining the materials supply process is to reduce the changeover time between operations, for which the framework developed by Shingo (1985) is being used.

Changeover time in an operation theatre setting is defined by Meredith et al. (2011) as the time from the last stitch to the first incision of the next patient. The project team specifically seeks to analyse the possibility of reducing the operation preparation phase, visualised in figure 2.2 by Meredith et al. (2011). To enable those analyses a process map of today's materials supply process will be drawn to be able to identify activities that could be streamlined (Harrington, 1991) or externalised (Shingo, 1985, Henry, 2013). Solutions to identified improvement areas are then illustrated in a second process map. Both process maps need to contain descriptions of the activities that are carried out, by whom the activities will be carried out, and the required time for each activity to be completed.

The materials supply process in this study is analysed by applying the concepts of workflow given by Liker and Meier (2006). This is used when analysing todays materials supply process and the new materials supply process with respect to minimising overproduction of sterile instruments and disposable material. Data that is needed for this analysis is the quantities of material delivered to the operation clinic today, how a material request is initiated, and what the agreement between the operation clinic and the central sterilisation department look like for material ordering. The key criterion given by Liker and Meier (2006) to enable a continuous flow, found in table 2.2, are then used to determine what prerequisites that need to be put in place to enable a move towards a continuous flow.

2.9.2 Quality

Quality, in this study includes patient safety, which is of highest priority. The patient safety can never be compromised when designing and evaluating the new materials supply process. Boyd (2004) said that procedure packs improved the quality level by minimising the risk of bringing the wrong material into the operation theatre. The number of wrong deliveries is therefore used as a measure to analyse the quality of the materials supply process.

The work environment for the personnel handling the material is also included in the analysis of the quality since it is a prerequisite for performing a good job in the long perspective. The reduction of work elements has been described by Boyd (2004) as lowering the stress level.

The degree of standardisation in the materials supply process is analysed to be able to determine how much variation there is in what disposable material and instruments that are used today. By studying operation cards and by interviewing operation room nurses it is possible to analyse the degree of standardisation. This information is then used when designing the new materials supply process to be able to say if material and instruments could be packed by someone else than experienced operation clinic personnel. Aspects of standardisation to analyse are according to Liker and Meier (2006); repeatability, reliability and amount of quality issues and will in this case be applied to the materials supply process.

Finally, standardisation serves as a basis for quality improvement (Liker & Meier, 2006). The variation in use of instruments and disposable material is analysed with respect to how it affects quality.

2.9.3 Cost

Cost, in this study, refers to the cost of storing surgical material, both during processing and when ready-to-use. Liker and Meier (2006) and M. Winroth, lecture, 8 September, 2014 define cost reduction as a result of waste reduction. The processing and storing of surgical material will therefore be analysed from a waste perspective. More precisely, cost will be analysed with respect to the waste denoted inventory. Waste in form of excessive inventory is sought to be minimised and the limited space at Uddevalla hospital has to be utilized most practically, but also economically.

3 Methodology

This chapter describes the way in which the study was conducted; it describes the research strategy, data collection techniques that were used and why, and it goes through the work flow including both how data was collected and analysed, step by step to generate a new materials supply process. Additionally, it touches upon topics such as ethics and trustworthiness. In the discussion chapter, a discussion regarding the chosen methodology will be held.

3.1 Research strategy

This project is built on a qualitative research strategy. Qualitative research design is closely linked to induction which implies that findings generate theory (Bryman & Bell, 2011). This study entails a detailed and intensive analysis of one single case, at one organisation and one location, why a case study design has been used. Case studies have, to some extent from a scientific point of view, been considered weak due to that they cannot be generalised. Nevertheless, Dubois and Gadde (2002) mean that it should be viewed as a strength to learn from a particular case, since all cases to a certain amount are different.

3.1.1 Data collection

In order to map out the flow of the surgical material and understand how different units within Uddevalla Hospital are connected to each other, and so in turn how processes could be changed for the better, the project team has performed structured observations in combination with semi-structured interviews. In table 3.1 below, it is illustrated from whom, where, and when data was collected, and to what purpose.

According to Bryman and Bell (2015) observations provide more reliable information about events, and greater precision regarding timing, duration and frequency, in comparison to just interviews and questionnaires. Observations allows for better understanding the employee's reality as the researcher is in close contact with the person, participating in the same activities. In addition, information that is rarely told verbally that the person under study takes for granted could be obtained during the observation.

There are things that can not be observed, where the only way to find out the answer is to ask. In addition, some events occur so rarely which makes them close to impossible to observe. For these reasons, semi-structured, exploring interviews were performed as a complement during the observations. The interviews are called semi-structured since the team was not, strictly, following an interview guide. Instead the project team prepared areas of questions before the observations, that were asked during the observations, along with upcoming questions.

Table 3.1. A presentation of how primary data was collected, from whom information was given, where and when, and for what purpose.

Purpose	Type of data collection method	Position	Unit	Date
Logistics within VGR				
Understand the challenges of materials supply in hospitals.	Interview	Logistician	VGR Regionservice	Continuously
Situational description and evaluation of new materials supply process Uddevalla.				
To map out the sterilisation process and evaluate the new process.	Interview & observation	Manager	Central sterilisation department Uddevalla	Continuously
To map out today's sterilisation process.	Interview & observation	Janitor	Central sterilisation department Uddevalla	Continuously
To map out today's materials supply process to the operation clinic.	Interview & observation	Janitor	Central sterilisation department Uddevalla	Continuously
To understand the material handling process at the operation clinic.	Interview	Shift leader	Operation clinic Uddevalla	4/3-2016
To map out the material handling process at the operation clinic.	Interview & observation	Operation room nurse	Operation clinic Uddevalla	22/2-2016
To understand the materials supply process requirements and to evaluate the new materials supply process.	Interview & observation	Manager	Operation clinic Uddevalla	15/2-2016 & 22/3-2016
To understand the materials supply process requirements and to evaluate the new materials supply process.	Interview	Manager	Central sterilisation department Uddevalla	22/3-2016

Table 3.1. (cont.) A presentation of how primary data was collected, from whom information was given, where and when, and for what purpose.

Purpose	Type of data collection method	Position	Unit	Date
Working methods at other hospitals and units in VGR.				
Investigate advantages and disadvantages with centralisation of material packing.	Interview	Manager	Outpatient surgery clinic Uddevalla	22/2-2016
Find out about work practices at other central sterilisation departments.	Interview & observation	Manager	Central sterilisation department NÄL	28/1-2016
Investigate procedure packs and operation table setting rooms.	Interview & observation	Operation room nurse	Orthopaedic operation clinic Mölndal	8/3-2016
Find out about requirements for centralised material packing	Interview & observation	Quality developer	Central sterilisation department Mölndal	10/2-2016

Secondary data, such as already documented operation statistics, have been collected and used during the study to better understand the processes within the organisation, and to validate the findings from the interviews. The advantage of using secondary data is, according to Bryman and Bell (2015), that it enables for time saving since the authors do not have to collect the data by themselves. The disadvantage of using secondary data, on the other hand, is that there might be a difference in definitions used by the collectors when collecting the data and the authors when using the data, which might lead to inaccurate conclusions. This was considered during the study, why secondary data was carefully interpreted before utilised.

Dubois and Gadde (2002, p. 555) state that "the main objective of any research is to confront theory with the empirical world". In this study, literature was used throughout the whole work, both during data collection as well as when analysing the data. The literature systematically supported the interpretation of the observations and the answers from interviews, and it was used to keep a critical view of the findings.

3.2 Workflow

The following section is a presentation of how the study was carried out step by step. The different steps constituting the workflow for the study, are illustrated in figure 3.1 below.

The very first step, as shown in figure 3.1, was the situational description, or the description of today's situation. In order to be able to map out the supply chain and understand the different processes that carry the surgical material forward, the project team has been following the disposable material and the instruments, from start to end, interviewing and observing personnel when packing the operation cart(s), setting the operation table, performing operations, disinfecting, packing and sterilising the instruments. Parallel activities such as ordering of material have also been studied by observing and interviewing the personnel at the central sterilisation department and at the operation clinic. Apart from collecting information from the personnel directly involved in the materials supply process, the project team has also interviewed management personnel that have a broader perspective of the process.

As a complement to the situational description of Uddevalla hospital, observations and interviews have been done in other hospitals in VGR and one other clinic at Uddevalla hospital. The reason for the collection of data at other units, was to gain input about other possible ways of performing work within materials supply processes, that are simpler and more time efficient than the current materials supply process providing surgical material to the operation clinic at Uddevalla hospital. The hospitals studied were NÄL and Mölndal hospital and the outpatient surgery clinic at Uddevalla hospital.

When the process of gathering information at the operation clinic and the outpatient surgery clinic at Uddevalla hospital, and the other hospitals, was finished, areas with improvement potential at the operation clinic were identified. More specifically, these areas were generally time consuming processes and activities that could be externalised.

In accordance with the found areas with improvement potential, a new suggestion for the operation clinic was taking form. The new materials supply process was built on the pre-given mission statement from Regionservice that meant to decrease changeover time between operations by focusing on freeing-up time for the operation clinic personnel, which moves activities from the operation clinic to the central sterilisation department. When stating prerequisites, needed to be put in place for the new materials supply process to live to the goal of decreased changeover time between operations, other ways of working at Mölndal hospital and NÄL hospital served as input.

The process was evaluated in accordance with the purpose of the study, and the ‘Analytical framework’, found in section 2.9. Further, the new materials supply process was analysed with the help of employees from the central sterilisation department and the operation clinic at Uddevalla hospital, plus operations managers. Input was given about their thoughts on the possible savings that could be reached by using the new concept. Prerequisites needed for the new materials supply process to live up to the given requirements, were analysed.

The implementation was discussed; activities to implement in the long term versus the short term were stated, change management was stressed, and the feasibility of the implementation of the new materials supply process was discussed.

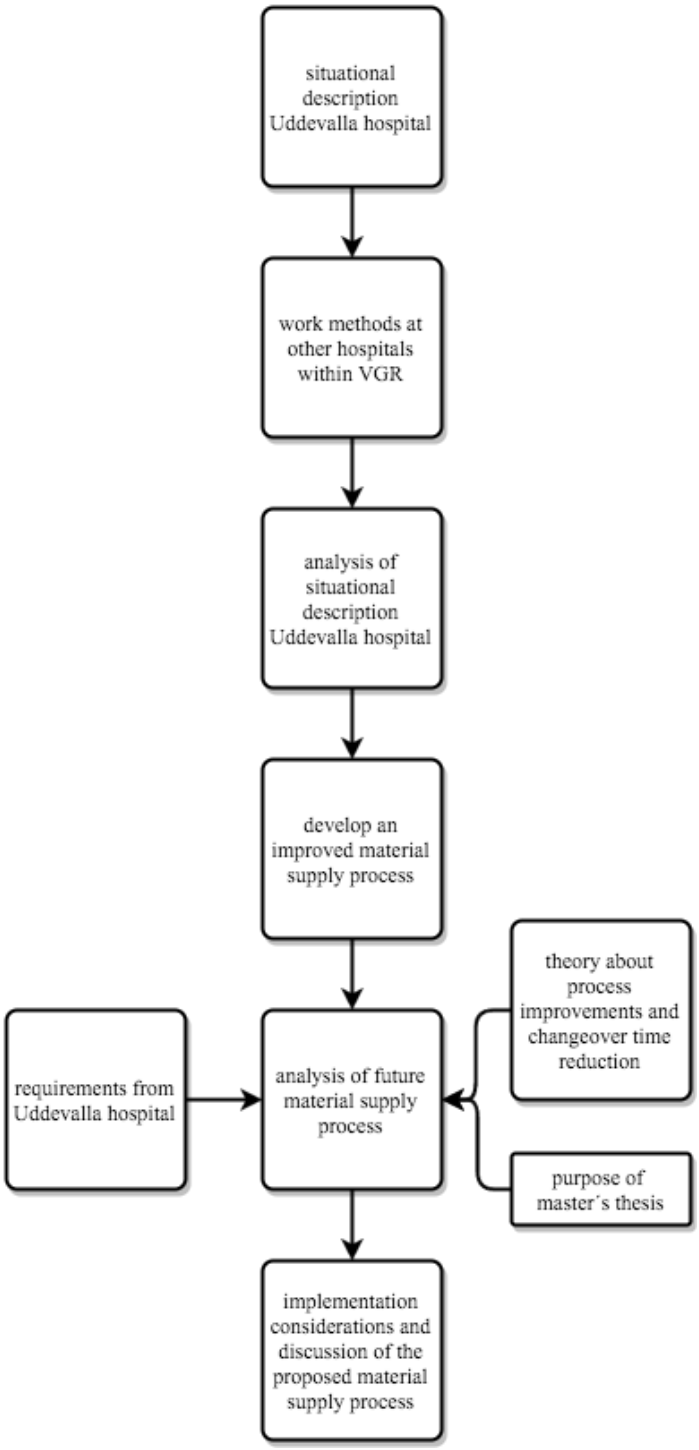

Figure 3.1. Workflow of the study.

3.3 Trustworthiness

When evaluating trustworthiness of a qualitative study, four criteria should be considered, namely: credibility, confirmability, transferability and dependability (Bryman & Bell, 2015). Credibility refers to how believable findings are. This is closely connected to the suitability of the literature and investigation methods that are used. Confirmability stresses the influence researcher's presumptions might have on the result.

Transferability concerns how applicable findings are in other contexts and dependability, on the other hand, how applicable findings are at other times (Bryman & Bell, 2015). It will be considered important to focus on transferability. It is of interest that findings are applicable for other hospitals within the VGR region, apart from Uddevalla hospital. The other hospitals are also facing the problem of needing to use resources more wisely within their surgical clinics. A discussion regarding the trustworthiness will be held in chapter 6, 'Discussion'.

3.4 Ethics

There are several ethical principles that a researcher should follow in order to avoid harm to participants. Harm to participants includes physical harm, negative effect on stress level, self-esteem and career opportunities (Bryman & Bell, 2015). In this study the most expected harm to participant is increase in stress level. This is due to that the project team will perform interviews which will take some time from the staff's, already, hectic work situation. This, however, can be avoided by keeping interviews short and clear. In order to protect participants of the study, informed consent will be considered, which allows participants to make an informed decision about whether to participate or not by knowing the purpose of the study and by whom it will be used. Additionally, invasion of privacy will be taken into consideration with focus on anonymity.

4 Situational description VGR

The following chapter provides an overview of the situation today at Uddevalla hospital; an introduction to hip surgery at Uddevalla hospital, a description of the material flow to and from the operation clinic, and an investigation of working procedures observed at other units. Further, the situational description is followed by a situational analysis, where areas with improvement potential at Uddevalla hospital are brought up to the surface. Data presented in this chapter was received during observations, and interviews with operation clinic personnel, central sterilisation department personnel, administrative personnel, and operations managers.

4.1 Situational description of Uddevalla hospital

The first part of this section aims to present information about hip surgery that take place at the operation clinic at Uddevalla hospital. It gives statistical information about the number of hip surgeries that have taken place at Uddevalla during 2013-2015, it describes how hip surgeries are classified into different operation codes, and it goes into detail about what type of personnel that is needed to perform hip surgery. In the second part of this section, the materials supply process is presented in a process map. Finally, time for performing material preparation activities, is presented.

The studied operation clinic at Uddevalla consists of four operation theatres. In this clinic, 499 hip replacement surgeries were performed in 2015 and 46 hip revisions. 700 joint surgeries are planned for 2016, including hip and knee procedures, both replacement and revision surgeries. The hospital receives a fixed budget for all the operations they perform annually.

Table 4.1. Number of the performed hip replacement and revision surgeries from 2013 to 2015 at Uddevalla hospital.

	Number of hip replacement surgeries	**Number of hip revision surgeries**
2013	511	47
2014	511	51
2015	499	46

Between 2013 and 2015, 21 different operation codes, meaning 21 specific surgical procedures, were used for hip surgeries, seven replacements and 14 revisions, see appendix B. All needed standard material, for each and everyone of these operation codes are found in its assigned operation card. Only patient specific material such as prostheses are excluded, combined with extra instruments required by the surgeon.

Two examples of operation cards for hip replacement procedures can be found in appendix C, where one is with, and the other is without cement. Revision surgeries require more material than regular hip replacements. However, the exact amount of material varies depending on the specific operation code. Every type of prosthesis procedure has a basic set of nets, in which the instruments are stored.

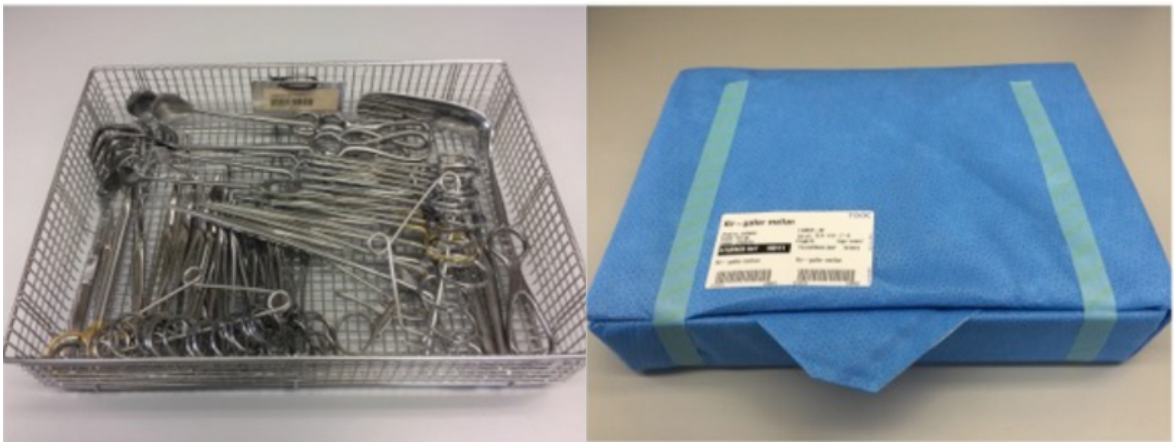

Figure 4.1. The photo to the left shows a disinfected and sorted surgical net, and the photo to the right is the same net after having been wrapped and sterilised (Lindholm & Barkenfelt, 2015).

To perform a hip replacement surgery is a standard procedure. It usually requires seven employees. Six people are needed in the operation theatre, namely one anaesthesia doctor, one main surgeon, one assistant surgeon, one operation room nurse, and two assistant nurses. Further, one operation room nurse or assistant nurse is needed outside the operation theatre if more material is urgently needed.

4.1.1 Materials supply process for hip surgeries Uddevalla hospital

The following section provides a description of the materials supply process that carry the surgical material forward, illustrated in figure 4.3. It considers both the flow and handling of disposable material and instruments.

The flowchart, and the flow of material, has been defined to start with the operation clinic personnel checking the operation schedule for the day. The schedule is retrieved from an IT-system called Orbit. Apart from the planned operations, the IT-system also contains extra instructions such as demands of specific instruments from the surgeon and information about the patient.

Once the operation schedule has been checked, and one knows what operation code that is about to be performed, the operation card corresponding to that very operation code, is looked up in a binder. An operation cart is then packed with standard material from the operation card, plus extra patient and surgeon specific material, if needed. Both sterile disposable material and instruments are packed on the operation cart(s).

The instruments are packed in either nets or single packages. The disposable material is packed in single packages. Instruments are scanned when they are taken from the storage, for traceability reasons. Prostheses, which are patient specific, are stored in a roller cart that is brought into the operation theatre together with the operation cart(s) when the surgery is about to be performed. The size of the prosthesis is not necessarily known before the operation, why different sizes are brought into the operation theatre.

Figure 4.2. The photo to the left shows an operation cart packed with both disposable material and instruments, ready to be brought into the operation theatre. The right picture is a photo of a roller cart, in which prostheses are stored. (The photos were taken at Uddevalla hospital.)

When the packing of the operation cart(s) is completed, it is brought into the operation theatre. In the operation theatre the operation table is being set; the operation table is covered with sterile tablecloths, sterile packages are opened and the table is being set with disposable material and instruments from the operation cart(s). During the performance of the surgery, the disposable material and the instruments are being used, and hence contaminated. After the operation, disposable material is thrown in the garbage and instruments are disassembled and loaded, by operation clinic personnel, into the washing machine for disinfection and drying.

The disinfected instruments are then transported down to the central sterilisation department by central sterilisation department personnel via a public elevator, since the operation clinic is located on the third floor while central sterilisation department is located in the basement. At the central sterilisation department, the instruments are inspected for cleanliness and dryness, and a functionality check is performed. If the instrument is not clean or dry it has to be re-disinfected. If it is made certain that an instrument does not live up to functionality requirements, it is replaced by another instrument of its kind. However, if the inspection goes well, instruments will be grouped back into nets and single packages. Nets are wrapped in paper and single instruments are put into sealed paper and plastic bags.

The packed instruments are then put into the autoclave in which they will be sterilised by hot steam. When the autoclave process is finished, the sterilisation program is checked, making sure that the instruments are sterile. If it is not approved, it has to be re-processed. The instrument packages are then transported back to the operation clinic when sterile. The operation clinic personnel then refill the storage of instruments located at the operation clinic.

Disposable material is stored both at the operation clinic and at the central sterilisation department. Operation clinic personnel checks their stock levels manually on a regular basis and place orders to the central sterilisation department. The orders are faxed to the central sterilisation department. The central sterilisation department personnel deliver the ordered disposable material approximately once a day to the operation clinic. Central sterilisation department personnel, in turn, checks the levels of their inventory of disposable material manually a couple of times every week and place orders to the suppliers. Some disposable material, however, is ordered directly by the operation clinic personnel from the suppliers, for example implants and other patient specific material.

Instruments are throughout the process barcode scanned and registered in T-Doc to be able to track where it was packed, by whom and when it was sterilised. T-Doc is an IT-system used to keep track of all instruments and to monitor the sterilisation process. From T-Doc it is possible to retrieve information about instrument availability and inventory levels. The central sterilisation department is informed about the priority of material needed, since some instruments need to be cleaned and sterilised more quickly than others due to their scarceness. This communication is not transferred via T-Doc, or any other IT-system. If material is urgently needed, the operation clinic calls the central sterilisation department and makes them prioritise that specific material.

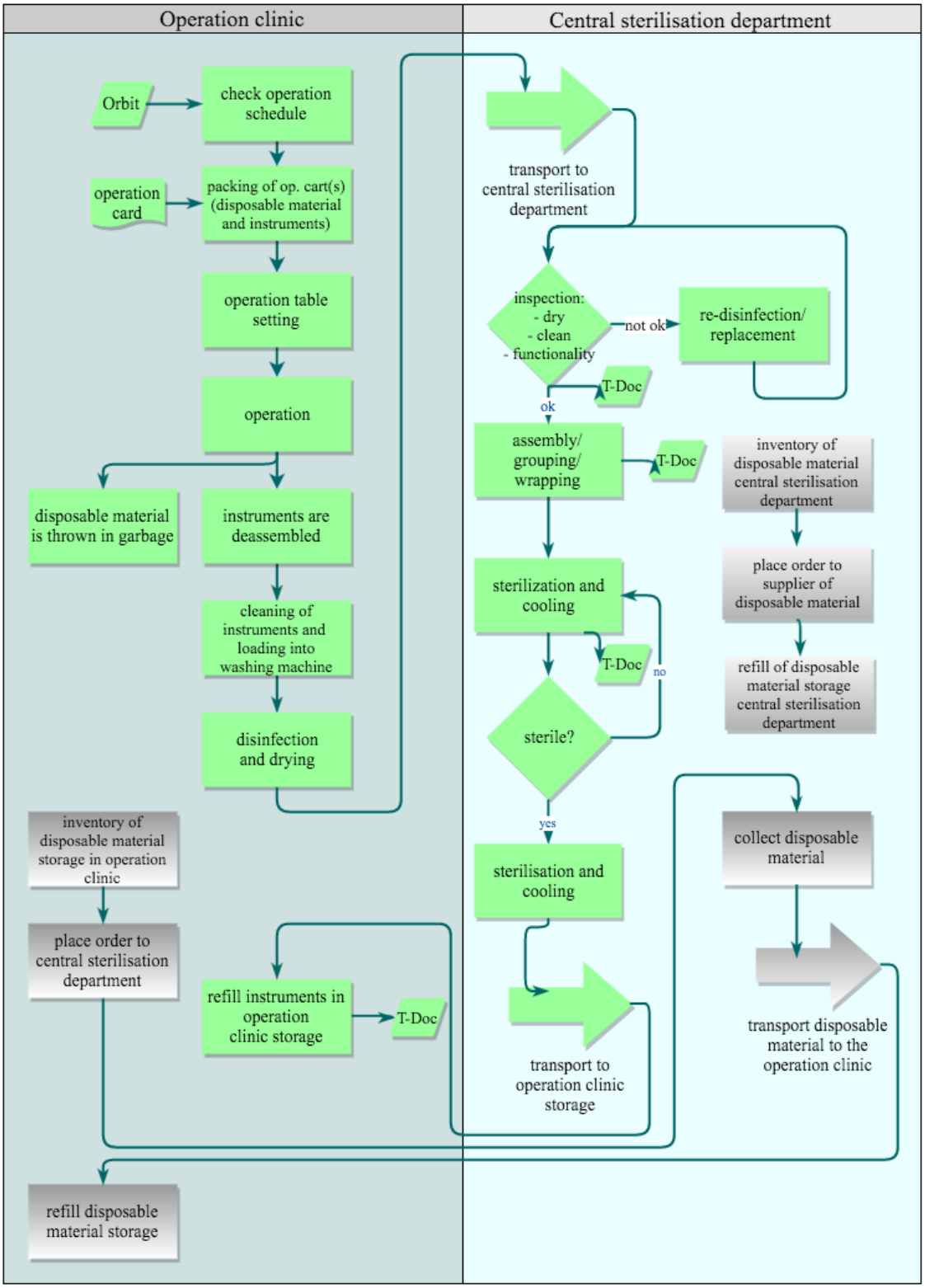

Figure 4.3. Flowchart illustrating today's flow of disposable material and instruments from the packing of the operation cart back to the refilling of the operation clinic storage. The right side illustrates tasks performed by central sterilisation department personnel and the left side represents tasks carried out by personnel at the operation clinic. The ordering and inventory activities are carried out in parallel to the main materials supply process and are visualised by the grey boxes.

For better understanding how material is carried forward through the different processes of disinfection, sterilisation, etc., figure 4.4 provides an illustration of the physical flow of both disposable material and instruments between the different units within Uddevalla hospital.

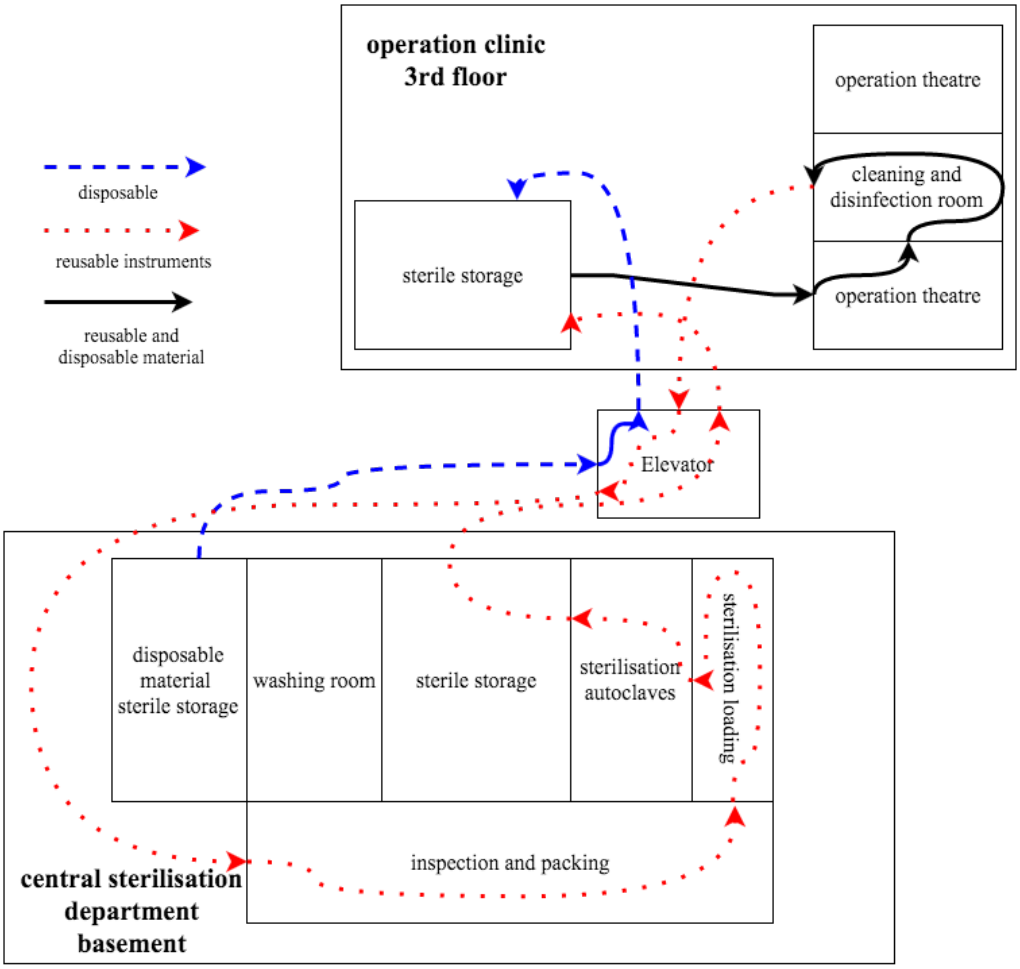

Figure 4.4. The physical flow of instruments and disposable material between the different units within Uddevalla hospital.

4.1.1.1 Changeover time between surgeries and changeover activities

Table 4.2 below, presents times for performing and preparing for replacement versus revision surgeries. The times were recorded from 2013-2015. The operation time is defined as the time from when the surgeon starts the procedure until the surgeon leaves the operation theatre. The changeover time is defined as the time interval from when the surgeon leaves the operation theatre until the surgeon starts the next operation, in the same operation theatre.

Table 4.2. Operation times and changeover times at the operation clinic at Uddevalla hospital.

	Replacement	**Revision**
Average op. time (min)	93.5	184.5
Standard deviation op. time (min)	30	76.2
Average changeover time* (min)	119.8	145.4
Standard deviation changeover time (min)	49.1	49.4

* Only when there has been a previous operation during the day

The times presented in table 4.3, are estimations made by operation clinic and central sterilisation department personnel during the project team's interviews. The estimations are averages of different hip operation codes. The activity and time for preparing the patient is not included in the table. The total time is a summation of the activities and should not be mixed with the changeover time in table 4.2 since the real changeover includes more activities and could include waiting time.

Table 4.3. Estimated times for changeover activities at the operation clinic at Uddevalla hospital.

	Replacement	**Revision**
Packing of operation cart (min)	5-10	15-20
Operation table setting (min)	20-30	35-45
Cleaning and disinfection* (min)	60	60-
Total (min)	~85-100	~110-125

*Does not require one person present during the whole process.

4.2 Working methods at other hospitals and units within VGR

The following section describes ways of working, that differs from the working procedures in the materials supply process at Uddevalla. The descriptions are based on observations and interviews conducted in the outpatient surgery clinic at Uddevalla hospital, the orthopaedic operation clinic at Mölndal hospital and the central sterilisation department at NÄL hospital.

4.2.1 Operation table setting rooms

A table setting room, is a room, in connection to the operation theatre, where the operation table can be set and prepared for the next operation. This is done in parallel to the ongoing surgery. When the operation is finished, the operation theatre just has to be cleaned and thereafter, the prepared operation table can be brought in, ready for use.
Table setting rooms have been identified by operation room nurses at NÄL, Mölndal and Uddevalla hospital, as the practice that reduces the changeover time between operations the most. Operation table setting rooms were recently introduced at NÄL hospital and have been used at Mölndal hospital for ten years, however, they do not exist at the operation clinic at Uddevalla hospital.

Figure 4.5. A photo of an operation table setting room, taken at Mölndal hospital. The operation table has been set, and has been covered by a drape, while waiting for the new operation to start.

4.2.2 Procedure packs for hip surgery

At Mölndal hospital, procedure packs for hip surgery were introduced for the first time in year 2008. The procedure packs are delivered to the operation clinic's storage three times a week. This inventory covers material for operations of the day and the upcoming day. According to the operation clinic personnel at Mölndal hospital, the procedure packs simplify the packing of the operation cart(s) since they decrease the amount of articles to bring together.

Aside from making the packing procedure less complex and less time consuming, according to nurses at Mölndal hospital, the procedure packs also shortens the process of setting the operation table since only one package of disposable material needs to be opened, in comparison to otherwise 27 packages for a hip replacement. See appendix A for the content of the hip surgery procedure pack. The procedure packs are also described as something positive in the aspect of ergonomics, the reason is that it is less strenuous for the wrists and fingers to open one package instead of 27. Finally, the reduction of articles also reduces the administrative work such as material ordering and invoice processing.

According to Dobson et al. (2014) there is a widespread understanding among surgeons that usage of a minimal amount of material allows for performing emergency surgery more efficiently. One example of where this agreement has led to use of a standardised and slimmed set of material, is the caesarean section procedure pack used within VGR. Apart from the disposable material provided in the caesarean section procedure pack, a net and four extra articles, are needed to perform a caesarean. In a situation in which the mother's and baby's life is in danger, there could be a need to have the baby out in only three minutes. According to nurses at NÄL hospital, a procedure pack is a necessity for urgent surgical procedures, such as this, as it saves time in the operation theatre. Procedure packs in general, allows the surgical team to work efficiently, since it opens quickly and the number of articles is slimmed why picking the right article is done quickly. Further, by using the procedure pack, the team is ensured that all needed material is present, and time is saved from not having to bring missing material.

4.2.3 Centralisation of material packing

The outpatient surgery clinic at Uddevalla hospital is a clinic in which minor surgeries are performed that do not demand as much disposable material and instruments as hip surgeries. This unit is to some extent working with centralised material packing. A simplified flowchart of the materials supply process is visualised in figure 4.6.

From the outpatient surgery clinic, a list of needed material, for a specific surgery, is sent to the central sterilisation department. The central sterilisation department packs an operation cart in accordance to sent instructions and delivers it to the outpatient surgery clinic. At the outpatient surgery clinic, the operation cart is completed with some disposable material and instruments that are stored at their department. The reason for the need of completion of the operation cart at the outpatient surgery clinic is that everything is not known in advance, certain material could be depending on the patient and the demands of the surgeon. The personnel at the outpatient surgery clinic mention benefits of centralised packing such as reduced need for inventory at the unit and time savings for the personnel since their material handling activities are reduced.

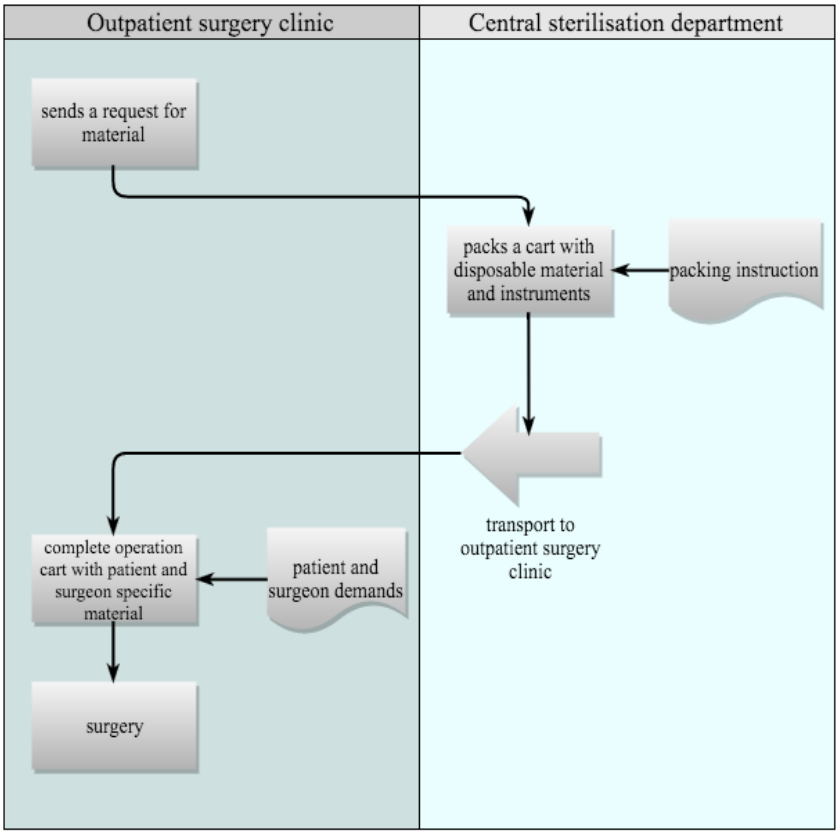

Figure 4.6. The materials supply process in the outpatient surgery clinic at Uddevalla hospital.

4.3 Analysis of the situational description Uddevalla hospital

This chapter is an analysis of the situational description of the materials supply to the operation clinic at Uddevalla. In this part, the present situation at Uddevalla hospital will be analysed from a time, quality and cost perspective, where decreased changeover time is of highest importance while maintaining the patient safety.

4.3.1 Time analysis

This section brings up time aspects noticed while performing the study at Uddevalla hospital. Based on the situational description, visualised in figure 4.3, some material handling activities at the operation clinic have been identified as time consuming and unnecessary to be performed at this unit. Table 4.4 illustrates four different time consuming activities, linked to material handling, that could be minimised or externalised from the operation clinic to speed up the changeover time between surgeries.

The storing of disposable material and instruments, activity one in table 4.4, at the operation clinic can be seen as duplication of work since this material has already been stored at the central sterilisation department. The storage keeping at the operation clinic is also generating duplication of work in terms of keeping record of inventory, ordering articles and refilling the storage. This is something that is already done at the central sterilisation department.

Activity 2-4, in table 4.4, constitute a part of the changeover process between two operations. Externalisation of changeover activities is one of the tools to reduce the total changeover time. Activity 2-4 are stopping the main "production", the care of the patient. Therefore, it is desirable to externalise those activities or prepare them in parallel to the ongoing surgery. Apart from decreasing changeover time, externalisation would allow the operation clinic personnel to focus more on medical work, which is what they are trained for, rather than logistics tasks.

Table 4.4. Identified material handling activities at the operation clinic to streamline and externalise.

1.	Storage activities ● Controlling and maintaining the inventory levels at the operation clinic storage. ○ Ordering of disposable material from the central sterilisation department. ● Refilling the operation clinic storage with both disposable material and instruments.
2.	Operation cart packing.
3.	Setting of the operation table.
4.	Cleaning and disinfecting surgical instruments.

4.3.2 Quality analysis

In this section different aspects of quality, regarding the work at the operation clinic at Uddevalla hospital, will be presented and analysed. The work environment and instrument variety levels will be analysed with respect to its effects on the quality of the performed tasks.

4.3.2.1 Work environment

The operation clinic personnel are often interrupted when performing material handling tasks, due to more urgent duties calling, often related to patient care. To handle the material work, such as operation cart packing, loading of the washing machine, and restocking, with all its interruptions, is considered stressful. Further, an unpredictable process is hard to standardise.

Today, the disinfection of instruments is performed at the operation clinic, by operation clinic personnel. The disinfection process has by the operation clinic personnel been described, as a stressful element, which is not really linked to their professional background. Since the disinfection of instruments is a side-task compared to patient care, it might become secondary and not performed with the highest quality. If the instruments are still contaminated when they arrive at the inspection at the central sterilisation department, they have to be re-processed. This increases the throughput time for the instruments. Further, quality defects complicate standardisation, as having to correct errors is an interruption to the regular tasks.

Apart from the previously mentioned disinfection process, which is considered a stressful activity by the operation room nurses, interviews with operation clinic personnel at Uddevalla hospital have revealed that the opening of packages of single disposable material, during the setting of the operation table, is a strenuous and stressful activity. Strenuous due to the repetitive work, and stressful due to great time consumption of the activity. Hence, reducing the amount of packages is desirable to improve the work environment for the operation clinic personnel, and improved work environment has the possibility of improving the quality of the performed task.

4.3.2.2 Variation in the use of surgical instruments

Different surgeons perform the same procedures slightly differently due to differences in background training. This issue has been stressed during interviews at Uddevalla hospital. Logistically, it has the consequences that different instruments could be requested for the same type of operation, which adds on a factor of variety in the material planning and handling, and the variation in turn increases the risk of forgetting to bring all needed material to the operation theatre. However, it has been concluded that surgeons generally do not ask for anything else than the material found in the corresponding operation card.

The lists of material needed for a hip replacement surgery with cement and a hip replacement surgery without cement, found in appendix C, illustrates that most of the material for a hip surgery is standardised. The only thing that is elective, procedure wise when performing these types of surgeries, is to make either an anterior or a posterior incision, where the anterior incision requires extra hooks and one more disposable article. Further, the choice of type of incision is not necessarily linked to the surgeon, but could be patient dependent.

Since the surgical instruments used for hip surgeries are standardised, according to appendix C, the utilisation of surgical instruments for hip surgeries is robust; material needed for hip surgeries is almost the same regardless of the surgeon in charge. This means that a late change of surgeon does not affect the operation cart packing. Very few, if any, changes have to be done to complement the operation cart(s) with material that the surgeon is specifically requesting.

4.3.3 Cost analysis

Today, almost all instruments and disposable material are kept stored at the operation clinic. Historically, it has been the aim of the hospital to keep the storage close to the operation theatre, if sudden demand of articles accrued during surgery. However, space at the operation clinic is more valuable than space in the basement at the central sterilisation department, why it is costlier to keep high storage levels at the operation clinic than the central sterilisation department. The cost per square meter is 35 percent higher at the operation clinic compared to the central sterilisation department. See appendix D for today's cost of different areas at Uddevalla hospital. In accordance with this, only the essentials should be stored at the operation clinic.

5 Development of a new materials supply process

This chapter begins with a presentation of requirements, stated by personnel at Uddevalla hospital, and is followed by the result of this study, the presentation of the new materials supply process. Prerequisites that need to be put into place to enable the proposed materials supply process to function and live up to its goal of decreased changeover time, will be presented in the analysis of the new materials supply process. In this study, prerequisites are referring to the elements that need to be put in place for the process to function. The chapter ends with an analysis of the proposed materials supply process with respect to time, quality and cost.

5.1 Requirements for the new materials supply process

As a complement to the situational description, requirements where gathered from the personnel at Uddevalla hospital. The purpose of gathering the requirements was to capture the voice of the customer, since the personnel are the ones that are working in the process. The requirements were received via interviews, from a range of personnel at Uddevalla hospital; central sterilisation department personnel, operation clinic personnel, and operations managers. The requirements are presented in table 5.1.

Table 5.1. A summary of requirements that the new materials supply process must live up to, presented by personnel at Uddevalla hospital.

Uddevalla hospital	**Requirement/demand**
Dependability	The operation cart(s) shall be packed and delivered in time for setting of the operation table to allow for the surgery to start on time.
	Time for delivery of extra or missing instruments to the operation theatre needs to be minimised.
Quality	The material shall be arranged in the procedure packs and on the operation cart(s), in such a way that the setting of the operation table is simplified.
	It shall be less stressful and less tiring for the personnel to work in the new process.
	The patient safety level shall be maintained or increased.

5.2 The proposed materials supply process

The new materials supply process is described, and presented in figure 5.1 below. In the description, the reader can follow the flow of material from it arriving at the operation clinic, to it being finished to use again after re-processing and packing with other items at the central sterilisation department. This section also illustrates the differences between the new materials supply process and the present one.

5.2.1 Presentation of the new materials supply process

In the new materials supply process, the operation clinic personnel will make the final touches to the operation cart(s) by adding only patient specific material such as prosthesis, that need to have the right size and shape to fit the patient, and instruments demanded specifically by the surgeon, from the operation storage. Additionally, gloves and surgical gowns will be added in the operation theatre as the size depend on the surgeon. Moving on, the operation table will be set by material from the operation cart(s), and shortly after, surgery will be performed.

The instruments will, after surgery, be transported to the central sterilisation department where the first step is to disinfect the instruments. After disinfection, the instruments will be inspected for cleanliness, dryness, and functionality. If the instruments are clean, dry, and functional, they will be packed in nets which will be sealed, or single sealed packages. Then they will be sterilised and kept stored until the operation clinic sends a new material request. When requested, instruments and disposable material will be packed on an operation cart(s), and sent to the operation clinic for completion with patient and surgeon specific material once more.

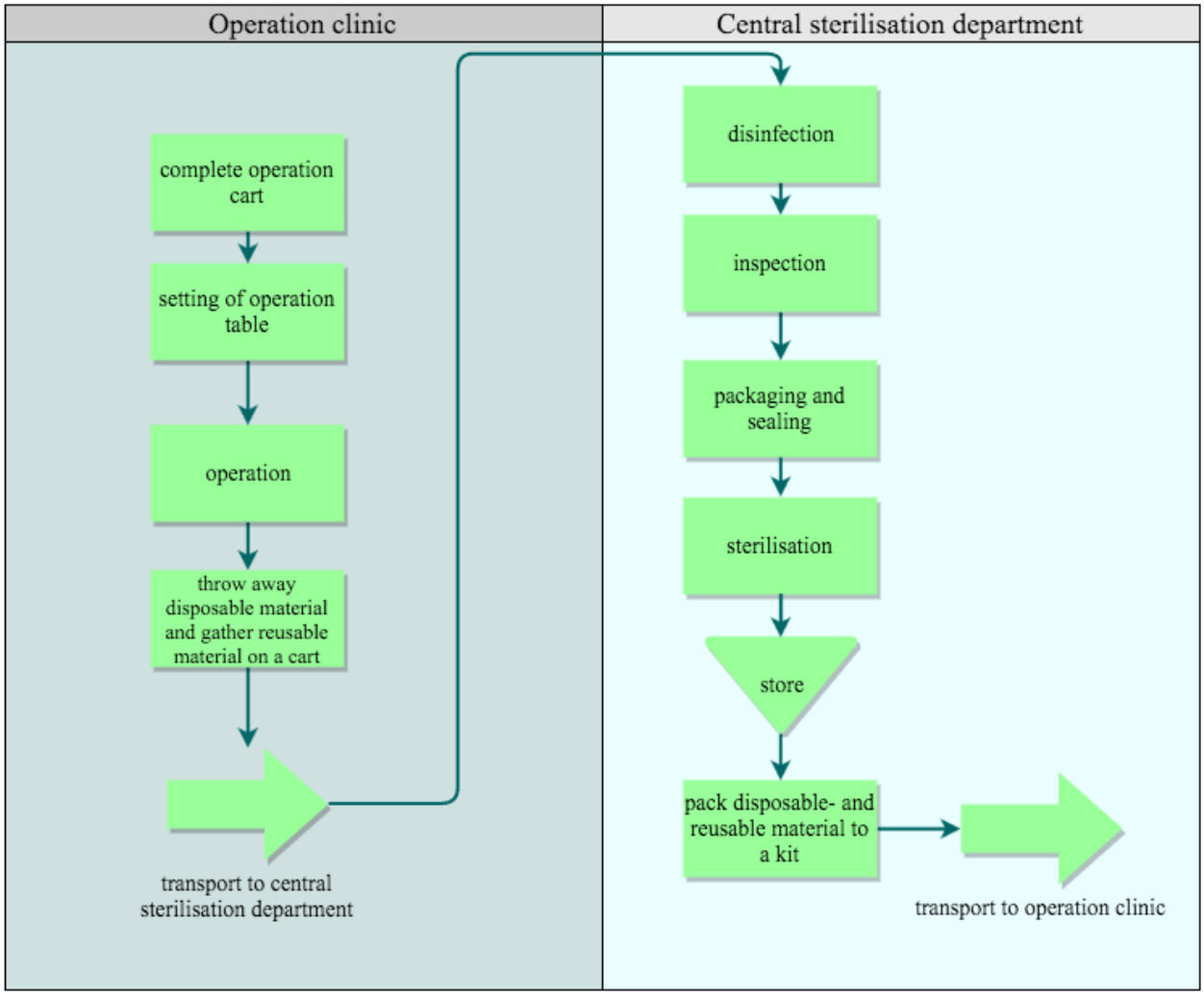

Figure 5.1. The new materials supply process.

5.2.2 Differences between the new materials supply process and today's process

There are several critical aspects that distinguishes the new materials supply process from today's. To begin with, various steps of material handling are externalised from the operation clinic to the central sterilisation department in the new materials supply process. The central sterilisation department is in the new suggestion fully responsible for turning the contaminated material clean and sterile, and for bringing all material needed together on an operation cart(s), with the exception of patient and surgeon specific material.

5.3 Analysis of the new materials supply process

Today, the operation clinic requests the right material, in the right amount, with the acquired functionality and cleanliness at the right time, delivered to the right place. These requirements will stand true, no matter how much the materials supply process is re-organised. However, a radical change, such as centralisation brings up new prerequisites, needed to be put in place, for the process to live up to already stated requirements. In this chapter, prerequisites needed for the proposed materials supply process will be presented. An analysis of expected time savings will be presented, and advantages and disadvantages of the new materials supply process, will be stated.

5.3.1 Prerequisites for the new materials supply process

In this section prerequisites needed for the new materials supply process to function and live up to stipulated goals will be brought to the surface, starting with the accurate planning and communication, continuing with the right amount of capacity, and finishing with elements needed for enabling time savings. The prerequisites could be described as the building elements that need to be put in place for the process to function according to figure 5.1.

5.3.1.1 Planning and communication

Centralised material packing means that the total processes that brings forward the needed material to the operation theatre will be more strongly linked to Just In Time. Centralisation, hence, requires better planning, making sure that needed material is delivered, and so in turn ordered, at the appropriate time, as there is less of a backup since stock has been eliminated in each step of the process.

To be able to plan for operations, the operation clinic needs to know what material that is needed, but also when material is needed. Further, the operation clinic must be aware of the required timespan it takes for the central sterilisation department to bring forward clean and sterile instruments, to be able to order material at the appropriate time. Additionally, the operation clinic needs a supportive system to be able to place orders to the central sterilisation department. The central sterilisation department, on the other hand, needs to know when, where and what to deliver, in time, to be able to bring forward instruments and disposable material, taking the lead time into consideration.

The planning of material packing is easily done if available information is shared between the central sterilisation department and the operation clinic in a common planning and ordering IT-system, as seen in figure 5.2. The common system enables for the operation clinic to plan for operations according to availability of instruments, and to a greater extent ensure that the right material is delivered to the operation theatre. An IT-system, is more accurate than verbal communication as the risk of missing articles to pack decreases. The scanning system, that today exists, should be connected to the system to simplify material ordering, so that the right material is packed to the right operation. This requires that all material is equipped with a barcode.

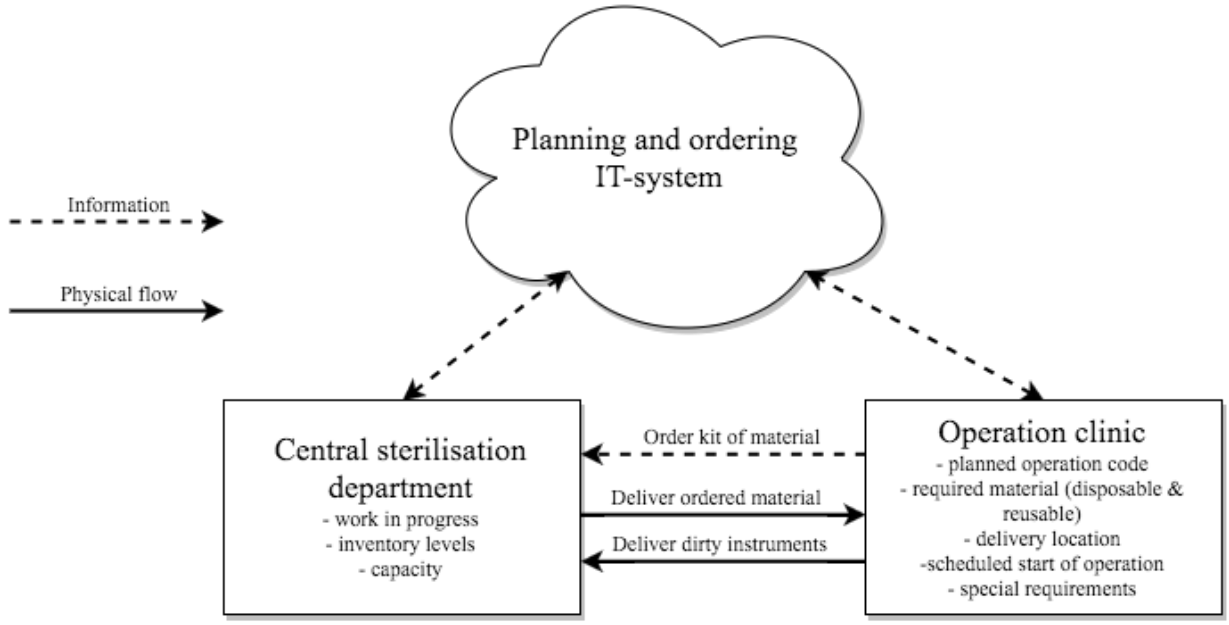

Figure 5.2. Information sharing between the operation clinic and the central sterilisation department through a common IT-system.

Something to consider when building the new operation house, to enable for more efficient communication between the central sterilisation department and the operation clinic, is to locate these two departments on the same floor, close to each other. This makes it possible, after surgery, to shortly explain what the instruments have been used for and special things to consider when disinfecting the instruments and inspecting them for functionality, etc. Another positive aspect of locating the central sterilisation department and the operation clinic on the same floor, is the decrease in transportation time.

The reason why the instruments have had to be disinfected at the operation clinic, is that it is not allowed to transport contaminated instruments in areas where people circulate, due to infection risk, and the public elevator is today the only available transportation form between the operation clinic and the central sterilisation department.

5.3.1.2 Capacity

To centralise the material handling to the central sterilisation department, making the central sterilisation department personnel responsible for the handling of material from disinfection to packing, can not be realised with the same working conditions as today. Centralisation would without internal changes lead to an unrealistic increase of the workload for the central sterilisation department personnel.

The centralisation of packing, means a step towards a one-piece-flow and Just-In-Time production of material kits, and it will demand a consistent capability from the process, meaning availability of people, material and equipment on a daily basis. In this section, prerequisites needed to enable the centralisation in connection to capacity will be analysed. Procedure packs, utilisation of equipment, and increased workforce will be the topics.

Moving the operation cart packing procedure to the central sterilisation department increases the workload at this department. However, introduction of procedure packs, would diminish the burden of the process. By using procedure packs, the personnel do not need to know, in detail, what disposable articles to pack and in what order to arrange them on the operation carts. Further, the process of packing operation carts will be feasible to perform at the central sterilisation department with the help of procedure packs as it takes shorter time to bring and pack one package in comparison to bringing and packing up to 27 packages for hip surgery.

To move the disinfection of instruments down to the central sterilisation department would, without changes, mean that more instruments would have to be disinfected with fewer machines, which in turn would increase the lead time. To avoid this, the machines at the operation clinic have to be brought to the central sterilisation department or new equipment has to be purchased.

If the disinfection process is moved, the time between finished operation and loading into the washing machines still has to be the same to avoid drying of blood etc., to prevent bacteria growth which is harder to disinfect. To ensure fast transportation, it would simplify if the central sterilisation department and the operation clinic were located on the same floor. One of the criterion to achieve one-piece flow is that the cycle times are balanced towards the takt time. The central sterilisation department needs to be able to work in the same pace as the operation clinic demands material. If there is an unbalance, the central sterilisation department will overproduce operation material or create waiting time for the operation clinic. The total throughput time for turning contaminated instruments in Skaraborgs hospital sterile and packed, has been recorded to approximately 200 minutes (Lindholm & Barkenfelt, 2015). The throughput time, and all processing times that it includes, need to be calculated for Uddevalla hospital as well. To be aware of the processing times and the throughput time enables for capacity planning at the central sterilisation department which balances the pace of work at the central sterilisation department to the demands of the operation clinic.

It is probable that a prerequisite for the centralisation to work smoothly is to hire more staff. This since the re-organisation moves new activities to this area, loading washing machines and packing operation carts, which are activities performed manually. Finally, it is crucial that the staff at the central sterilisation department, taking over these activities, receive proper training concerning how the washing machines should be operated, how instruments should be disinfected and how disposable material and instruments should be composed during the packing of the operation carts.

5.3.1.3 Prerequisites for decreased changeover time

There exists a need for decreasing the changeover time, which enables for performing more operations per time unit. In the following section, prerequisites needed to be put in place to decrease the changeover time between operations, will be analysed.

5.3.1.3.1 Operation table setting rooms

The possibility to prepare for an operation while surgery is still performed is a prerequisite for decreasing the changeover time between operations. To enable setting of the operation table during ongoing surgery requires specific rooms in connection to the operation theatre in which the activity can be performed. Additionally, it requires staff, operation room nurses and assistant nurses. This stands in comparison to today's solution, where the table is being set when the operation room has been prepared after finished surgery. The 35 to 45 minutes, that it takes to set the operation table for hip surgery in between the operations, can be viewed as non value adding time. In this context, it is worth mentioning the introduction of procedure packs once more since the use of procedure packs, decreases the time of setting the operation table, since the number of packages to open are decreased dramatically.

5.3.1.3.2 Teamwork

To put the procedure of decreasing the changeover time between surgeries to its extremes, a further prerequisite observed is increased teamwork. There is a great contrast between working together, and just working simultaneously. A team that is working towards common goals and whose team members are willing to collaborate and communicate across hierarchical boundaries, has great potential for increased quality of the surgical performance and hence decreased medical risks for the patients (Edmondson & Nembhard, 2009). Good teamwork increases the quality as it makes the team more aligned with the task as all members are respecting each other's background, trust each other's skills and develop strategies for who does what, at what time, which is a prerequisite for working fast and determined in critical moments (Rothrock, 2003, Sheard & Kakabadse, 2001).

Good teamwork increases the efficiency of the surgical performance at the same time as it may increase the working satisfaction among the members of the group. At Uddevalla, lack of involvement of the surgeon has been expressed as a weakness in terms of team building. If the surgeon is involved in procedures such as cleaning, dressing, lifting and moving the patient, a lot of time could be saved. The possibility of decreasing changeover time by involving the surgeon in preparatory, and final surgical activities, is supported by Meredith (2011).

5.3.2 Time savings achieved from the new materials supply process

Figure 5.3 below, illustrates the differences in how time is used at the operation clinic in today's materials supply process, and the new materials supply process; in the figure, three similar operations are performed successively, in the same operation theatre. The times presented in the figure are based on estimations made by operation clinic personnel, and historical time records for standard hip replacement procedures. In the figure, activities for preparing the patient, such as anaesthesia, insertion of catheter, cleaning, wrapping, etc. are excluded, as none of the project team's suggestions affect these procedures.

The upper picture in figure 5.3 shows how the work is carried out today at the operation clinic, and the bottom picture illustrates how work will be executed in the new materials supply process. The difference between the current and the future state, firstly, is that time is saved in the new materials supply process as the setting of the operation table is done in parallel to ongoing surgical activity. This is believed to be the biggest contribution to the reduction of the changeover time between operations. According to the operation clinic personnel, parallel operation table setting can reduce the changeover time with 20 to 30 minutes for replacement hip surgery, and 35 to 45 minutes for revision hip surgery. Secondly, the relocation of the disinfection process, frees-up time from the operation clinic personnel. This process takes approximately 60 minutes, however, the operation personnel were not, in the previous materials supply process, occupied during the entire time of the disinfection process, only when loading and unloading the washing machine. Thirdly, in the new materials supply process, the operation material only needs to be completed at the operation clinic. The time it takes to complete the packing of the operation cart(s) in the new materials supply process, in comparison to the total operation cart packing in the old materials supply process, is substantially less. Fourthly, the time for setting the operation table is reduced by approximately ten minutes if procedure packs are introduced.

Additionally, the movement of storage of instruments and disposable material to the central sterilisation department, entails time savings for the operation clinic, which is not shown in figure 5.3. The movement eliminates activities such as keeping record of the inventory levels, ordering new material, and refilling the storage. The only remaining administrative activity, for the operation clinic personnel, is to place orders to the central sterilisation department. The ordering of material to the central sterilisation department is also excluded in the picture.

What figure 5.3 truly illustrates, is that there exist potential to reduce changeover time, comparing the current situation with the new materials supply process. However, one must keep in mind that the figure illustrates an ideal situation. The situation is ideal, since all activities are performed directly after each other, with no breaks, which might not be the case in reality. Further, the time it takes to perform each surgery is equal to each other, which is not true in reality since the time to perform the same procedure might vary for different patients. Variation in time holds true for all materials supply activities; the time for packing an operation cart is not always exactly 10 minutes, neither is the time for cleaning the operation theatre always exactly 15 minutes, etc.

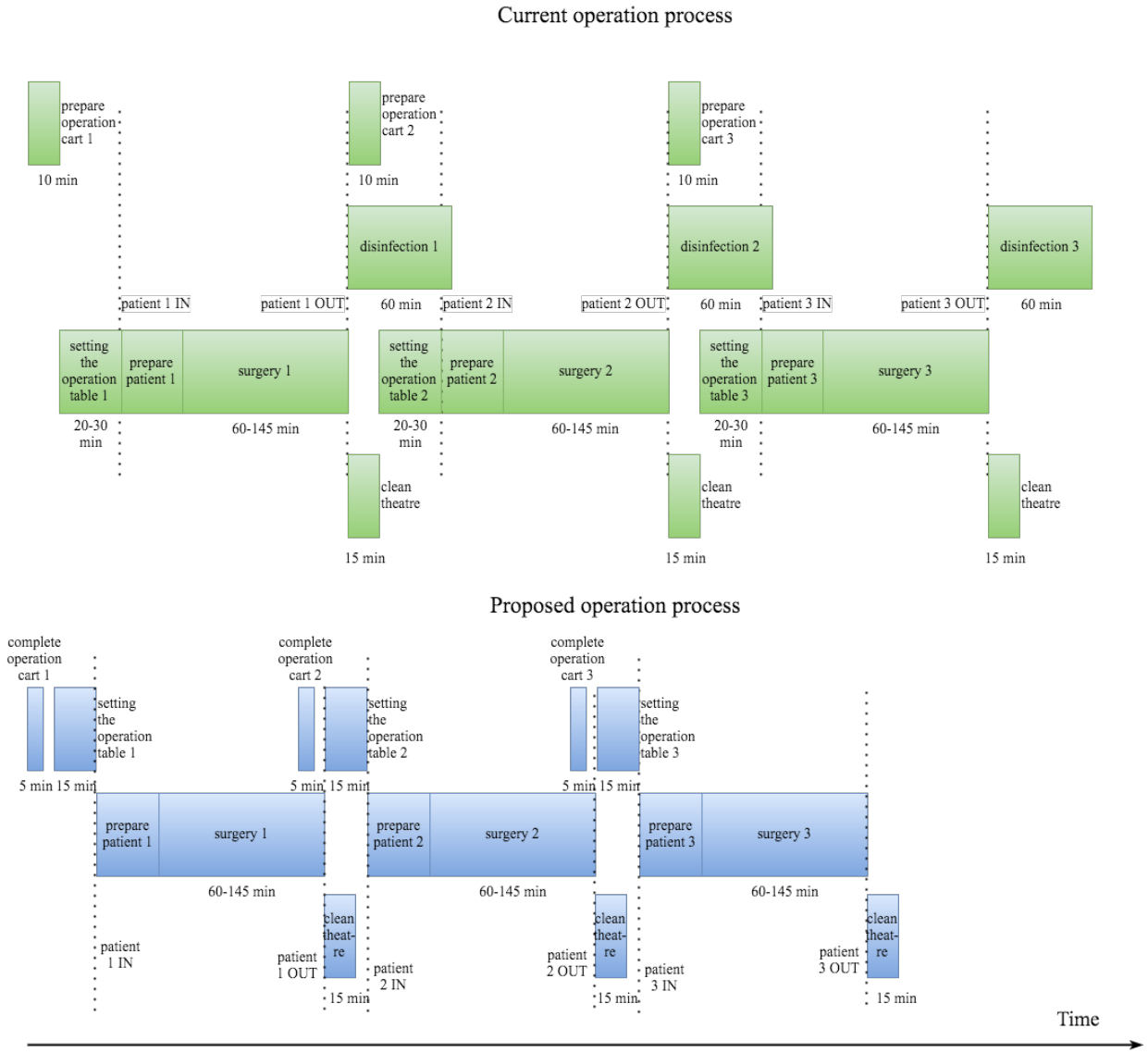

Figure 5.3. Comparison between the operation process with the new materials supply process (bottom) and the operation process with the current materials supply process (top).

5.3.3 Advantages and disadvantages of the proposed work methods

Two time consuming activities, namely cart packing and disinfection, have been proposed to be moved from the operation clinic to the central sterilisation department to free-up time for the operation clinic personnel. The project team has focused on moving activities from the operation clinic that are related to the background of the central sterilisation department personnel and to logistics, and not medical work. This enables for the right focus for the different employees. Further, introduction of procedure packs and table setting rooms, have been stressed. Advantages and disadvantages for the suggestions are presented below in table 5.2, with respect to time, quality and cost.

Table 5.2. Identified advantages and disadvantages of the proposed work methods. The central sterilisation department will in the following table be referred to as CSD, and the operation clinic as OC.

	Time	**Quality (including patient safety)**	**Cost (including personnel and storage space)**
Centralisation (material packing and disinfection at the CSD)	**Advantages**: It saves time for the OC personnel if the disinfecting process is moved and if material packing activities are reduced. The reduction of material packing diminishes the inventory activities at the OC.	**Advantages:** The CSD will own the process of producing usable instruments, which simplifies the procedure of finding the root cause of errors in the materials supply process (George et al., 2015), such as poorly cleaned or lost instruments which increases quality. Increased quality of the disinfection process since the personnel at CSD have better knowledge of preparing the instruments for surgery as it is the highest priority, while operation clinic personnel are only disinfecting the instruments as a side-task. To move the disinfection, the operation cart packing, and the inventory work to the CSD enables for more standardised material handling as the CSD personnel will not be interrupted in their tasks to the same extent as the operation clinic personnel, and this in turn enables for improved quality.	**Advantages:** Decreased cost at the OC due to decreased material handling. To move the disinfection activity saves space from the scullery at the OC. To move the packing of standard articles to the CSD saves space from the OC storage. **Disadvantages:** Increasing cost at the CSD due to increased workload. More space needed for disinfection at the CSD. Increased need for storage at the CSD.

Table 5.2. (cont.) Identified advantages and disadvantages of the proposed work methods. The central sterilisation department will in the following table be referred to as CSD, and the operation clinic as OC.

	Time	**Quality (including patient safety)**	**Cost (including personnel and storage space)**
Procedure packs	**Advantages:** Less articles to pack, saves time for operation cart packers. Less packages to open, saves time during the setting of the operation table. Less inventory management for the OC and the CSD, e.g. inventory, ordering etc.	**Advantages**: Reduced risk of delivery of wrong, or too few articles to the operation theatre. Improved working conditions for the OC personnel due to less package opening.	**Disadvantages:** More expensive purchase price than single disposable packages. Packages are big and requires much storage space.
Operation table setting room	**Advantages:** Enables a concurrent work method, decreases the changeover time between operations.		**Disadvantages:** Requires more personnel to be able to work concurrently. Requires space at the OC.

As table 5.2, shows, some of the changes proposed entails not only advantages, but disadvantages. The main disadvantage if material handling is centralised, is the increased cost due to increased need for staff at the central sterilisation department. Operation room nurses at Uddevalla hospital estimate that only to centralise the material handling for hip surgeries, would require two more employees, to enable the disinfection process, and two extra employees to make the operation cart packing possible, at the central sterilisation department. However, at the same time as costs increase at the central sterilisation department, time savings are enabled at the operation clinic. The freed-up time, could be used for more value adding activities that will benefit the treatment of patients.

6 Discussion

The discussion, firstly, brings up implementation considerations, where the time aspect regarding elements that can be implemented in the short term versus in the long term are presented. Further, change management is discussed with respect to how to get everyone involved in the change process. Additionally, the choice of level of innovativeness will be discussed in connection to implementation. Secondly, a discussion of the proposed materials supply process will be held, and how it affects the measures time, quality, and cost. Further, how different incentives were taken into account when conducting the study will be discussed. Finally, a method discussion is held, in which the trustworthiness of the study is brought to the surface and limitations are presented.

6.1 Implementation considerations

In this section a discussion is held about the time aspect that must be considered when implementing different activities of the suggested new materials supply process at Uddevalla hospital. Some activities can be implemented on a short term horizon, while others on a long term horizon. Secondly, change management is discussed; a discussion about how to reach a successful implementation, by including the people that the change concern, is held. Thirdly, the level of innovativeness of the new materials supply process is discussed with respect to the feasibility of the implementation of the new activities.

6.1.1 Time aspect

The activities suggested in the new materials supply process, are divided into activities that could be implemented in the short and the long term. Short term, refers to activities that Uddevalla hospital could start implementing today and start working with shortly. Long term, on the other hand, refers to activities that require a couple of years to fully implement and start working with, since the preconditions that enable for the new activities take a couple of years to put in place. The suggested activities derive from the analysis in section 5.3 and they are presented together with their corresponding preconditions in table 6.1, and discussed in the following text.

Table 6.1. Time aspect of the different materials supply process activities to implement.

Activity	Preconditions
Short term	
Procedure packs	Agree on content, storage space
Start the work of specifying what material that is possible to pack in advance at the central sterilisation department.	
Long term	
Table setting room	New operation building
Move central sterilisation department next to the operation clinic.	New operation building
Move disinfection to central sterilisation department.	Material carriers, transportation route, new operation building, equipment and personnel capability
Pack kits of disposable material and instruments at the central sterilisation department.	Specify what material that should be packed by the central sterilisation department and what material that should be added by the operation clinic, ordering system for material requests

Procedure packs could be introduced in a near future; minor agreements between operation room nurses regarding the composition of the disposable material need to be done to enable the introduction, and collaboration with the supplier. Finally, before introduction, decisions about where to store the procedure packs and how to replenish the stock have to be made. Since the introduction of procedure packs is not dependant on any major physical changes, it could be introduced shortly.

To implement centralised packing and disinfection, and table setting rooms with today's facilities is not possible, why these activities have to be implemented on a long term horizon. For the new materials supply process to be successful, it needs to be taken into consideration when designing the new operation building.

Even though long term solutions will take years to be fully implemented, it is still possible to start preparing for change. For example, to specify what material that should be packed at the central sterilisation department and what material that should be kept at the operation clinic, could be done today, and the knowledge of the operation room nurses should be considered when making these decisions. Pre-work in terms of decision making is not hindered by today's physical constraints. By starting making practical decisions on how material should flow, and how activities should be performed in reality the implementation phase will be simplified once the new operation building is in place. The same holds true for personnel and equipment capacity; the planning of making sure that the right capacity is available should start before the operation building is finished. Then the right personnel could be hired and trained in advance which further simplifies the start of production.

6.1.2 Change management

Apart from creating a plan of implementation, to manage change, it is important to consider soft values and include the people that work in the process. The personnel's view of the relevance for change, and their perception of the pace of the change, has impact on the success of the implementation phase, and the functionality of the new process once fully implemented (Nadler & Tushman, 1997). This section brings up the three main problems related to change, mentioned in section 2.8, but this time set in context to the new materials supply process at Uddevalla hospital.

As mentioned in section 2.8, there are three main problems, related to the people that the change concern, to take into account during the implementation phase. To begin with, to tackle "the problem of power" the hospital will need support of key power groups. Key power groups in this case are the managers at the operation clinic and the central sterilisation department, that are responsible for ensuring that there is enough capacity in terms of staff and equipment to successfully perform the process. Further, it is recommended that a process owner is designated, who is fully responsible for the functionality of the process and takes action when quality deviates, or the flow stops, etc. To involve these groups in the implementation work, they should be invited to meetings in which they are given the possibility to speak their mind regarding change and the setup of the implementation plan. If these key groups, or key people, can agree upon the reason for change, and accept the implementation plan, the chance of the implementation to work smoothly and generate a functional process increases.

To create support among the personnel, directly connected to the process, it is important that the process owner, and the managers, articulate the vision of the future and spread a positive image of change to their employees. This is linked to the second problem, "organisational control". The problem of organisational control further requires a description of what is next to come along with continuous evaluations of the transition phase. Additionally, in order to build in stability in the change phase, the leaders must allow time to prepare for change. It is therefore suggested that the personnel are involved in deciding the pace of the implementation phase.

In order to avoid the third problem, the "anxiety" of having to replace old habits with new one's as a result of change, it is crucial that the leaders motivate constructive behaviour in response to change among the personnel by, for example, creating dissatisfaction with the current system. To create dissatisfaction with the current system could be done by emphasising the inefficiency of the current process, and gains that could be achieved with the new one, such as increased quality, focus on accurate activities, etc.

6.1.3 Level of innovativeness

When designing the new materials supply process, the project team, as a request to the mission statement, included centralisation of the material handling and introduced activities that enable decreased changeover time. Apart from these requirements, the project team was allowed to think freely when designing the new materials supply process. Hence, the project team could have chosen to develop a more revolutionary suggestion, for example a suggestion containing robot systems that completely would have eliminated all manual work connected to material handling. However, the project team wanted to, primarily, focus on the material supply process itself, and how it could be improved, before maximising its efficiency with high technology.

6.2 Discussion of the proposed materials supply process

In this section it will be discussed what the freed-up time from the operation clinic personnel could be used for. How quality will be affected by moving the operation cart packing and the disinfection process to the central sterilisation department is discussed. Further, how storage cost might be affected when building the new operation house will be discussed, along with the way in which cost has been approached in this study, as a secondary measure. Finally, a discussion regarding different incentives, presented by different stakeholders during interviews, will be held.

6.2.1 Usage of the freed-up time

The main purpose of the study was to design a materials supply process, built on the concept of externalisation of changeover activities, that enables for reduction of changeover time between operations. The proposed new materials supply process shows that there is a significant possibility of reducing the changeover time by doing changeover activities in parallel to the main activity, surgery, and by moving material handling work back in the supply chain to the central sterilisation department. The reduction of changeover time, enables for increased number of performed operations, however, it is up to the management to choose how to utilise the decrease in changeover time, caused by the new process.

6.2.2 Quality related to the relocation of the operation cart packing to the central sterilisation department

Quality, in terms of patient safety increases when introducing procedure packs due to decreased risk of bringing the wrong disposable material to the operation theatre. However, it could be discussed if moving the operation cart packing to the central sterilisation department, could affect patient safety, since the central sterilisation department personnel has less knowledge of what instruments that are needed for different surgeries, and hence could pack wrong instruments to the operation. No data has been analysed about how often this happens today, at the outpatient surgery clinic, where the material handling has been centralised to the central sterilisation department. The risk of bringing the wrong material to the operation theatre, as a result of placing the operation cart packing at the central sterilisation department is assumed to be low. The operation cart packing is only supposed to include standard instruments and disposable material, which will be stated in the order from the operation clinic in the operation card. Nevertheless, it is suggested to keep track of quality deviations such as delivery of wrong instruments and disposable material, when centralised packing is introduced. To prevent that wrong material is packed and brought to the operation theatre, the scanning system, that is used today to track where material is and who has been processing it, should be a component even in the new materials supply process.

6.2.3 Quality related to the movement of the disinfection process to the central sterilisation department

To move the disinfection process to the central sterilisation department is believed to lead to improved quality of the process as mentioned in table 5.2, in section 5.3.3. However, it is not likely that the movement of the disinfection process to the central sterilisation department will increase patient safety as the instruments today are exposed to extensive controls, to make sure that they are sterile before they are sent to the operation clinic. Hence, the process is today mistake proofed for letting contaminated instruments into the operation theatre. However, the increased quality of the disinfection process, decreases the need for re-processing the instruments which saves time.

6.2.4 The new operation building's effect on storage cost

Cost in this study, refers to storage cost. From Regionservice, it was desired to reduce the space of operation storage at the operation clinic since the space close to operation theatres is expensive and could be used for patient care instead of storage of material. With the new materials supply process, a reduction of storage space in connection to the operation clinic is achieved.

The new operation building is supposed to include a central sterilisation department. It is not known today what the cost of storage will be at the central sterilisation department in the potential new building. However, it is assumed that storage space at the central sterilisation department in the new operation building will be less expensive than storage space at the operation clinic in the hospital today.

6.2.5 Different incentives to take into account

When performing the study, it has been clear that different stakeholders have different incentives, views problems differently, and have different ideas of what is most critical to improve. The personnel at Uddevalla hospital are mostly focused on solutions that could simplify the daily job. Regionservice on the other hand, are more focused on long-term improvements regarding resource utilisation. To have such different stakeholder input made it hard to find a focus of the study, that all parts could be satisfied with, and not take side. Regionservice asked specifically for a proposal of a new materials supply process which took the measures time, quality and cost into account. Whereas the personnel at Uddevalla hospital were more interested in dependability of deliveries, and quality, see table 5.1. It is understandable that the different stakeholder groups take interest in different measures, since they perceive the situation at Uddevalla hospital from different angles. The different views were useful when evaluating the future materials supply process since it had to lead to improvements in terms of time, quality and cost, but at the same time be able to fulfil the demands of the people running the process.

For the personnel at Uddevalla hospital, patient care, is the most central activity around which the rest of the activities in the hospital are circulating. This makes it understandable why quality has become an important measure, as it is closely linked to patient care and patient safety. For the personnel to perform their tasks with high quality, a convenient work environment is needed, that contains functional supporting activities, why dependability of deliveries has been stressed. Without a reliable organisation, where material is delivered at the right time, etc., the patient might be affected, which is not acceptable.

Regionservice has an organisational view of the situation at Uddevalla hospital and has logistical competence that could be used in hospital environment. This might be the reason for the harder values of cost and time. However, Uddevalla hospital and Regionservice agree upon the importance of quality, and that it cannot be lost as an effect to the new materials supply process. Regionservice is seeking to investigate alternative ways of performing tasks with the same, or better quality, that is more time and cost effective.

The new materials supply process is believed to provide a good working environment for the personnel operating in the process, mainly because time is freed-up from time consuming, stressful, strenuous, material handling activities. Improved work environment is linked to improved quality. The dependability requirement of deliveries, that is crucial for the functionality of the process, is highly dependent on the standardisation of the process. It is up to Uddevalla hospital to ensure that the process is standardised, in terms of material ordering, delivery, and storing, to ensure patient safe operation procedures.

6.3 Method discussion

This section presents why the choice of only presenting one new materials supply chain was made. Further, the fulfilment of the four different criteria of trustworthiness are discussed. Finally, a discussion is held regarding how the absence of secondary data limited the study.

6.3.1 Concept generation

This study, with the purpose of decreasing changeover time between hip surgeries, presents one suggestion of a new materials supply process, which is based on centralised material handling. The new materials supply process is supported by identified prerequisites such as procedures packs and operation table setting rooms, which further enable time saving at the operation clinic. Undoubtedly, there are other possible ways of providing the operation clinic with surgical material. From the start, the thought approach of the project, was to bring forward several design suggestions of the materials supply process, from which the hospital could find the most applicable one. However, this made the study unfocused, why all resources were put on designing one suggestion in the end.

6.3.2 Trustworthiness

To reconnect to the section of trustworthiness in the 'Methodology' chapter, this section provides a discussion of how well the study lives up to the four criteria of trustworthiness; credibility, confirmability, transferability, and dependability.

Credibility, to begin with, is a criterion that describes how believable findings are. In this particular study, no new findings have been presented. This study presents a new materials supply process, that is built on centralisation, and a requirement of decreased changeover time. The study contains data collection via interviews, observations, and literature, but nothing groundbreaking is presented. Instead it presents a structured suggestion, where the most time saving solutions found at other clinics are implemented. However, data on which the study is built on, is credible; literature has mostly been collected from Chalmers library, and the people interviewed have great insight in the daily work at the operation clinic and the central sterilisation department at Uddevalla hospital.

Confirmability concerns the researcher's influence on the result. The project team has from the start been influenced by the mission statement given by VGR of creating a new materials supply process that is based on centralisation. The project team was given the opportunity to freely explore and suggest solutions, connected to the materials supply process, for decreasing changeover time between operations, but the base of the new materials supply process was going to be centralisation. It is probable that the result would have been different if centralisation had not been mentioned as a requirement in the mission statement. The mention of centralisation might have given the project team a positive view of the concept from the start. However, no conclusions were made and no solutions were presented until all needed data was gathered. All advantages and disadvantages that the project team could think of for the new materials supply process, including centralisation, were evaluated before presenting the final result.

The project team gathered data from a large range of people in different positions, from both the central sterilisation department and the operation clinic, to avoid drawing conclusions without enough input and to prevent being affected by just one group of people. By interviewing different people, the project team minimised the risk of "going native", and steering the result. Going native, in a research context, means to take on the view of the people that are being studied (Nadler & Tushman, 1997). The mixed input, gave a broad perspective of the situation and possible improvements that could be made.

Transferability refers to how applicable findings are in other contexts. The result of the study is applicable in other hospitals since Uddevalla is representative for other hospitals within VGR in terms of size, and complexity of materials supply. However, it is possible that suggested solutions do not give the same gains for all kinds of clinics. Solutions are probably most applicable at orthopaedic clinics, or other clinics in which operations are performed that require a lot of material. Centralisation of material handling is mainly recommended for operations that require a lot of material, for operations that require less material it is probable that the processing and storing can take place within the specific clinic. Further, it is possible that centralisation mostly fits clinics in which elective care is performed; clinics that perform emergency surgery might need a storage in connection to the operation clinic due to the difficulty of assessing exactly what material that will be needed on beforehand.

Dependability refers to how applicable findings are at other times. The result presented is applicable for other hospitals in which centralisation, procedure packs, and operation table setting rooms have not been implemented. Time is not really the important variable to consider when deciding if the result of the study is useful in the future or not, rather the reached level of improvement work at the particular hospital.

6.3.3 Limitations

During the study, absence of secondary data, limited the project team in terms of being able to present concrete numbers of gains related to procedure packs, operation table setting rooms, etc. Further, it made it difficult to present data on time consumption for performing different activities. The absence of secondary data will be discussed in terms of how it affected the study, and alternative ways that the project team had to take to conduct the study will be presented.

The project team did not withhold much secondary data during the study, referring to hard values. Data that the project team was interested in was gains in terms of time, quality and cost received from the introduction of procedure packs and operation table setting rooms at Mölndal hospital, gains for the centralisation of the operation cart packing procedure for the outpatient surgery clinic at Uddevalla hospital, and gains for moving the central sterilisation department to the same floor as the operation department at NÄL hospital. No such specific studies had been done, hence no data of that kind could be found.

The project team was also interested in knowing the time for performing activities such as operation cart packing, but no data of that kind existed. The project team, hence, considered performing a time study to get input about the time it takes to pack operation carts. However, this was cancelled since it could not be ensured that the study would be useful because of variation; to perform a time study of the procedure of packing operation carts for hip surgery, is difficult since the time to perform the task varies depending on the amount of instruments that have to be packed, which in turn vary depending on the type of operation code, and there are 21 different operation codes for hip surgeries. Had the study been performed on one type of operation code it is not certain that that result could have been used generally, for the rest of the operation codes. Had the operation codes been chosen randomly, on the other hand, it is not likely that the average result of the cart packing would have corresponded to the separate times for the other operation codes.

The gains achieved from introduction of procedure packs, etc., as well as the times for performing tasks at Uddevalla hospital, are based on estimations collected during interviews. Secondary data, could have made the study more detailed, but was not a requirement to fulfil the purpose of the study.

7 Conclusion

This chapter summarises the suggestion of the new materials supply process, its prerequisites, and the gains that can be achieved from it. Further, it summarises the implementation phase, and finally, it is concluded in which way the results fulfils the purpose of the study.

7.1 New materials supply process

This section concludes the current situation, presenting its most time consuming activities and the main solutions that can reduce the changeover time, while maintaining the patient safety.

The current process has improvement potential in the area of changeover time reduction between operations. Activities that have been considered as time consuming today, related to material handling are operation cart packing, disinfection, and operation table setting. Further it has been stressed that space at the operation clinic, used for storage of instruments and disposable material, could be used for more value adding activities.

In the new materials supply process, the activity of packing operation carts is moved from the operation clinic to the central sterilisation department. All standard material will be prepared at the central sterilisation department, and the operation carts will only be completed at the operation clinic with surgeon and patient specific material. To have the operation cart packing procedure moved to the central sterilisation department, also moves the storage at the operation clinic to the central sterilisation department. Further, in the new materials supply process the disinfection process is located at the central sterilisation department instead of at the operation clinic, operation table setting rooms are introduced at the operation clinic in connection to the operation theatre, and procedure packs are implemented.

7.2 Prerequisites for the new materials supply process to function

In this section, prerequisites needed for centralising the operation cart packing and the disinfection process to the central sterilisation department will be presented. Prerequisites needed for speeding up the operation table setting process will also be brought up.

7.2.1 Prerequisites for centralising the operation cart packing and the disinfection process

The operation clinic personnel will in the new materials supply process send material requests for specific scheduled operations to the central sterilisation department, pull, instead of as it is now, having material delivered to the operation clinic storage when it is processed. Prerequisites needed for centralising the operation cart packing is planning and communication. A system which enables sharing of information regarding what material that is available and scheduled operations, is required for the new materials supply process to function. The central sterilisation department must be aware of what types of operations that are scheduled in the nearest future, to be able to prepare the acquired material. The operation clinic on the other hand need to know what and how much material that is available to be able to schedule appropriate operations after each other. Further, the system need to include an ordering system, in which the operation clinic can place orders to the central sterilisation department.

Procedure packs can also be seen as a prerequisite for centralisation of the operation cart packing, as it decreases the number of packages that need to be collected to the operation cart(s) Without the procedure packs, the increase in workload would be unrealistic for the central sterilisation department workers. However, to move the operation cart packing procedure to the central sterilisation department will require more personnel at this very department.

Prerequisites needed for moving the disinfection process to the operation clinic are capacity in terms of personnel and washing machines. The washing machines at the operation clinic could be moved to the central sterilisation department, and the movement of the activity of loading and unloading the washing machines will require more personnel at the central sterilisation department.

Finally, the centralisation of the material handling, the operation cart packing and the disinfection process, would work more frictionless in a new operation building, in which the central sterilisation department and the operation clinic are located on the same floor. To have the operation clinic and the central sterilisation department at the same floor enables for better communication between the two units and it simplifies the transportation of surgical material. Further, a new operation building is a requirement for the implementation of operation table setting rooms, due to lack of space at the operation clinic today.

7.2.2 Prerequisites for speeding up the operation table setting process

The operation table setting is a time consuming procedure, and it is considered, by the operation clinic personnel at Uddevalla hospital, as the process that has the greatest potential of reducing the changeover time, if it is done simultaneously to ongoing surgery. A prerequisite needed for decreasing the changeover time between operations is table setting rooms. Table setting rooms enable for setting the operation table in parallel to ongoing surgery, a procedure which take 30 to 45 minutes to complete for hip surgeries, which would otherwise be taken from potential operation time. Procedure packs enables for simplified and faster operation table setting by decreasing the number of packages to open, which can be up to 27 for hip surgeries.

7.3 Gains achieved from the new materials supply process

This section goes through the gains that can be achieved through the new materials supply process. The gains are divided into the categories time, quality and cost.

7.3.1 Time

Gains achieved from the new materials supply process, is first and foremost decreased changeover time. No exact figures are presented, but time can be saved at the operation clinic by moving the disinfection process and the operation cart packing activity to the central sterilisation department. To move the operation cart packing, frees-up time from the operation clinic personnel, that could be used for patient care. To move the operation cart packing to the central sterilisation department, further, decreases the need for storage at the operation clinic, and so in turn decreases activities related to the storage such as refilling and checking inventory levels. Additionally, to move the disinfection process saves time for the operation clinic personnel, since the activity of loading and emptying the washing machines will be a responsibility of the central sterilisation department.

The time for ordering material will decrease due to the introduction of procedure packs. The procedure packs will also enable for faster operation table setting and operation cart packing. The operation table setting room, and the possibility of setting the operation table in parallel to ongoing surgery that it brings, will decrease the changeover time the most.

To decrease the material handling activities at the operation clinic, frees-up time from the operation clinic personnel, which enables for more patient care, and maybe even more operations per time unit. However, it is up to the management to decide what to do with the freed-up time.

7.3.2 Quality

Apart from gains in terms of time savings, the new materials supply process enables for increased patient safety, increased quality; the introduction of procedure packs reduces the risk of forgetting or bringing wrong disposable material to the operation theatre since the procedure pack entails all needed disposable material for the operation in one package instead of in separate packages.

The movement of the disinfection process enables for higher quality of the processing of instruments as the central sterilisation department personnel have greater knowledge of instrument handling than the operation clinic personnel, who on the other hand have greater knowledge of what the instruments are used for in the operation theatre. Further, the central sterilisation department will be fully responsible for all activities that are linked to making the contaminated instruments useful again, which is likely to increase the quality of the process as it is easier to find the root cause of potential errors if all activities are located in the same department.

By mistake proofing the process, it has been concluded that the new materials supply process is patient safe. The only aspect which has been questioned in terms of quality is the movement of the operation cart packing to the central sterilisation department as the central sterilisation department personnel have less experience of what material that is needed for different operations than the operation clinic personnel. However, the new process is not going to be knowledge based, but information based. The operation cart packing is only going to contain standard material, all included in the operation card that the operation clinic includes when sending the order to the central sterilisation department.

7.3.3 Cost

The new materials supply process decreases the need for storage space at the operation clinic as the operation cart packing from now on is moved to the central sterilisation department. Since space at the operation clinic is more expensive than space at the central sterilisation department, this change means decreased storage cost. Apart from storage cost, procedure packs enable for decreased cost of material ordering as less articles have to be ordered separately.

7.4 Implementation of the new materials supply process

This section, firstly, concludes the time aspect of the implementation phase, where some activities can be implemented in the near future and others on a long term horizon. Secondly, it states the importance of change management, for the implementation to be successful, with specific examples. Finally, the transferability of the results of the study is concluded.

7.4.1 Short term versus long term implementation

When implementing the new materials supply process, some activities can be implemented on a short time horizon while others will only be fully implemented on a long term perspective. To implement procedure packs can be done today, while implementing table setting rooms and moving the central sterilisation department require a new operation building, and hence cannot be implemented in the short future. Neither, to move the disinfection process nor the operation cart packing procedure to the central sterilisation department will be completed on a short time horizon. However, nothing is standing in the way for preparing for implementation of activities that cannot be fully implemented in the near future.

7.4.2 Change management

To implement change requires good planning, but also that the people that the change concern stand align and work towards the common goal of change. To achieve support among the people connected to the process and have them striving towards a new materials supply process, firstly, requires leaders. It has been suggested that key power groups are involved in the change process. Key power groups in this case are managers at the operation clinic and the central sterilisation department, responsible for ensuring that there is enough capacity in terms of staff and equipment to successfully perform the process. The managers should participate in the planning of the implementation, since they can provide the sources needed for the process to perform, and hence for simplifying the transition phase before reaching the new materials supply process. Secondly, a process owner should be designated, responsible for the process, who takes action when quality deviates or flow stops during the transition phase. Thirdly, to achieve support among the personnel directly connected to the process the leaders must communicate the vision of the future state, for the personnel to understand the reason for change. The leaders must also provide a description of what the change constitute in practical terms for the employees and the hospital. Further, to build in stability to the change, the leaders must allow the personnel to participate in deciding the pace of the implementation phase, since it is them that the change concern the most, and they must feel comfortable with their new working tasks to be able to perform a patient safe job.

7.4.3 Transferability

It is concluded that the results of the study are applicable in other hospitals due to that Uddevalla hospital's size and complexity of materials supply, is representative for other hospitals within VGR. However, it is likely that the results primarily are applicable in orthopaedic clinics, or other clinics in which operations are performed that require a lot of material. Further, results are primarily aimed at hospitals and clinics performing elective care.

7.5 Achievements

Finally, reaching the end of the study, a conclusion regarding achievements will be made. The study proposes a new materials supply process which enables for changeover time reduction between surgeries, by externalising activities from the operation clinic to the central sterilisation department, which is aligned with the purpose of the study. The externalisation of activities from the operation clinic, frees-up time from material handling activities for the operation clinic personnel that could instead be used for patient care, which was mentioned as a goal in the purpose. Further, the new materials supply process has been evaluated with respect to time, quality, and cost, just as stated in the purpose. Different ways of reducing changeover time have been suggested, evaluated and discussed. Patient safety has been a central part in the analysis of the new suggestion, as it is a main pillar for keeping the hospital open. Further, the way storage location can cause the storage cost to decrease has been analysed.

The aim of presenting prerequisites needed to be put in place for the new materials supply process to function and to decrease changeover time has been fulfilled, where procedure packs, table setting rooms, a new supportive communication system, and a new operation building are presented. Finally, the report gives input to the future implementation phase of the new materials supply process regarding the time aspect and change management, and it gives design input to the potential new operation building.

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Appendix A Höftset C-op Mölndal PP

Antal	Artikel
2	HANDDUK 60X40CM
2	OP-ROCK CLASSIC FÖRSTÄRKT HP, XL-L
1	SLITSLAKAN 200X260CM, SLITS 20X102CM
1	OP-LAKAN M HÄFTA 300X175CM
2	OP-HANDDUK M HÄFTA 75X75 CM
1	OP-LAKAN M HÄFTA 175X175CM U FÖRSTÄRKT
1	OP-HANDUK M HÄFTA 75X75 CM
1	INSTRUMENTBORDSLAKAN 100X150CM
1	INSTRUMENTBORDSLAKAN 200X280CM
1	INSTRUMENTBORDSLAKAN 150X190CM
1	SUG- OCH DIAPÅSE 40x35 CM
4	CELLDUK 18X25 CM
10	OP-DUK NONWOVEN 30X40 CM XRD, BRUN
1	SUGSET MIDI 2,5M [II.]
15	TVÄTTORK NONWOVEN L, 45MM
1	PLASTPÅSE ZIPLÅS 20X30CM [I.]
2	KNIVBLAD NR 21
1	PLASTPÅSE ZIPLÅS 20X30CM [I.]
2	LAMPHANDTAG GRÖNT
1	SPRUTA 50 ML KATETERTIP
2	OP-TEJP 9X49CM
1	SUG- OCH DIAPÅSE 40X35CM
1	NÅLRÄKNARE 20 NÅLAR SKUM/MAGNET [I.]
1	ELASTISK LINDA 12CM X 5M
1	PLASTPÅSE ZIPLÅS 20X30CM [I.]
1	ASSISTANSBORDSPÅSE FÖRSTÄRKT 79X145 CM
1	INSTRUMENTBORDSLAKAN 150X190CM FÖRST.

Appendix B Operation codes for hip surgeries Uddevalla hospital performed 2013-2015

1. Annan primär ledprotesoperation i höftled
2. Annan sekundär ledprotesoperation i höftled
3. Primär halv- eller delprotes i höftled med cement
4. Primär halv- eller delprotes i höftled utan cement
5. Primär total höftledsplastik med cement
6. Primär total höftledsplastik med hybridteknik
7. Primär total höftledsplastik med ytersättningsprotes
8. Primär total höftledsplastik utan cement
9. Sekundär halv- eller delprotes i höftled med cement
10. Sekundär implantation av interpositionsprotes i höftled
11. Sekundär totalprotes i höftled med cement, alla delar reviderade
12. Sekundär totalprotes i höftled med cement, cuprevision
13. Sekundär totalprotes i höftled med cement, revision av annan del
14. Sekundär totalprotes i höftled med cement, stamrevision
15. Sekundär totalprotes i höftled med hybridteknik, alla delar reviderade
16. Sekundär totalprotes i höftled med hybridteknik, annan eller ospecificerad
17. Sekundär totalprotes i höftled med hybridteknik, cuprevision
18. Sekundär totalprotes i höftled utan cement, alla delar reviderade
19. Sekundär totalprotes i höftled utan cement, annan eller ospecificerad
20. Sekundär totalprotes i höftled utan cement, cuprevision
21. Sekundär totalprotes i höftled utan cement, stamrevision

Appendix C Material list example hip replacement procedure

Höftoperation

Totalprotes
Lubinus
Blå klädsel

Teknisk utrustning

Sug
Diatermi

Grundutrustning

Höftset
Goretexrockar
Strumpa
Steridrape
1st. Förstärkt ass.påse
(1 st oförstärkt ass.påse vid främre snitt)
Koppset stort
Lamphandtag x 2
Diatermi
Cementburk
2 pkt handdukar till övertäckning

Instrument

Lubinusvagn med galler & implantat **(OBS höger eller vänster)** Lubinus femurgaller 8 st
Hall Eldriven Power Pro borr och såg + höftsågblad 8 st Lubinus SP 7st
Höftspol Micro Air + Spolset höft + 1000 NaCl 9 st
Cementspruta 8st Lubinus femurrast höger 7st
Optipac 40 och 60 (tas in när man sterildraperar pat.) el vänster 7st

Charnley spärrhake – främre snitt 6 st

Förband

Tegaderm Foam Adhesive

Höftoperation Cementfri Totalprotes
BI-METRIC RINGLOC REGENEREX

Blå klädsel

Teknisk utrustning
Sug
Diatermi
Buffébord

Grundutrustning

Höftset
Goretexrockar
Buffékläsel
Strumpa
1 Förstärkt ass.påse
1 Ass.påse (vid främre snitt)
Steridrape
Koppset stort
Diatermi
Lamphandtag x2
2 pkt handdukar till övertäckning

Instrument

Höftgaller Ben & Mjukdel 7st +7st
Bi-Metric Exact Femur Reamer 3
Bi-Metric Exact Femur Instrument 3
Bi-Metric Exact Femur Provproteser 3
Regenerex Ringloc Acetabulumgaller 2
Trilogy acetabulumreamer 4
Hall Eldriven Power Pro borr och såg + höftsågblad 8
Höftspol Micro Air + Spolset höft + 1000 NaCl 9
Charnley spärrhake – ~~främre snitt~~ 6

~~Protesvagn Bi-Metric Exact~~

Förband
Tegaderm Foam Adhesive

Appendix D Cost for different areas at Uddevalla hospital

Uddevalla

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Förvaltningsobjektsbenämning	Byggnad	Byggnadsbenämning	Plan	Rum/Bostad/Lokal ID	Rum/Bostad/Lokal Titel	Yta	Kostnad	Kostnad per kvm	Lokaltypsfaktor	Värdefaktor
Uddevalla sjukhus	110201	Hus B	1	L002	Dagkirurg	1 288,00 m²	1 755 296,96 kr	1 362,81 kr	1,30	1,20
Uddevalla sjukhus	110301	Hus C	02	L005	Op/iva/sterilcentral	694,00 m²	873 035,90 kr	1 257,98 kr	1,20	1,20
Uddevalla sjukhus	110301	Hus C	3	L002	Operation	1 280,00 m²	2 180 493,12 kr	1 703,51 kr	1,50	1,30