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Lean at Hospitals

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A case study of two Norwegian-based hospital wards



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Abstract

Hospitals are facing a huge paradox; although the system retain immense competence, the business is not developing as expected (Lord, 2019). Medical advancements have been remarkable, but more than 30% of allocated funds in the healthcare sector are wasted by inefficiencies in the use of personnel, services, equipment and processes (OECD, 2017). In addition, the scarcity of nurses has become substantial across Norway and the current deficit of 5 600 nurses is expected to increase to nearly 30 000 over the next sixteen years (Aftenposten, 2019). These challenges combined has prompted hospitals and governments to search for solutions.

Lean is a modern mind-set that is claimed to increase quality, reduce costs and bring a more acceptable workload. This philosophy has been put in use for more than a decade at the first hospitals. However, research up until today is inconclusive regarding both its applicability and output. Based on a literature review of Lean, inventory management and supply chain management at hospitals in combination with a comparative case study of two hospitals in the southeastern region of Norway, this thesis examines *“How can Lean contribute to improve hospital supply chains?”*

From a comprehensive analysis of the gathered data, the main findings are a considerable number of hours spent on non-value adding activities, inadequate inventory control and shortcomings in retaining a holistic view. While we have identified several shortcomings at the two hospitals, there is no doubt that the nurses and employees endure heroic efforts every day. Consequently, redesigning the system is recommended. To a large extent, this entails an urgency of enhancement in communication both internally at the hospitals and between the various supply chain actors. In addition, it is suggested that Lean tools are implemented in daily operations to release employees from being underutilized and carrying out non-value adding activities. In general, the main step towards Lean is to identify and eliminate the root causes - not just the symptoms. This entails a mindset that focuses on problem-solving rather than fire-fighting. Ultimately, value for the end customer, the patient, will increase.

Preface

Lean is a hot topic, and has been so for a while. To many, Lean is just a fancy word. When we were to decide on a topic for our master thesis we were interested in learning more about this hot topic. Additionally, we have a shared interest for the healthcare sector. Among other things, this interest derives from our friends working in that sector who frequently express challenges in their workday. We have been told that in order to be able to complete a master thesis one should pick a topic of true interest. In turn, Lean at hospitals became a rather natural choice of topic. As we study logistics, the flow of materials and product availability instinctively became the scope of the thesis. Consequently, we formed a thesis from scratch by ourselves. This brought some additional challenges. Even the research before the research required a lot. However, the interest we both shared for this topic gave us the motivation and drive to keep going.

Motivation and drive is far from the only reason that made us able to go from raw material to a finished product. There are several people that are worthy of our gratitude. Firstly, none of this would have been possible without the cooperation from personnel at the hospitals and in administrative positions. We want to express our gratefulness for them taking time from a hectic workday to provide valuable information. Secondly, we would like to express our appreciation to our supervisor, Marianne Jahre. You have provided us with essential counselling, guidance and motivation. We highly doubt one could find a supervisor that responds as quickly and is as flexible as you. Thank you. Lastly, our friends and family deserves a big thank you for the support they provided in many forms; food, coffees and motivating words when needed.

To all, we could not have done this without you. Your help and support has been indispensable, and highly appreciated. We are grateful.

List of Abbreviations

5S – The five S methodology

CMI – Co-Managed Inventory

FIFO - First in, first out

EOQ – Economic Order Quantity

GDP – Gross Domestic Product

H1 – Hospital 1 (Oslo)

H2 – Hospital 2 (Eastern Norway)

HSC – Hospital Supply Chain

ICT – Information and Communication Technology

IW1 - Internal Warehouse 1

IW2 - Internal Warehouse 2

JIT – Just-in-Time

LIFO - Last in, first out

OECD – Organization for Economic Co-operation and Development

OUH – Oslo University Hospital

POU – Point-of-Use

RDC - Regional Distribution Center

RFID – Radio Frequency Identification Technology

RH1 – Reference Hospital 1

RH2 – Reference Hospital 2

SC – Supply Chain

SCM – Supply Chain Management

SENRHA - South-Eastern Norway Regional Health Authority

SKU – Stock Keeping Unit

SR - Stockroom

US – United States

VMI – Vendor Management Inventory

VSM – Value Stream Mapping

Translations and Definitions

Active supply: aktiv forsyning. Bestemmelse fra Helse Sør-Øst

Box-calculated: bokskalkulert

Cabinet list: skapliste

Chip: brikker til brikkesystemet

Chip system: brikkesystemet

Chore list: oppgaveliste

Department packages: avdelingspakke. Bestemmelse fra Helse Sør-Øst

Green Cross: daily risk management to become increasingly aware of deviations.

The employees use an A3 sheet with all days formed as a cross to report deviations in different color-codes. The day after they go through the deviations and risks they have written down and come up with improvement initiatives.

Hospital department: a hospital department consists of one or more wards, along with a polyclinic (Store Medisinske Leksikon, 2019).

Hospital size:

- Small-sized hospital: >5000 employees
- Medium-sized hospital: 5000 - 10 000 employees
- Large-sized hospital: <10 000 employees

Hospital ward: a hospital ward is a unit at a hospital where the patient is admitted to overnight stay. The employees at hospital wards mainly consists of nurses, with one head-nurse in charge of the ward (Store Medisinske Leksikon, 2019). A hospital ward can also be referred to as nursing unit (sengepost/døgnområde).

Lean: a concept developed with focus on continuous improvements. Can also be referred to as Lean philosophy, the Lean concept, Lean principles and Lean thinking.

Main stockroom: hovedlager på avdeling

Order request: anmodning

Package level: pakningsnivå

- Dispatch unit: unbroken pallet delivered to the customer as it is stored at the warehouse (transportpakning).
- Traded unit: normal transport carton. At this package level the packaging can be transported without being damaged (lagerpakning).

- Consumer unit: is adjusted to the consumption requirements at department level. Thus, they are common for the wards receiving department packages (forbrukerpakning).

Product availability: tilgjengeligheten av produkter på avdelingslager, til rett tid og kvantum

Receipt of goods / goods receipt: varemottak

Regional Distribution Center: forsyningscenter

Regional distribution-logistics: regional løsning. Bestemmelse fra Helse Sør-Øst

Service employees: servicemedarbeider på avdeling

Smaller stockrooms: små nærlagere på avdeling

Specialized roll containers: bur tilpasset AGV / "AGV bur"

Stockroom: lager inne på avdeling

The cookie box: a box located at each ward with all its preapproved items for ordering (kakeboksen).

Tied up capital: bundet kapital

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1. Introduction

Healthcare plays an important role in any society and requires constant improvement and significant investments in order to deliver quality service. Thus, the expenses are severe. Within the OECD countries there are great variations regarding the expenses linked to healthcare, but the average in 2017 was to spend 9% of the country's GDP on healthcare (Statistisk Sentralbyrå, 2019a). To compare, the US spent 17% of their GDP in 2017 on healthcare, and Norway spent 10.4%. Despite the variations in healthcare spending, in most countries hospitals are the largest expense. Hospital expenses accounted for 40.4% of the total healthcare spending in Norway in 2018 (consult appendix 8; (Statistisk Sentralbyrå, 2019b)).

Efficiency is crucial in order to maintain sustainable, which is of increasing importance for the healthcare sector in the coming years. The population is aging, diseases related to life-style are increasing and patients' needs are becoming increasingly complex (World Health Organization, 2018). Additionally, there are certain shared challenges facing healthcare institutions such as cost pressures and patient safety. Thus, the healthcare sector, including hospitals, faces an increasing amount and variety of challenges. For instant, it is forecasted that by 2020 supply chain costs will exceed personnel costs and become the new number one cost in healthcare. Therefore, it is claimed that the hospitals that will succeed are the ones that manage their supply chain in the most efficient manner (Sanborn, 2018). A recent analysis reveals that U.S. hospitals could save about \$25.4 billion annually by streamlining their supply chains (Bryant, 2019).

Further, in a recent study conducted in Ohio, around 60% of hospital staff disclosed that they did not have the necessary medical item during a procedure. Additionally, around 20% could recall a situation where a patient was harmed due to absence of the required medical item (White, 2017). Hence, an increasingly important issue facing hospitals is the availability of medical items. All this combined indicate that there is great room for improvement. The concept of Lean is one of the approaches claimed to be the solution to meet the aforementioned challenges (EY, 2019, March).

1.1 Lean

Lean is a concept derived and developed from Toyota in Japan since the 1980s (J. Womack, Jones, & Roos, 1990). The core of the concept regards organizational focus of continuous improvement. Lean Enterprise Institute (2019) provides the following definition “*Lean is a set of concepts, principles, and tools used to create and deliver the most value from the customers’ perspective while consuming the fewest resources and fully utilizing the knowledge and skills of the people performing the work*”. The concept has been adopted in a great variation of sectors and companies since its arrival (Modig & Åhlström, 2014). Over the last two decades it has also been more implemented in healthcare organizations (Hallam & Contreras, 2018; Roemeling, Land, & Ahaus, 2017).

“Twenty-first century healthcare faces the challenge of growing costs, rising patient expectations, and tightened resources. Lean methods directed at trimming wastes and enhancing quality in hospital facilities and processes offer one significant way to meet the challenges” (Nicholas, 2012, p. 54).

Toussaint and Berry (2013, p. 81) defines Lean healthcare as an “*...innovative management approach that offers the promise of improving quality and efficiency while controlling costs in the provision of optimum patient care*”. In essence, Lean applied in healthcare is about distinguishing between the activities that are value-adding for the patient and the activities that are not, where the latter should be avoided or removed (Filser, Silva, & Oliveira, 2017). Porter (2010, p. 2) defines value in healthcare as “*patient health outcomes achieved relative to the cost of care*” and argues that all stakeholders can benefit from improved value. This indicates the importance of developing increasingly effective solutions regarding the various activities at a hospital in order to reduce costs, while at the same time safeguard that the patients’ needs are not compromised.

1.2 Purpose of the Thesis

“Staff can spend ridiculous amounts of time searching for equipment and medication. Patient care is undoubtedly affected by all of this” (Campbell, 2018), a nurse stated in an article The Guardian published last year.

Medical advancements have been remarkable, while the hospital systems seem to struggle. Certain areas, such as availability, costs and working environment, even seem to be aggravated. Thus, hospitals are facing a huge paradox; although the system retain immense competence, the business is not developing as expected (Lord, 2019). A report made by OECD (2017) reveals that more than 30% of allocated funds in the healthcare sector are wasted by inefficiencies in the use of personnel, services, equipment and processes. As hospitals constitute the majority of healthcare spending worldwide, pressure is put on cost reductions.

Of hospital costs, more than 30% are linked to logistics activities (Volland, Fügner, Schoenfelder, & Brunner, 2017). It is estimated that the logistics costs can be halved by increasing emphasis in logistics management (Böhme, Williams, Childerhouse, Deakins, & Towill, 2016). Further, inventory costs accounts for a large portion of total expenses at a hospital (Schneller & Abdulsalam, 2017). It is estimated that hospitals might achieve a reduction in its total expenses by more than 2% through better inventory management (Mathur, Gupta, Meena, & Dangayach, 2018). Consequently, hospital material management has been identified as one key cost containment lever to cope with steadily increasing healthcare costs.

By this, it is acknowledged that improvement in materials management at hospitals can lead to tremendous cost- and time-savings. In addition to hospitals facing an increasing amount of challenges. This combined intrigued us to gain greater understanding of how this can be handled in an effective manner without compromising humanitarian needs and dignity. Thus, our first objective is to identify how inventory costs can be reduced and product availability enhanced, by maximizing the cost-effective use of personnel and resources through a more streamlined flow. Further, Lean is claimed to be an approach directed at trimming wastes and enhancing quality in hospital facilities. Thus, our purpose is twofold, where the second objective is to investigate how implementing Lean at a hospital can contribute to reducing inventory costs and enhancing product availability.

1.3 Research Question

Based on the aforementioned challenges at hospitals worldwide today, the focus of this master thesis regards the potential impact of the Lean philosophy in the

flow and availability of medical supplies, ultimately leading to more and better patient-oriented care. By this, we have derived the following research question:

“How can Lean contribute to improve hospital supply chains?”

In order for a hospital supply chain to become more efficient it should have control over its material flow. Thus, improvements are operationalized in this study to efficiency in flow of material. Efficiency in turn relates to product availability, and not costs in this thesis. The product availability is in turn affected by inventory management and the delivery of material, namely the measure on-time-in-full. Consequently, both the design of the supply chain and the hospitals' supplier's inventory management must be considered. Additionally, the concept of Lean emphasizes the importance of a holistic view.

Although Lean has been applied in healthcare the past two decades, research to date is inconclusive of its applicability and impact (D'Andreamatteo, Ianni, Lega, & Sargiacomo, 2015; Mazzocato, Savage, Brommels, Aronsson, & Thor, 2010; Narayanamurthy, Gurusurthy, Subramanian, & Moser, 2018). By this, we have derived the following sub-question:

“What are the challenges of implementing Lean at hospitals?”

1.4 Relevance of the Thesis

To ensure the significance of the research, it is vital that the thesis has both theoretical and practical relevance. These are presented in the succeeding sections.

1.4.1 Theoretical Relevance

The concept of Lean embraces a broad variety of topics, but a central part of the concept is improved flows of material and information (Bicheno & Holweg, 2009; Grunden & Hagood, 2012; Modig & Åhlström, 2014; Regattieri, Bartolini, Cima, Fanti, & Lauritano, 2018). However, when applied in healthcare, research primarily focuses on optimizing the patient flow. EY (2019, March), among others, emphasize that Lean in healthcare should be patient-centered. While this is natural, considering that the patients constitute the dominant flow in healthcare (Hicks, McGovern, Prior, & Smith, 2015), we perceive this as a gap in the literature regarding Lean. The flow of materials should be optimized in order to

achieve an efficient patient flow (Böhme et al., 2016). The literature covers waste and how it could be reduced, but not the actual flow of materials. Thus, we attempt to bridge this gap in our study.

Further, in addition to accounting for large portions of healthcare costs, hospital systems are highly complex. They have great variability and unpredictability of patient profile and care demand (Ageron, Benzidia, & Bourlakis, 2018). In fact, the hospital supply chain is perceived to be more complex than any other service supply chain (Mandal, 2017). It requires efficient coordination of many various processes and resources to deliver appropriate patient care (Rais, Alvelos, Figueiredo, & Nobre, 2018). There may be no other supply chain with a more urgent need of performance improvement (Dobrzykowski, 2019; Dobrzykowski, Deilami, Hong, & Kim, 2014; Smeltzer & Ramanathan, 2002). One of the main challenges identified in hospital supply chains is to ensure the availability of medical supplies to sustain quality and timely patient care, at the lowest inventory costs (Pinna, Carrus, & Marras, 2015). Despite this, compared to other industries, inventory management have not been given high priority in hospital management research until recently (Volland et al., 2017). Moreover, the search for managing the supply chain in a more efficient manner has only recently been recognized by hospital administrators as something of high impact potential (Nabelsi & Gagnon, 2017). By this, our study brings theoretical relevance through identifying how Lean methodology could improve inventory management at hospitals, and hospital supply chains in general.

In sum, we aim to contribute to the identified literature gap concerning the flow of materials and product availability at hospitals with regards to the concept of Lean. Product availability is reliant on inventory management, while flow of materials is dependent upon supply chain management. The theoretical relevance is attempted ensured by a two-folded approach. First off, a conceptual framework for implementation of Lean at hospitals is developed based on the literature review. Next, this framework is utilized in the analysis of two hospitals in the southeastern region of Norway to further secure the relevance of such a conceptual framework.

1.4.2 Practical Relevance

First, it is claimed that through improved supply chain management, hospitals can reduce costs. However, research reveal that the healthcare sector has been rather slow to embrace supply chain management practices (Regattieri et al., 2018). Moreover, hospital managers have traditionally paid little attention to inventory management in general (De Vries, 2011; Nicholson, Vakharia, & Erenguc, 2004; Rossetti, Buyurgan, & Pohl, 2012). If this still is the case, this thesis contributes with insights in areas of improvements and *to some extent* how hospital supply chain performance is affected by improved hospital supply chain management.

Second, Lean healthcare is used in a growing number of hospitals to increase efficiency and quality of care. However, healthcare organizations encounter problems with the implementation. Further, it has been decided by the largest regional health authority in Norway that all hospitals in their region are to implement and work Lean. This study aims identify the opportunities and challenges with implementing Lean philosophy at hospitals. Thus, our research could bring relevance to these Norwegian-based hospitals in their journey of implementing and continuously working Lean. In addition, it may be of relevance to the other regional health authorities and hospitals to consider implementing Lean. Perhaps abroad-based hospitals find the study of relevance when evaluating adoption of the concept.

Third, right now Norway experiences a deficit of 5 600 nurses (Aftenposten, 2019). The scarcity of nurses has become substantial across the country and the deficit is expected to increase to nearly 30 000 over the next sixteen years. Working at a hospital is increasingly hectic, the employees run faster and faster. Nurses express that they feel like they do not have enough colleagues at work. This pressure is described to be so high at times, that some nurses are afraid that serious errors will occur. Further, one nurse expressed to Aftenposten (2019) “*if you have eaten, visited the restroom or laughed during the day, it has been a good day*”. The nurses claim that over the last two years, it has become fewer of those days, and more of the days where they are completely exhausted when the shift is over. Thus, we aim to identify opportunities for a more optimal material flow at the hospitals that may facilitate for a less hectic workday for the currently overworked nurses.

1.5 Structure of the Thesis

This master thesis is divided into 5 chapters. Following this introduction, the ensuing chapter presents a review of relevant literature along with a proposed conceptual framework. The third chapter describes the choice of methodology and the approach to this study. Our research is conducted based on a mixed method approach with an embedded design, where data is primarily collected through interviews, supported with some quantitative data. Presentation of the results from the data collection, the analysis of these linked to the research question and conceptual framework is covered in chapter four. Lastly, the thesis is concluded with suggestions followed by practical and theoretical implications, a reflection of the research question and lastly, interesting ideas for future research.

2. Literature Review

Our research question is how Lean can contribute to improve hospital supply chains, where improvements operationalize to efficiency in flow of materials and high product availability. In order to investigate this, theory regarding supply chain management and inventory management at hospitals are highly relevant to understand the context, opportunities and limitations. In addition, previous research has primarily focused on improvements in flow of patients. Therefore, we find it interesting to look at the flow of materials. Thus, the literature review is divided into three main parts; hospital supply chains, inventory management at hospitals and Lean at hospitals. To cover all the theory aspects, some of the literature presented is linked to healthcare in general, but we find the theory applicable to hospitals as well.

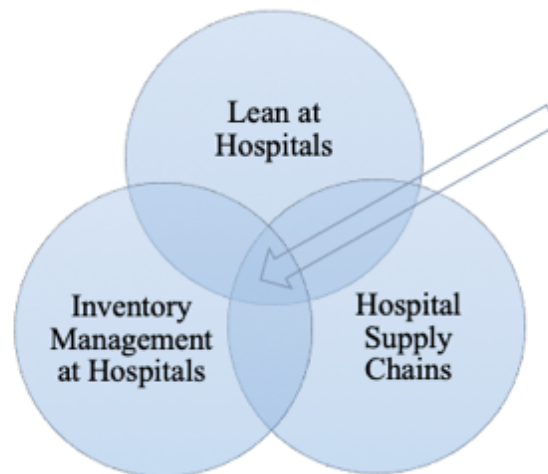


Illustration 1: Literature review

First, theory of hospital supply chains is presented. In this section, we provide an overview of the typical hospital supply chain and how to manage both the internal and external supply chain. Second, we present theory of inventory management where we also focus on the importance of warehouse location and replenishment systems for efficient material flow and product availability. Thirdly, we give an extensive review of Lean at hospitals. This section covers the background of the concept Lean, its translation to a hospital setting and the concepts of value and waste. Next, enablers and barriers for successful Lean implementation are presented along with benefits and drawbacks of Lean. After this, we provide an overview of research regarding the success of Lean implementation at hospitals. All sections are summarized with key concepts. Lastly, we provide a conceptual framework that illustrates how the three theories are linked.

2.1 Hospital Supply Chains

A supply chain (SC) is dynamic and typically consists of various types of manufacturers, suppliers, distributors, retailers and customers. It involves a constant flow of materials towards the customer, along with a constant flow of information both upstream and downstream in the SC (Chopra & Meindl, 2016; Khorasani, Cross, Feizi, & Islam, 2017). Hugos (2018, p. 3) defines supply chain management (SCM) as “... *the coordination of production, inventory, location and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served*”. SCM thus regard managing varied activities such as planning, coordination and flow of material/parts/finished goods from the first supplier to the end customer (Bø, Jahre, & Grønland, 2018; Chopra & Meindl, 2016). In addition, SCM has a prominent influence on budget (Manzini, Gamberi, & Regatierra, 2006). Further, most SCs can visually be seen as supply networks, as there may be several manufacturers, suppliers and distributors, where the network design determines the tradeoff between costs and responsiveness (Chopra & Meindl, 2016).

2.1.1 From Products to Services

SCM in the service sector is quite different compared to industries that provide physical products. Hospitals are highly complex organizations with many structures, material flows, actions and people, attempting to facilitate for value creation for patients (Dobrzykowski, 2019; Rais et al., 2018). Hospital SCM includes activities that aims to integrate a continuous, seamless flow of both materials and services in order to deliver customer service and meet the patient's expectations (Pinna et al., 2015). Customer value is usually created by meeting, or even exceeding, the expectations of the customer (Persson, 1995). An added complexity is that hospitals provide customer driven services where customers are a part of the processes. The journey of a patient often includes many various departments and staff members (Fillingham, 2008). In addition, the customer group is often highly vulnerable and many procedures have a high level of risk (Fillingham, 2007). Lord (2019) states that any patient who is admitted to a hospital ward exhibits such high complexity that fixed routines or rigid plans become inappropriate or even harmful. He further claims that for a hospital to be able to handle this great variation in patient needs, it must facilitate at least as high flexibility in their services. Further, hospital logistics consists of a wide range of

items, in varying quantities, which are handled in response to a large number of distinct diagnosis types and procedures (Pinna et al., 2015). Lastly, hospitals are also highly influenced by legislation and healthcare professionals (Eman, Jameela, Sanja, & Nader, 2014), along with its many different stakeholders (De Vries, 2011).

In addition to the flow of materials and services, it is also important to ensure transparent flow of information. This may support utilization of the SC assets and the coordination of SC flows, which in turn will lead to increased responsiveness and reduced costs (Ageron et al., 2018; Chopra & Meindl, 2016). Persson (1995) states that any endeavor to improve process performance must always show in either the flow of information- or materials. He further proposes nine strategies for redesigning logistics processes; (1) reduce or redistribute lead times, (2) reduce or adapt to uncertainties, (3) redistribute or increase frequencies, (4) eliminate or adapt to expected pattern of demand, (5) simplify structures, systems and processes, (6) differentiate, (7) postpone, (8) improve the information processing and the decision support system, and lastly (9) strengthen the internal and external integration. The proposed strategies are still relevant and suitable in a hospital environment.

The patient, and patient care is the primary concern at hospitals. However, the logistics-related activities are critical for ensuring both availability and affordability of supplies (Moons, Waeyenbergh, & Pintelon, 2019). Moreover, efficient logistics at hospitals is crucial for management and distribution of time-sensitive materials and supplies (Rais et al., 2018). In addition, the quality of the supplies at hospitals is vital as any defects can have fatal effects (Akkermans & Voss, 2013). Consequently, poor management of logistics-related activities can have tremendous effects on the quality of service (Nat Natarajan, 2006). Further, Jarrett (1998) argues that improvements in hospital logistics processes lead to both cost reductions and increased customer value.

Application of SCM techniques can optimize inventory levels and ordering processes. Although there has been a wider adoption of SCM in healthcare organizations over the past decades, hospitals have been rather slow to embrace SCM practices (McKone - Sweet, Hamilton, & Willis, 2005; Regattieri et al., 2018). Moreover, SC costs constitute the second largest spend category at

hospitals and it is estimated that they can be halved by increasing emphasis on SCM (Böhme et al., 2016; Freund, 2013).

Hospitals can be considered as being part of two SCs; an internal- and external chain (Landry & Beaulieu, 2013). A hospital is much more than just a link in a SC, and a hospital's internal SC is often very complicated (Regattieri et al., 2018). Research-wise, the external SC has been dominating the internal SC (Landry & Philippe, 2004; Volland et al., 2017). In the following sections, we distinguish between the internal hospital supply chain (HSC) and the external HSC, where the latter consists of many various actors such as suppliers and the end customer, the patient.

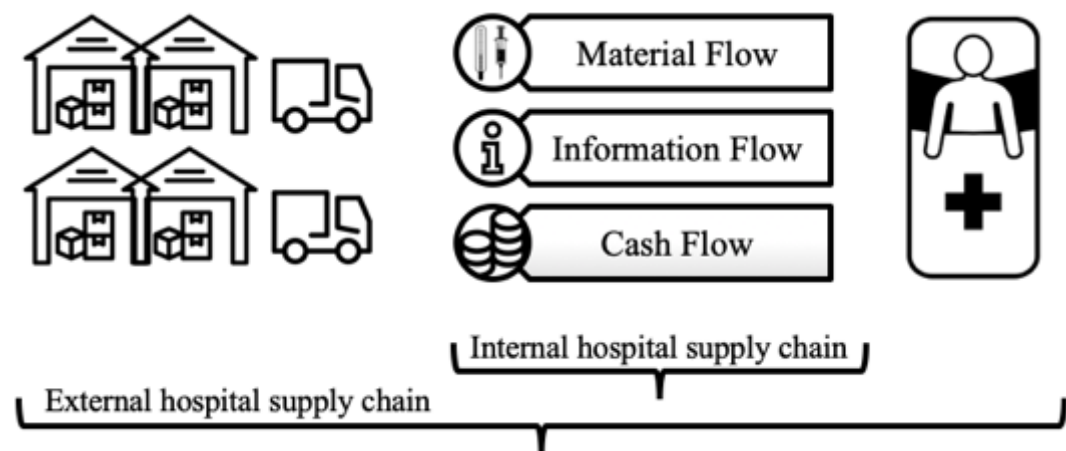


Illustration 2: Hospital supply chains

2.1.2 Managing the Internal Hospital Supply Chain

The internal HSC is highly complex and unique, where the overall performance is determined by cost, quality and safety (Khorasani, Maghazei, & Cross, 2015; Nabelsi & Gagnon, 2017). Ideally, these should be optimized through the three various types of flows in HSC processes; physical-, information- and financial flow (Pinna et al., 2015). The latter one concerns the money flow, typically moving upstream in the SC (Bø et al., 2018). This is not covered further due to the scope of the study. The physical flow includes the supply of various materials necessary to support doctors, nurses and patients. The information flow mostly concerns availability of necessary information or data. In order to support patient care processes, the operational functioning of the internal SC is fundamental. Attentive management of supplies, equipment and information is decisive with regards to improving the core activity of healthcare (Regattieri et al., 2018). Additionally, it is crucial that internal SC processes are both well-integrated and -

coordinated in order to increase efficiency while at the same time ensuring high quality patient care (Moons et al., 2019). In particular, hospitals must concentrate on the structure of their respective hierarchy and their functional silos to optimize their entire process flow (Van Rossum, Aij, Simons, van der Eng, & ten Have, 2016).

Information flows are a source of improvement of hospitals (Ageron et al., 2018), and failure to provide adequate information flows will often result in severe inefficiencies where workers will have to either trust incomplete information or spend valuable time making sure the information is trust-worthy (Böhme et al., 2016). Throughout the hospitals there is often lack of information of actual inventory data (Kaakeh et al., 2011; Volland et al., 2017), making it rather difficult to optimize the SC and ensure continuous efficiency and effectiveness. Poor visibility in both demand and inventory often leads to a mismatch in demand and supply of medical items that creates economic and patient care consequences. Availability of medical items at the right time is a key to ensure a smooth flow and assists hospitals in making best use of scarce resources (Böhme et al., 2016).

Internal hospital logistics includes routing and scheduling of various medical supplies within the hospital premises, often from a central location to designated hospital departments or wards (Rais et al., 2018). The location of various medical supplies in multiple storage rooms within the many hospital departments may make it difficult for hospital staff to locate where the needed supplies might be (Nabelsi & Gagnon, 2017). By this, hospitals will achieve great benefits from synchronizing the information and material flows (Bicheno & Holweg, 2009), e.g. greater transparency of their inventory. In addition, logistics costs often represent more than 40% of a hospital's operating budget, thus, this is an area of high improvement potential (Moons et al., 2019; Nabelsi & Gagnon, 2017). Despite this, logistics management has not received much attention in research until rather recently (Volland et al., 2017).

2.1.3 Managing the External Hospital Supply Chain

The distribution of various medical and surgical supplies, pharmaceuticals, food and linen to hospitals along with the return of waste and soiled materials, have developed into a complex network of support services from various external SC actors (Bélanger, Beaulieu, Landry, & Morales, 2018; Landry & Beaulieu, 2013).

Distribution to a hospital is typically designed as a multi-echelon inventory system (Volland et al., 2017). Echelon refers to the physical location where supplies are being held. In a multi-echelon SC suppliers deliver goods to a central warehouse closely connected to the hospital facilities, which in turn regularly delivers to the various hospital departments (Ahmadi, Masel, Metcalf, & Schuller, 2018). However, some hospitals eliminate the central warehouse and apply “semi-direct delivery” where suppliers deliver directly to hospital departments. Thirdly, some hospitals practice “direct delivery” where the supplier takes responsibility to respond to patient demand and replenish medical items at the various hospital departments (Ahmadi et al., 2018; Nicholson et al., 2004; Volland et al., 2017). To make “direct delivery” to work, the supplier should be located close to the customer in order to be responsive enough (Wild, 2018). Whichever distribution method the hospital practices, a key to success is to make sure that the external SC processes are properly integrated with the internal hospital logistics. This is important to assure that patient needs are met, unforeseen events can be tackled and continuous improvement of quality and cost control (Nabelsi & Gagnon, 2017).

HSCs are often highly fragmented (Rais et al., 2018) and decentralized (Dobrzykowski, 2019), where each level of the SC performs their respective tasks separately (Khorasani et al., 2015). Additionally, HSCs are often characterized by an absence of coordination mechanisms between the chain members (Dobrzykowski, 2019; Schmoltzi & Wallenburg, 2012; Tachizawa & Wong, 2015). However, research argues that having effective supplier integration and coordination is a necessity for enhanced SC performance (Azar, Kahnali, & Taghavi, 2010; Dobrzykowski & Tarafdar, 2015; H. K. Lee & Fernando, 2015; Mandal & Jha, 2018; Mathur et al., 2018). Wild (2018) emphasize that mutual confidence amongst SC members will allow for optimizing supply/demand matching, focus providing quality service for the patient, where the ultimate goal is to optimize added value throughout the whole SC and for all its respective members.

Information sharing is a prerequisite to optimize SC performance (Dobrzykowski, Leuschner, Hong, & Roh, 2015). To manage continuous information exchange among the SC actors, there is a need for robust cooperation and integration (Savino, Mazza, & Marchetti, 2014) and ICT can play a significant role

(Khorasani et al., 2017). Innovations in information technology have bloomed recently as a mean to improve SC collaboration and thus matching supply with demand (Kochan, Nowicki, Sauser, & Randall, 2018). However, HSC members are often limited in their information sharing by regulations. Thus, Mandal and Jha (2018) propose collaborative planning, -decision-making and -execution as ways to improve SC collaboration.

2.1.4 Key Takeaways

Hospitals are highly complex organizations attempting to facilitate for value creation for patients (Dobrzykowski, 2019; Rais et al., 2018). The HSC can be considered as both an internal- and external chain, where research on the external SC has been dominating the literature (Landry & Beaulieu, 2013; Landry & Philippe, 2004; Volland et al., 2017). Internal hospital logistics includes routing and scheduling of various medical supplies within the hospital premises, often from a central location to designated hospital departments or wards (Rais et al., 2018). External hospital logistics includes the whole SC from raw materials to the patient, where the distribution to a hospital is typically designed as a multi-echelon inventory system. Some hospitals alternatively apply either “semi-direct delivery” or “direct delivery” (Ahmadi et al., 2018; Nicholson et al., 2004; Volland et al., 2017; Wild, 2018).

Successful SCM requires planning, managing and controlling of its respective flows, mainly; physical-, information- and financial flow (Ageron et al., 2018; Pinna et al., 2015). Moreover, it is crucial that the external SC processes are properly integrated with the internal hospital logistics in order to increase efficiency while at the same time ensuring high quality patient care (Mandal & Jha, 2018; Mathur et al., 2018; Moons et al., 2019; Nabelsi & Gagnon, 2017). However, HSCs are often characterized by an absence of coordination mechanisms between the chain members (Dobrzykowski, 2019; Schmoltzi & Wallenburg, 2012; Tachizawa & Wong, 2015).

Finally, logistics activities often represent more than 40% of a hospital’s operating budget (Moons et al., 2019; Nabelsi & Gagnon, 2017) indicating a great potential in cost reductions through redesign of their logistics processes. To do so, hospitals may take use of the nine strategies proposed by Persson (1995).

2.2 Inventory Management at Hospitals

SC costs represents the second largest hospital cost center, behind patient-care staff (Freund, 2013). This implies that revealing savings in the SC could impact the bottom line greatly. Zepeda, Nyaga, and Young (2016, p. 30) state in their article “*hospital inventory costs, as a percentage of their operating budgets, vary markedly within the same peer group for service performance*”. However, they found that these costs in general were quite high. This is supported by scholars who claim that inventory costs at hospitals are estimated to lie between 10-18% of the total net revenue (De Vries, 2011; Jarrett, 1998; Nicholson et al., 2004; Volland et al., 2017). These findings indicate the room for improvement in inventory management at hospitals in order to reduce costs and improve service levels.

“*Inventory management is the activity that organizes the availability of items to customers*” (Wild, 2018, p. 1). In a hospital setting “the items” are medical supplies, food and linen. The inventory management activities vary based on how the respective HSC is organized, namely whether it is a part of a multi-echelon, direct or semi-direct delivery system. Regardless of the SC structure, Zepeda et al. (2016) argue that challenges in inventory management root to two typical SC risks: when demand exceeds supply (supply risk) it results in stockouts, or when supply exceeds demand (inventory risk) which leads to an inventory surplus. Although this is quite general, it is very much applicable to a hospital setting as maintaining the right inventory is a challenge for any healthcare organization (Mathur et al., 2018).

Hospitals are reliant on available items in inventory when needed (Khorasani et al., 2015; Moons et al., 2019; Tettey, Gholston, Welch, & Dyas, 2016), and the consequences of supply shortages can be especially severe as the quality of the patient care is at stake (Chen, Preston, & Xia, 2013; Moons et al., 2019). This often leads to overstocking, and the true cost of extra inventory becomes severe in terms of money tied up inventory in addition to obsolescence, depreciation, spoilage and increased interest costs (Bicheno & Holweg, 2009; De Vries, 2011). These high inventory costs combined with the general need to improve the service level makes “*efficient, precise inventory management more important than ever before*” (Freund, 2013, p. 1). Schneller and Smeltzer (2006) found in their study that a hospital might achieve a reduction in its total expenses by more than 2%

through better inventory management. This was later confirmed by Mathur et al. (2018). Thus, many hospitals would benefit from introducing or re-evaluating their current inventory management solutions in order to improve their performance. However, (re)shaping of inventory systems in hospitals is far from a straightforward design process (De Vries, 2011). The main goal for any healthcare organization is to provide high quality patient and any efforts for inventory cost reduction cannot compromise this (Moons et al., 2019). Thus, the goal of inventory management in hospitals is to reduce the costs associated with materials and supply without sacrificing the quality of care (Bélanger et al., 2018; Rossetti et al., 2012).

Conner (2016) claims that decision-makers should not only consider how much inventory is needed, but also how to store it and who should be the responsible to handling it. However, Volland et al. (2017) found that hospital staff dealing with logistics activities often lacks the technical background and knowledge that their counterparts in manufacturing etc. typically have. As a result, sophisticated inventory management systems in hospitals may be difficult to implement.

Further, inventory decisions at the hospital wards, the downstream location of the internal SC, are highly connected to the inventory decisions at upstream locations such as a central storage at the hospital (Ahmadi et al., 2018) or its suppliers. Thus, there is a need of coordination and communication between the various actors to optimize the inventory levels and product availability at the hospital wards. In sum, inventory management involves organising and co-ordination between warehouse operations, replenishment, inventory control and logistics, suppliers and customers to improve the SC profit, and not just improve product availability while reducing inventory (Wild, 2018). Additionally, the warehouse location at a hospital ward might impact the availability of medical supplies (Bélanger et al., 2018). Coordination in the SC was covered in the previous chapter. Hence, the next section covers inventory control, replenishment policies and warehouse location.

2.2.1 Inventory Control at Hospitals

Most hospitals lack a standardized process to manage materials (Ahmadi et al., 2018), and the traditional arrangement of materials produces a LIFO procedure (Persona, Battini, & Rafele, 2008; Regattieri et al., 2018). This could result in

expiration of medical supplies and increase the costs. Thus, hospitals could benefit from better inventory control to reduce obsolete products. In addition to obsolescence, the lack of proper inventory control could among others bring the following challenges (Bosire & Gandhi, 2012; Conner, 2016; De Vries, 2011; Wang, Cheng, Tseng, & Liu, 2015):

- Par-levels too low/high for some supplies
- Inefficient shelf, floor and space utilization
- The setup complicates storage and restocking
 - Under/over-stocking for some supplies due to ineffective management of par-levels
 - Unstandardized setups of storage space – complicates inventory counts and replenishment
- Overreaching /crawling (physically) to get some supplies
- Insufficiently labeled supplies – too much time searching /finding supplies on shelves

Possible solutions to these challenges might be (Ahmadi et al., 2018; Bélanger et al., 2018; Bosire & Gandhi, 2012; De Vries, 2011; Wild, 2018):

- Par-levels reviewed to align demand-supply
- Supplies grouped into categories
- Standardized setup for all supply rooms
- (Re)arranging the replenishment policy

An attempt to implement these solutions could be through the use of more sophisticated inventory control. *“Most sophisticated inventory maintenance systems today have automated tracking features that allow the organization to track (through bar coding processes) the movement of inventory from receipt to utilization”* (Conner, 2016, p. 41). These features include tools that contribute to secure the inventory, maintain compliance and patient safety along with a more effective SCM. Hospitals are investing in technology such as barcodes to reduce inventory and at the same time avoid stockouts, reduce cost of supplies and improve tracking of inventory (Rosales, Magazine, & Rao, 2015). However, the usage of barcodes in healthcare often differs from other industries such as retailing as the barcodes are used to reorder batches and does not normally count every item in stock. The barcode technology requires personnel spending time scanning tags for items at or under reorder level. The responsible employee(s)

should also conduct a manual cycle count to capture the usage of supply and to match the inventory level in the system with the actual physical inventory (Ahmadi et al., 2018). Consequently, despite the benefits of this technology a hospital should carefully consider these against the cost of required personnel time.

A substitute to the labor-intensive barcode technology is the adoption of radio frequency identification (RFID) technology. RFID has the potential to resolve operational and managerial inefficiencies (Nabelsi & Gagnon, 2017). However, these alone do not achieve optimal inventory control and should be supplemented by other measures like standardization. Further, appropriate inventory control will facilitate the decision of replenishment.

2.2.2 Replenishment Policies

Replenishment policy regards decisions about when and how much to reorder (Chopra & Meindl, 2016). In hospitals, replenishment of materials normally follows a periodic inventory system where the items are replenished in batches (Bélanger et al., 2018; Little & Coughlan, 2008). Further, it is usually a demand-based ordering system where the nurses conduct regular manual inventory counts combined with estimates of consumption (Aguilar-Escobar, Bourque, & Godino-Gallego, 2015). In many hospitals the nurses and staff members use only their experience or heuristic rules to determine the time and volume of the replenishment (Nicholson et al., 2004; Regattieri et al., 2018), rather than the calculated inventory levels (Volland et al., 2017). This leads to experience- or policy-driven par level decisions, rather than data-driven. In turn, this may result in high inventory levels and costs (Nicholson et al., 2004; Regattieri et al., 2018).

A major factor that influences the inventory management and the organizations ability to meet customer needs is the variation in demand (H. Lee, Padmanabhan, & Whang, 1997; Zepeda et al., 2016). When an organization faces high variation in demand, it tends to hold a higher inventory level as a buffer against potential shortages. The trade-off with keeping minimum stock and the temptation to overstock is often poorly handled, resulting in overinvestment in inventory (Graban, 2011; Tettey et al., 2016). However, efficient SCs hold little inventory. For hospitals, it would be a matter of holding inventory low, but to remain the quality of care. Thus, the managers should use techniques to ensure this quality.

Vendor management inventory (VMI) contrasts traditional inventory management through its shift of responsibility for replenishment decision making from the customer to the supplier/vendor (Krichanchai & MacCarthy, 2017), towards just-in-time (JIT) (Volland et al., 2017). “*Just-in-time means that, in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed*” (Ohno, 1988, p. 4). There is a potential of VMI in the healthcare sector (Kim, 2005) where hospitals can reduce inventory stock significantly. Despite this, Bhakoo, Singh, and Sohal (2012) found in their study that VMI adoption in healthcare has been ignored. However, previous studies suggest that adoption of VMI at the hospital enhances cost reduction (Kim, 2005; Matopoulos & Michailidou, 2013), and less time spent by nurses on replenishment.

Even though there may be several benefits to VMI there are also potential challenges identified in VMI adoption; lack of trust, information inaccuracies or delays and inefficient co-ordination (Krichanchai & MacCarthy, 2017). These challenges can be partly coped with by adopting an intermediate approach between VMI and full in-house responsibility namely co-managed inventory (CMI). CMI is a form of VMI where the hospitals remain parts of the responsibility of inventory (Volland et al., 2017). However, Chen et al. (2013) note that the hospital industry lags behind adopting collaborative inventory management approaches compared to manufacturing and retail sectors. This can be a result of at least two things, limited knowledge on these approaches and that the priority lies on clinical tasks, placing inventory management as a lesser concern.

Whichever replenishment model or cycle chosen, it is important to incorporate the transportation activities meaning the management and scheduling of delivery, and the logistic providers role in the replenishment process; are they only delivering or are they also to stock the shelves (Schneller & Smeltzer, 2006). This requires clear role definition, coordination and communication between the various actors and stages in both the internal and external HSC.

2.2.3 Warehouse Location at Hospital Wards

The location of inventory at hospital wards should help fulfil its main function, namely to support the delivery of care, in addition to meet the SC cost imperatives

(Bélanger et al., 2018). Supplies are traditionally stored in each hospital ward in one or several stockrooms, depending on the various facilities room size and space availabilities. Further, the inventory is often kept at one primary stockroom that meets the entire ward's need, which may lead to reduced storage and replenishment costs (Bélanger et al., 2018). However, its location might affect factors such as distances to the care delivery areas, creating a need for more time spent on walking. If the inventory is located at the end of a long hallway it will result in more walking than if this station was located in the centre of the patient rooms (Grabau, 2011). Not only will the walking distances be reduced with a centred warehouse location, it will also allow faster response and closer monitoring of patient needs.

Various studies have shown that the main reason for decreased nurse time at bedside is caused by nurses having to look for supplies or replenish stockrooms (Jackson Healthcare, 2013). One solution to increase the time spent on direct patient care is to redesign the wards to increase the availability of supply, medications and linen. Consequently, there has been conducted research on decentralizing storage areas closer to the point-of-use (POU), i.e. small inventories in each patient room (Rosales et al., 2015). However, these types of layouts would require more human resources to replenish all these smaller storage, which in turn can increase costs (Crans, 2007).

2.2.4 Key Takeaways

The goal of inventory management in hospitals is to reduce the costs associated with materials and supply without sacrificing the quality of care (Bélanger et al., 2018; Rossetti et al., 2012). There are identified two main challenges to improved inventory management. First, hospital staff dealing with logistics activities often lacks necessary knowledge (Volland et al., 2017) leading to experience- or policy driven par level decisions, rather than data-driven (Nicholson et al., 2004). Second, there is a need of coordination and communication between the various actors in the SC to optimize inventory level and product availability at the hospital wards (Ahmadi et al., 2018).

The location of inventory at hospital wards should help fulfill its main function, namely to support the delivery of care, in addition to meet the SC cost imperatives (Bélanger et al., 2018). Thus, a non-optimal location of stockrooms affects the

nurses walking distances resulting in lost time for direct patient care. Another reason for decreased time at bedside is nurses having to look for supplies (Jackson Healthcare, 2013) as a consequence of stockouts or poorly organized stockrooms. Research suggests adoption of barcode or RFID technology, standardization and improved organization of the stockrooms as tools and measures to improve inventory control and replenishment decisions (Landry & Beaulieu, 2013; Nabelsi & Gagnon, 2017; Rosales et al., 2015). Other suggested initiatives are a shift towards FIFO, utilization of EOQ and adoption of VMI or CMI (Krichanchai & MacCarthy, 2017; Persona et al., 2008; Tettey et al., 2016; Volland et al., 2017).

2.3 Lean at Hospitals

Healthcare worldwide experiences challenges of some kind. Some examples of such challenges are increasing costs, long waiting times, complexity of diseases, patient safety and higher expectations from various stakeholders (Cheng, Bamford, Papalex, & Dehe, 2015; Moraros, Lemstra, & Nwankwo, 2016; Noori, 2015b). This has led to a worldwide call for redesign in healthcare delivery and created an interest in improving quality and productivity in healthcare (Noori, 2015b; Toussaint & Berry, 2013). Many healthcare organizations has begun to realize that it is the system itself that causes much of these challenges (Løkken, 2013a). The excellent workers are put in an obsolete production structure that is built on almost hundred-year-old principles. However, there exists a more modern mind-set that is claimed to create higher quality, in addition to lower costs and a more acceptable workload. This new philosophy has been put in use for more than a decade at the first hospitals and is referred to as Lean healthcare (Hallam & Contreras, 2018; Roemeling et al., 2017; Van Rossum et al., 2016).

Lean was initially developed and used in the automotive and manufacturing industries, but has the last decade expanded to the healthcare sector (Moraros et al., 2016; Noori, 2015b). With the complexity and increased expectations from all stakeholders it can be stressful and challenging to work in healthcare. Employees can feel the need for inspiration and encouragement. Applying Lean in healthcare may contribute to just that for those who work there (Fillingham, 2007), and at the same time increase value for the patients (Mazzocato et al., 2010; Toussaint & Berry, 2013).

2.3.1 Background of the Concept Lean

The term “Lean production” was first introduced in an article in 1988 written by John Krafcik where he argues against the myth about economies of scale and technology being the drivers of productivity. He claims that companies with low inventory levels, low safety stocks and simple technology are able to deliver both high productivity and quality. This idea originated from the “father” of The Toyota Production System, Taiichi Ohno, who stated that Toyota’s productivity was created through flow, namely by reducing waste that did not add value to the process, nor to the customer (Ohno, 1988).

The term was later spread by J. Womack et al. (1990) through their book “The Machine that changed the world”. Toyota Motor Corporation chose to focus on flow efficiency as a measure to win over the negative effects caused by resource efficiency focus. Flow efficiency focus became the foundation of the Lean concept. Womack and Jones continued the following years developing the concept of Lean and in 1996 they published the book “Lean thinking” which focuses on what a company should do in order to both “become and stay Lean”. Womack and Jones articulates in this book five main principles that constitute the essential dynamic of Lean management. These are still the five principles of Lean according to the Lean Enterprise Institute. Both of Womack and Jones’ books have been best sellers all over the globe and are recognized as the biggest contributions to develop and spread the Lean concept.

Despite several publications there is still no general accepted definition of Lean, but there exists a general understanding of the core of the concept. It is argued that the fragmentation of the definitions and constant development of the concept Lean leads to a problem for the practicing (Modig & Åhlström, 2014). However, the definition we find most suitable is “*Lean thinking is a systematic quality improvement approach to identify and eliminate non-value-adding activities in work processes*” (Aherne & Whelton, 2010; H. Andersen & Rovik, 2015, p. 1). The philosophy is driven by “what the customers want”, where the organizations strive to define the value-adding and non-value-adding activities (Filser et al., 2017). Further, Lean is a means to increase productivity (D’Andreamatteo et al., 2015), and could be conceptualized as an operation strategy that prioritizes flow efficiency over resource efficiency.

According to Modig and Åhlström (2014), Lean is not a program to be implemented in an organization, nor is it a set of quality improvement tools. Lean is rather a cultural transformation where everyone in the organization plays a role in changing how the organization works. The aim is to improve processes at each level of an organization (D. Womack & Flowers, 1999). Lean can in turn also be defined as “*A dynamic state characterized by a continuous improvement approach*” (D’Andreamatteo et al., 2015, p. 1204). Hence, Lean is not a quick fix, it is continuous work; Lean is the journey, not the destination.

2.3.2 Lean Principles at Hospitals

Toussaint and Berry (2013) state that Lean has shown just as applicable in complex knowledge settings as in manufacturing. Cookson, Read, Mukherjee, and Cooke (2011) argue that Lean is applicable in healthcare as both manufacturing and healthcare involve long, sequential and complex processes through several departments, all with varied queuing and resource sharing. However when adopted to non-manufacturing contexts Lean is a “translated” idea (H. Andersen & Rovik, 2015; D’Andreamatteo et al., 2015). Toussaint and Berry (2013, p. 75) defines Lean healthcare as “*an organization’s cultural commitment to applying the scientific method to designing, performing, and continuously improving the work delivered by teams of people, leading to measurably better value for patients and other stakeholders*”. And further suggests that Lean at its best involves “*employees keep raising the bar, the organization becomes increasingly innovative, more staff want to be directly involved, and an attitude of continuous improvement becomes the driving force behind all work*” (Toussaint & Berry, 2013, p. 75).

The significant contextual differences between healthcare and manufacturing raise a requirement of some of the principles of Lean to be adapted to a healthcare setting before they are put into use. Among others, Noori (2015a) have made such an adaptation of the five Lean principles meaningful for a hospital:

1. Determine value desired by the patient
2. Determine the value stream for each hospital service
3. Make the hospital service flow continuously
4. Standardize processes around best practice
5. Deliver free times for creativity and innovation

The idea when implementing Lean and working under the Lean philosophy is to use the concepts and its principles in all activities in the various processes in the organization. Examples of Lean activities in a hospital are continuous improvement of medical processes, increase patient satisfaction, reduce medication errors and improving work conditions, all of which focuses on both maximizing value and eliminating waste (D'Andreamatteo et al., 2015). However, it is essential to keep in mind that also when applied in healthcare, Lean is still not a set of tools or a tool in itself. Nevertheless, there are several tools that can be applied in the Lean journey. The most commonly used tools when service industries adopt Lean thinking are value stream mapping (VSM), just-in-time (JIT), kanban and the 5S standardization (Leite & Vieira, 2015; Poksinska, Fialkowska-Filipek, & Engström, 2017). These are presented throughout the remainder of this chapter.

2.3.3 Enablers and Barriers of Successful Lean Implementation

In order to prepare any organization for implementing Lean, it is a necessity to be aware of the various enablers and barriers for successful implementation (Leite, Bateman, & Radnor, 2016). The original literature regarding Lean does not provide a clear roadmap of what will enable for implementation success and what barriers that might prevent it. In turn, many researchers have tried to identify these by conducting various case studies of hospitals that have or are implementing Lean. The most frequently mentioned enablers and barriers could be divided into the following groups: context, culture, management and information transparency.

Context

Research has found that context is a key to understand why similar Lean interventions produce different outcomes (H. Andersen, Røvik, & Ingebrigtsen, 2014; Daultani, Chaudhuri, & Kumar, 2015; Noori, 2015b). Actors in different contexts tend to translate and adopt these interventions in different ways, thus creating different versions of Lean (H. Andersen & Røvik, 2015). Daultani et al. (2015, p. 1095) found during their literature review that “*different healthcare services pose unique challenges to Lean implementation due to their inherent characteristics of service delivery*”. Thus, Lean initiatives in a hospital setting have been found to be context-dependent (H. Andersen & Røvik, 2015).

One root cause of failure to Lean implementation success is often misunderstanding of the patients' needs and their values (Holden, Eriksson, Andreasson, Williamsson, & Dellve, 2015; Simon & Canacari, 2012). Moreover, research suggests that a holistic view is of importance. D'Andreamatteo et al. (2015) found that barriers often relate to difficulty of many units acting as a whole. A common source in this regard is professional silos (de Souza & Pidd, 2011). Further, Daultani et al. (2015) stresses the importance of recognizing the consequences of implementing Lean in just one or few departments. In addition, the importance of translating and adapting Lean principles into a hospital language to create ownership is frequently underpinned (Drotz & Poksinska, 2014; Fillingham, 2007; Poksinska, 2010).

Culture

Organizational culture is another frequently mentioned enabler of Lean implementation success (Noori, 2015b). The respect for the human being should be embedded in the culture and thus it becomes a factor of success regarding Lean and its sustainability (Løkken, 2013b). D'Andreamatteo et al. (2015) emphasize the importance of creating a cultural change that fosters a long-term view of continuous improvements. This is supported by J. Womack and Jones (2003) and Tharaldsen (2011), who also stresses the relevance of creating a culture for continuous improvement.

de Souza and Pidd (2011) points out resistance to change and skepticism as one main barrier for success, where Fillingham (2007) states that employees often feel that they are "too busy to do it". D'Andreamatteo et al. (2015) states that a common barrier is misunderstanding of what Lean aims to achieve (e.g. cuts and layoffs). A narrow focus on the tools and techniques, and not the overall concept of Lean could lead to failure of alignment with the long term vision, as the providers are dedicating their focus to the short-term activities (Radnor & Boaden, 2008). As a result, sustainability activities often become neglected, such as developing a culture of continuous improvements.

Management

Management is a third category of enablers and barriers that is frequently mentioned with regards to successful Lean implementation. Simon and Canacari (2012) propose that leaders must be able to create an environment where problems

are recognized as opportunities for improvement. This involves seeing employees as problem solvers and that finding solutions are more important than assigning blame. This is supported in H. Andersen et al. (2014) and Toussaint and Berry (2013).

Moreover, organizational momentum, hierarchy and lack of leadership, resources and training are highlighted as barriers to successful implementation (de Souza & Pidd, 2011; Leite et al., 2016). Toussaint and Berry (2013) argue that implementing Lean requires major shift in roles. Managers and leaders must become teachers, mentors and facilitators. This is supported by H. Andersen et al. (2014) who claim that it is important that managers ensure training of employees and team involvement. The reasoning is that lack of people with knowledge and experience of both Lean principles and healthcare culture, can also create a barrier for successful implementation (Drotz & Poksinska, 2014; Fillingham, 2007; Poksinska, 2010). Management becomes an important enabler as research has found that a barrier towards successful implementation is disbelief in tools that derive from a non-hospital context (Drotz & Poksinska, 2014; Fillingham, 2007; Poksinska, 2010). In addition, management should focus on simplifying terminology, as de Souza and Pidd (2011) found that terminology itself often is a common source of implementation failure.

Further, Mazzocato et al. (2010) highlight the importance of management to develop methods for understanding, increasing efficiency, reduce errors and manage change. This is supported by D'Andreamatteo et al. (2015) who identified problems in defining waste as a barrier of successful Lean implementation. In addition, Leite et al. (2016) refer to lack of direction and strategy as a barrier.

Information transparency

In addition to context, culture and management, many researchers have found information transparency as an important enabler for success. This entails that information should be available, comprehensive and understandable. Information in this setting can regard both information sharing in terms of data and internal and external communication (Simon & Canacari, 2012; Sogand, 2017). Hallam and Contreras (2018) suggest that an important enabler for implementation success of Lean is to develop a clear transformation roadmap and modifying policies to encourage this transformation. They further stress the importance of

communicate the roadmap to all involved parties. Wild (2018) argue that communication is a key concept to enable Lean success. Further, Graban (2011) claim that flow is streamlined when communication across or between departments are improved. Sogand (2017) emphasize that Lean hospitals are based on information sharing and open communication between staff, suppliers and partners.

Porter (2010) emphasize that agreeing in advance of the outcome metrics is critical for the implementation to be successful. D'Andreamatteo et al. (2015) found that for Lean to be successful a clear definition of the quality targets must be present along with availability of data. This is supported by H. Andersen et al. (2014) who also stress the importance of accurate data. In sum, information transparency and communication can be an enabler and lack of it can in turn be a barrier for successful implementation.

These four main categories lay the bases for successful Lean implementation and must thus be carefully considered before embarking upon the Lean journey. In short, we could argue that the focus areas of Lean at hospitals concern no delays (JIT), zero defects, respect for the human being and continuous improvement. These focus areas should be fulfilled in order to reduce waste and add value to the patient (Toussaint & Berry, 2013). Consequently, the next two sections consider value and waste at hospitals.

2.3.4 Lean and Value at Hospitals

The customer at hospitals is the patient. Thus, to identify value-added, the question “does the patient benefit from this activity?” should always be considered. The answer to this question will identify what is considered as value, and what is considered as waste (Nicholas, 2012). Many healthcare professionals will say they know what the patients want as they are with them “all day every day”. However, the daily interactions with the patients is not necessarily the same as really understanding what is valuable to the customer (Fillingham, 2007). Consequently, many healthcare organizations seem to concentrate on amenities, the hospital profit, (isolated) cost cutting and efficiency instead of focusing on the value of the patient. Although those issues are important, the lack of patient-oriented focus ultimately becomes an expense of the patient care (Dart, 2011).

Through Lean thinking, value can be created for the patient whilst increasing efficiency and other important measures.

Porter (2010, p. 2) states that “*value should define the framework for performance in healthcare*”. However, many hospitals struggle to both identify and measure the values of their patients along with value-adding activities. To cope with this, the organization can conduct VSM. VSM is a popular tool in Lean healthcare, and its focus is to eliminate all non-value-adding activities and waste from a given process (Daultani et al., 2015; Rother & Shook, 2003). VSM can reveal waste that originates from poor organization of the workplace and even the facility layout (Nicholas, 2012). Examples here might be nurses wasting their valuable patient-time looking for supplies or simply walking great distances between patients and the nursing station. The reason for these revelations is that VSM show both time and resources spent in each activity. Examples are: waiting between the steps, the size of the inventory, performance of cycle time per activity and also the change-over time between the various activities (Kovacevic, Jovicic, Djapan, & Zivanovic-Macuzic, 2016). Consequently, VSM is used to get an understanding of the as-is situation before designing a future state for the flow of both materials and information that would bring service to a patient (Khorasani et al., 2017; Leite & Vieira, 2015).

2.3.5 Lean and Waste at Hospitals

Hospitals have tried to reduce costs for a long time, but costs keep rising (Kaplan & Porter, 2011; Porter & Kramer, 2019). The Lean concept brings hospitals to focus more on reducing waste than cutting costs (Graban, 2011). Reducing waste can often provide more value to the patients through providing improved service and quality, with less effort and costs. The presence of waste is not an indication of employees not working hard, rather waste causes employees to work too hard combating the issues that interrupt the value-adding activities. Waste is often driven by the (lack of proper) design and the system itself (Graban, 2011). Ohno (1988) proposed that there are in particular seven types of waste and his list of waste has later been customized to a hospital setting (Graban, 2011; Khorasani et al., 2017; Nicholas, 2012; Noori, 2015a; Platchek & Kim, 2012), displayed in the table below:

Waste category	Brief description	Example(s) from a hospital setting
Overproduction	Producing greater, faster or sooner than required	Requesting unnecessary test, e.g. MRI
Waiting	Patients and information idle time	Waiting for a page to be returned, diagnosis process, exam delay, discharge patients delay, the length of stay, patient waiting for doctor
Transportation	Unnecessary movement of the product in the system (patient, specimens, materials)	Poor layout, excess travel distance e.g. lab located far away from the department
Overprocessing	Doing work that is not valued by the patient	Re-entering patient's social history by the nurse, duplication of information, request patients details several times, never using data
Motion	Any unnecessary staff movement	Lack of basic equipment in each room, nurse walking to several rooms searching for supplies e.g. manual blood pressure cuff
Inventory	Excess inventory cost through financial costs, storage and movement costs, spoilage, wastage	Extra stock in hospital warehouse, expired supplies that must be disposed, incorrect inventory: out-of-stock, unable to get exactly what was required or substitute products
Underutilization	Underutilized human talent and ability	Nurse changing diapers, employees having ideas for improvement but not given the opportunity to act on those
Defects	Time spent doing something incorrectly, inspecting or correcting errors	Patient dies, wrong medication, wrong dose, repeating tests

Table 1: Waste

Regardless of the waste type, hospital waste can result in inconsistent care, unreliable treatment and constant interruptions (Hallam & Contreras, 2018). Dart (2011) pointed at the importance of waste reduction as patients are infuriated by waste because it forces them to endure boring, tedious and bureaucratic processes that do not add value to their health problem.

Non-value-adding activities are typically viewed as “a part of the way we work around here”. Thus, understanding waste is critical for improvement because it adds costs but not value (Simon & Canacari, 2012). Further, building awareness regarding which activities that actually are waste can be motivating. The employees often struggle with these activities daily, but rarely have the ability to change them. The motivation can be further increased when it is emphasized that reducing waste activities frees up time that can be used in value-adding work.

Additionally, it is more cost-effective and sustainable to reduce waste and redesign workflows, than to work more and harder (Graban, 2011). Thus, instead of increasing employee count to overcome an overworked hospital, reduction in waste is the more favorable solution. Bicheno and Holweg (2009) emphasize in their book that everyone in an organization, from the chairman to the cleaners should wear the “muda spectacles” at all times in order to improve efficiency.

In terms of our research question, motion and inventory appear to be the two waste categories that could have most impact to an efficient material flow and product availability. Thus, these two types are elaborated. Not all inventory is inherently wasteful, but excessive inventory is waste (Graban, 2011). Overstocking lead to hospital cash being tied up in the inventory, and possibly expiration of supplies and medication. Despite that too much inventory waste space and cash, stockouts can result in harm to patients (Grunden & Hagood, 2012). Further, inventory shortages may lead to additional wasted motion and costs as employees might have to place expensive orders to vendors or take unplanned trips to stockrooms (possibly located far away from the patient room). The balance is delicate, but improved inventory management can help reduce this waste. One important factor to include in inventory management is the suppliers’ lead time, as this often is a root cause of holding inventory (Wild, 2018). Under the Lean philosophy, keeping the right supplies and inventory available will facilitate delivery of quality patient care, while reducing hospital costs and waste (Torabi, Pour, & Shamsi, 2018). Kanban is a tool which aims to control material flow in a SC, and is frequently used under Lean, (Ohno, 1988; Torabi et al., 2018).

The Kanban method allows the organization to quantify an optimal reorder point for suppliers (Graban, 2011). It entails that when a stockroom is low on a specific item, a signal is sent by e.g. an empty bin or a message sent by a barcode scanner (Torabi et al., 2018; Trent, 2008). The method can be used to pull materials from a central internal warehouse to POU location (Graban, 2011). Graban (2011) further states that Kanban minimizes stockouts along with preventing an accumulation of excess inventory. This is supported in a study by Aguilar-Escobar et al. (2015) who found that changing to a Kanban system contributed to reduced time spent by nurses on logistics activities. In addition, the results of the study conducted by Khorasani et al. (2017) demonstrated that waste in a

healthcare SC can be reduced from 17% to 5% by utilizing the EOQ model together with a Kanban system. EOQ is an inventory-oriented model used to calculate optimal order quantity at minimum costs where ordering costs and holding costs are central (Chopra & Meindl, 2016). Although the effect of improving the quantity of orders was more significant than using Kanban, the improvement achieved through the latter was meaningful. Therefore, Khorasani et al. (2017) suggest that investing in Kanban in HSCs can yield significant improvements in waste, and ultimately reduction in costs.

A workday at a hospital ward is full of interruptions, wasted motions, and workarounds (Graban, 2011). The waste of motion refers to the movements required by employees to get their work done. The most obvious wasted motion in a hospital setting is unnecessary walking. A study conducted in the US, covering 36 hospitals, found that the nurses spent under 20% of their time at work on patient care, and that average walking distances per dayshift was 3 miles (Hendrich, Chow, Skierczynski, & Lu, 2008). More recent studies found that the major driver of nurses wasting time on other activities than direct patient care was looking for and restocking supplies (Jackson Healthcare, 2013; Nabelsi & Gagnon, 2017; Simon & Canacari, 2012). Toussaint and Berry (2013) refers to a study where one of the findings show that nurses were spending 38 minutes per shift on average looking for needed equipment. Relieving nurses from this non-patient care related activity, searching for supplies, will free up more time for the employees to conduct value-adding activities, particularly more and better patient care (Volland et al., 2017).

Hospital employees often think their job is their ability to deal with problems, for instance when supplies are missing, hospital staff will run to find them. Further, if the workspace is poorly designed, the distances to get supplies can be quite far. According to Nabelsi and Gagnon (2017) this issue is more present at the larger hospitals, where nurses report that they have to look for medical supplies outside their ward, often across several floors and often without success. However, these extra efforts put in by the nurses will not prevent the same situation from re-occurring. Yet, improving the workflows, in particular the layout of the departments and the organization of supplies and equipment, can reduce these walking distances (Graban, 2011; Hicks et al., 2015). Consequently, when the employees or the departments are overworked, it is essential to aim to reduce

waste, instead of just asking for more resources and people (Graban, 2011). Investigating improvements that may be achieved through a good facility design should be a priority.

5S standardization is a tool that can be applied in the work of organizing supplies to reduce waste of inventory and motion. 5S involves sort, set in order, shine, standardize and sustain (Cohen, 2018; Graban, 2011; Nicholas, 2012). Leite and Vieira (2015) emphasize that especially in the service sector with frequent movement of people and materials, 5S can help ensure process stability. Torabi et al. (2018) claim that as time is an increasingly sensitive factor, the necessity of performing 5S increases. By 5S, preferably combined with VSM, supplies can be sorted by need and accessibility (Nicholas, 2012). High volume-items are located close at hand while low-volume items are less accessible and zero-volume items are removed. When the stockrooms additionally are set in order and shined this can result in large benefits. Nicholas (2012) claims that the time spent looking for supplies can be reduced by 50-80%, which frees up more bedside time with the patient. Further, Torabi et al. (2018) found that an organized stockroom with closets and labeled equipment located correctly reduces mistakes associated with not finding the appropriate equipment at the required time.

2.3.6 Benefits and Drawbacks with Lean at Hospitals

In general, there is growing evidence that the Lean philosophy impacts quality, cost and time when applied in healthcare (Hallam & Contreras, 2018). The reported results have been in terms of both tangible and intangible outputs.

Among others, the tangible outputs regard

- reduction in waiting times (Hallam & Contreras, 2018; Holden, 2011; Moraros et al., 2016; Radnor & Boaden, 2008),
- increased quality through fewer errors (Mazzocato et al., 2010; Moraros et al., 2016; Radnor & Boaden, 2008),
- cost reductions (D'Andreamatteo et al., 2015; Dart, 2011; Holden et al., 2015; Khorasani et al., 2017; Leite & Vieira, 2015; Mazzocato et al., 2010; Radnor & Boaden, 2008), and
- productivity enhancements and time-savings (Aguilar-Escobar et al., 2015; D'Andreamatteo et al., 2015; Mazzocato et al., 2010; Moraros et al., 2016)

and the intangible outputs regards

- increased employee satisfaction (Aguilar-Escobar et al., 2015; Dart, 2011; Dellve, Williamsson, Strömngren, Holden, & Eriksson, 2015; Holden et al., 2015; Mazzocato et al., 2010; Radnor & Boaden, 2008), and
- patient satisfaction (Aguilar-Escobar et al., 2015; Mathur et al., 2018; Mazzocato et al., 2010; Moraros et al., 2016; Radnor & Boaden, 2008).

Other benefits identified as a result of successful Lean implementation are reduction of process lengths, staff walking distances and time to resolve errors, increased process understanding, staff engagement and willingness to collaborate along with improved teamwork (Mazzocato et al., 2010). Lean thinking may also contribute to the breakdown of barriers between various silos, which enhances the various departments to work greater together for the patients' benefits. Kovacevic et al. (2016) found that successful Lean implementation at hospitals significantly improved various processes in different departments, both with measurable and valuable benefits for both the patients and the hospitals. This was also the result of the study conducted by Simon and Canacari (2012). The common denominator in these success stories is the redesign of the departments after conducting a thorough VSM analysis.

Further, Kovacevic et al. (2016) found that total nurse walking distance at a hospital was reduced by 750 miles per day, resulting in more than 250 hours freed up from staff walking time for direct patient care. In addition, the implementation of Lean philosophy reduced patient waiting time for amazingly 70%, and total length of stay was reduced by 23%. In sum, they found that the concept enabled hospitals to focus more on their core operations and dedicate more time to patients, without adding costs to patients or the hospital. However, despite all these identified benefits of Lean implementation, the required efforts and potential Lean benefits is difficult to compare directly as hospitals differ in both type and size (Daultani et al., 2015). This also applies to drawbacks.

In general, there are not any identified drawbacks with implementation of Lean. However, if the implementation is not successful, especially if the enablers and barriers are not properly considered, one may find “negative” results of the project. For instant, Moraros et al. (2016) argue in their literature review that Lean interventions have no statistically significant association with patient satisfaction

of health outcomes. Additionally, they claim a negative statistical association with financial costs and worker satisfaction. Further, if the implementation is unsuccessful, potential drawbacks are the accrued cost and possible skepticism amongst employees for future improvement initiatives (Lord, 2019). Moreover, Moraros et al. (2016) found that Lean has shown to have no impact on workplace engagement, inclusion and productivity, which are listed as essential to succeed with Lean. Drotz and Poksinska (2014) found in their review that Lean has been criticized in areas such as limited potential for creativity and innovation. In addition, they claim that it may create a stressful working environment, despite its intentions being the exact opposite.

In sum, the drawbacks of Lean implementation are somewhat unclear, and in most cases contextual dependent. To get a better overview of the impact of Lean projects in hospitals we present conclusions from various research on the success of these projects in the following subsection.

2.3.7 Summarizing Lean Success at Hospitals

Hospitals worldwide have been introduced to Lean thinking as a quality improvement approach, but many scientists state that the evidence for its impact is scarce (D'Andreamatteo et al., 2015).

The “fathers” and developers of the concept of Lean; J. Womack et al. (1990), Trent (2008), Bicheno and Holweg (2009), Graban (2011) and Modig and Åhlström (2014), are all convinced that Lean can bring countless benefits to a healthcare organization if done correctly. Research and literature reviews from the last decade on the impact of Lean in healthcare show various results. Brackett, Comer, and Whichello (2013) acknowledge that application of Lean principles at hospitals is successful in improving specific outcomes. However, they cannot conclude that the implementation of Lean increases time spent on direct patient care nor improved quality of care delivery. Moraros et al. (2016, p. 163) conclude with the following statement “*While some may strongly believe that Lean interventions lead to quality improvements in healthcare, the evidence to date simply does not support this claim*”. Finally, in the literature review by Hallam and Contreras (2018) they found that evidence suggest that Lean can improve the operational effectiveness in healthcare, but that studies show implementation is highly localized and with small successes.

Research draw different conclusions about the success of Lean implementation in healthcare. We found many articles that claim Lean management approach creates several benefits and can address challenges in healthcare (e.g. Adebajo, Laosirihongthong, & Samaranayake, 2016; Dart, 2011; Dellve et al., 2015; Drotz & Poksinska, 2014; Fillingham, 2007, 2008; Hicks et al., 2015; Khorasani et al., 2015; Kovacevic et al., 2016; Krichanchai & MacCarthy, 2017; Mazzocato et al., 2010; Savino et al., 2014; Simon & Canacari, 2012; Toussaint & Berry, 2013). We also found articles concluding that the success rate of Lean implementation is low, and that the evidence of its impact is scarce (e.g. D'Andreamatteo et al., 2015; Moraros et al., 2016; Narayanamurthy et al., 2018; Poksinska et al., 2017; Roemeling et al., 2017). For comparison, the application of Lean tools and Lean thinking practices is also a hot topic in the construction industry. Although there is not a clear guide of how to prioritize the various Lean tools, similar to Lean in a hospital setting, there is established consensus that adoption of Lean tools in construction projects is very significant for e.g. control of delays (Abdelhamid, El-Gafy, & Salem, 2008; Ansah & Sorooshian, 2017; Aziz & Hafez, 2013; Nikakhtar, Hosseini, Wong, & Zavichi, 2015).

Despite the lack of evidence to draw a final word on Leans positive impact in healthcare, there are reasons to believe that Lean might be the next revolution for a better, improved, value-based healthcare. For instant, de Souza and Pidd (2011) claim that the aspect of staff empowerment and the concept of gradual and continuous improvement intrinsic to Lean make this philosophy more applicable to healthcare context than other improvement approaches.

2.3.8 Key Takeaways

The five principles of Lean adapted to a hospital setting are 1) Determine value desired by the patient, 2) Determine the value stream for each hospital service, 3) Make the hospital service flow continuously, 4) Standardize processes around best practice, and 5) Deliver free times for creativity and innovation (J. Womack & Jones, 1996). The idea when implementing Lean and working under the Lean philosophy is to use its principles and tools in all activities in the various processes in the organization. Their denominator is the focus of both maximizing value and eliminating waste. Value is defined from the patient's viewpoint. Waste is regarded as non-value-adding activities and is divided into eight categories;

overproduction, waiting, transportation, overprocessing, motion, inventory, underutilization and defects (Graban, 2011; Khorasani et al., 2017). The most commonly used tools applied in the Lean journey at hospitals are VSM, JIT, 5S standardization and Kanban (Graban, 2011; Torabi et al., 2018).

Timesaving, cost reduction and increased quality are the most recognized benefits of applying Lean at hospitals (Hallam & Contreras, 2018). To date, there are not identified any direct drawbacks. However, if the implementation of Lean does not bring the intentional outcome, it is considered an unsuccessful project and could be very costly. Successful implementation of Lean is subject to how the enablers are facilitated and how the barriers are combated. The most frequently mentioned enablers and barriers identified are: context, culture, management and information. Lastly, hospitals worldwide have been introduced to Lean thinking as a quality improvement approach the past two decades, but research about the success of Lean implementation in healthcare draw different conclusions.

2.4 Conceptual Framework

While the concept of Lean has been applied at hospitals the last two decades, research regarding its impact is inconclusive. Moreover, the importance of efficient material flow regarding the Lean methodology has not been addressed. The following section contains a conceptual framework that illustrates the link between the three parts of the literature review. This serves as the basis for the investigation of the research question.

Before one can evaluate Lean implementation, it is necessary to identify the hospitals' enablers and barriers. Identification of these is a prerequisite for Lean implementation success. Hence, looking at the internal HSC in isolation would be insufficient as the hospital can be highly affected by the upstream SC actors. This in turn is emphasized in the Lean concept, namely having a holistic view (D'Andreamatteo et al., 2015; Modig & Åhlström, 2014; Van Rossum et al., 2016). From literature, we identified context, culture, management and information transparency as the most frequent mentioned enablers/barriers. Thus, these are included in our framework. It is worth noting that theory also suggest additional enablers/barriers that could emerge as relevant in our case.

Lean philosophy aim to continuously improve the organization (J. Womack & Jones, 2003) and the principles adapted to a hospital setting serves as the essential dynamic of Lean methodology. Further, many of the strategies for redesigning logistics processes proposed by Persson (1995) are highly relatable to the Lean principles, and Lean thinking in general. Additionally, since the concept of Lean is more a philosophy and methodology rather than a fixed set of tools, Persson's strategies can contribute in identifying areas and ways to improve the HSC. Consequently, the combination of these serves as the point of departure in the implementation of Lean at hospitals. However, both the principles and strategies consider the organization as a whole. Thus, they concern improvement activities exceeding this study's scope set by the research question. Therefore, we have eliminated and/or adapted some, to make it more applicable to this specific study. These are elaborated below, with regards to the three literature review chapters.

1. Ensure continuous flow of materials and product availability

This principle is a combination of the third Lean principle, to make the hospital service flow continuously and two of Persson's strategies, reducing or redistributing lead times and increasing or redistributing frequencies. To the best of our knowledge, the flow of materials at hospitals combined with Lean thinking, has not received attention in research so far. The focus has been on patient flow (Modig & Åhlström, 2014), often in isolation. An important facilitator in the work of achieving continuous flow of materials and product availability is inventory control and replenishment policies.

2. Ensure continuous transparency in information

The HSC is complex, involving many actors and a great variety in types of material (Bélanger et al., 2018; Dobrzykowski, 2019). Ahmadi et al. (2018) emphasize that there is a need of coordination and communication between the various actors in the SC to optimize inventory levels and product availability. Consequently, ensuring information transparency is a central factor in making the hospital service flow continuously and is a combination of two strategies by Persson: improve the information processing and the decision support system, and strengthen the internal and external integration.

3. Standardize and simplify structures, systems and processes

Persson's strategy to simplify structures, systems and processes is highly linked/relatable to the Lean principle: standardize processes around best practice. In this work, the Lean tool 5S standardization is applicable. Additionally, inventory management and control can be encountered as central processes that should be simplified and standardized.

4. Eliminate waste to increase value

These are the central pillars of the Lean concept. In Lean, it is not about increasing value in itself, it is about eliminating waste which in turn will increase value. In the concept of Lean in a hospital setting there are eight categories of waste; overproduction, waiting, transportation, overprocessing, motion, inventory, underutilization and defects. In turn, the lack of proper inventory management may result in waste.

Lastly, it is the identification of potential benefits and drawbacks through implementing Lean in a hospital setting. From theory we established that Lean philosophy impacts quality, cost and time when applied in healthcare (Hallam & Contreras, 2018). These three categories are highlighted as the wanted outcomes from healthcare delivery (Lord, 2019). Quality regards increased value for the patient through eliminating waste. Costs regards, amongst other thing, reduced inventory cost and cost-effective use of personnel and resources (Iannone, Lambiase, Miranda, Riemma, & Sarno, 2013). Time regards improved efficiency in processes, reduced waiting and improved utilization of resources.

In sum, the conceptual framework is used to investigate how, and in which ways, Lean can contribute to improvements in the SC at hospitals in terms of efficient material flows and product availability. Identifying enablers, barriers, waste and value are central to determine the potential benefits and drawbacks.

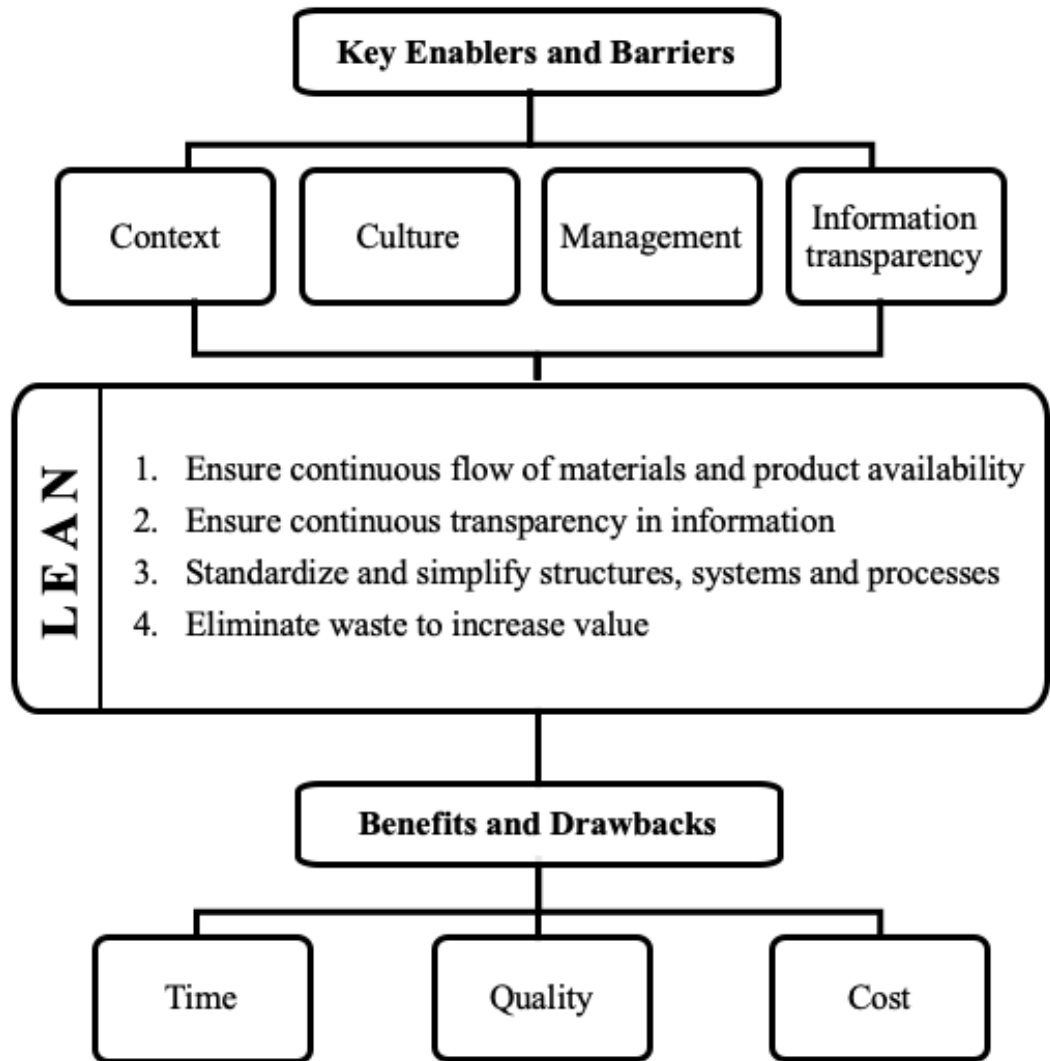


Illustration 3: Conceptual framework (developed by authors)

3. Research Methodology

Our research is based on a mixed method approach with an embedded design. We primarily collected qualitative data through interviews, but also attempted to support the interviews with quantitative data to get more depth to our research. The conceptual framework provided guidance and simplified both the collection, transcript and analysis of data, by giving order to and distinction of topics of interest. In this section, we describe and justify the methodological approach chosen to answer our research question; “*How can Lean contribute to improve hospital supply chains?*” and the sub-question; “*What are the challenges of implementing Lean at hospitals?*”. This includes the choice of research strategy and design and our approach to the sampling, data collection and analysis. We end this chapter with a subsection regarding the quality assessment of the thesis.

3.1 Research Strategy

Research strategy is defined by Bryman and Bell (2015, p. 37) as “... *a general orientation to the conduct of business*”. Essentially, the research strategy guided us in how we would go about to answer our research question (Saunders, Lewis, & Thornhill, 2008).

Bryman and Bell (2015) makes a clear distinction between qualitative- and quantitative research strategy, and expresses that contrasting the two approaches can easily make them appear as incompatible. However, in many cases it will be difficult to totally exclude one of the approaches and a combination can serve as an appropriate solution. By the nature of our research question we believe that a combination of collection of both qualitative and quantitative data was most suitable. We found it beneficial to first and foremost understand the phenomena through qualitative interviews and observations. To support our findings and provide greater depth, we also collected and used quantitative data. Thus, qualitative data serves as the main research strategy, collected mainly through interviews, supported by some quantitative data. More detailed description of how we collected this data is presented in section 3.3.

Initially, it came to our attention that Oslo University Hospital (OUH) had decided to implement Lean in their organization (Oslo Universitetssykehus, 2016b). At the same time, we had explored existing theory on the concept of

Lean. We came to know more about Lean at OUH, and read more about these aspects in the literature. As we read on we noticed some theoretical aspects of interest and aimed at finding out more about these in practice. Consequently, we went back and forth between the empirical source and the literature. Thus, neither the theory nor observations and findings in isolation served as the point of departure for this study and our research resembles mixed methods with an abductive research approach (Bryman & Bell, 2015). This approach provided the benefit of theory emerging out of the data collection and analysis, creating a better way to see emerging patterns, rather than forcing ideas from theory on the data.

3.2 Research Design

Despite the numerous studies regarding Lean in healthcare, the actual impact of this concept does not seem to be agreed upon yet. Although there have been several Lean projects at Norwegian hospitals (Brovold, 2013, 2015; Fuglehaug, 2016), there has not been conducted a mentionable amount of research regarding Lean at hospitals in Norway. Further, we found during our literature search that inventory management and material flow in HSCs has gained little to no attention in research so far. Consequently, case study design appeared appropriate. Case design is suitable when existing theory is perceived to be inadequate with regards to covering the empirical phenomena in a satisfying way (Kristoffersen, Tufte, & Johannessen, 2010). A case study is an objective, in-depth study of a current phenomenon (Yin, 2014) in a bounded situation or system (Bryman & Bell, 2015). This is appropriate for our study as we wanted to identify how the concept of Lean can contribute to improve a HSC.

S. Andersen (1997) argues that in areas with well-developed theory, a focused study of two cases can be sufficient in order to answer a precise theoretical question. Although there is not much existing theory concerning the flow of materials and inventory management with regards to Lean at hospitals, there is much theory related to Lean, both in general and in relation to hospitals. Additionally, due to the complexity of one HSC, and our time constraints, we found two SCs to be sufficient to get a grasp on the actual implications of Lean when applied in HSCs.

According to Daultani et al. (2015) the impact of Lean depends on the hospital's context. Consequently, we wanted to conduct a comparative analysis of two HSCs. Comparative studies provide better conceptual precision, both regarding detecting nuances and diversities (S. Andersen, 1997). One way to conduct comparative analysis is through most different designs. In most different systems design, cases are chosen in an attempt to maximize diversity in surrounding conditions (S. Andersen, 1997). The logic behind the most different system design is that "... a relationship which is invariant across highly diverse conditions is thereby shown to be valid irrespective of these conditions" (Pickvance, 2005, p. 4). Due to the context dependency of Lean's success this approach became a natural choice. Thus, comparing and contrasting the material flow in two different HSCs provided us with the opportunity to obtain a broader information basis. This information basis was used in the attempt to disclose the impact of Lean through their different designs, along with the possibility of generalizing potential findings (S. Andersen, 1997).

3.2.1 Sampling

Sampling regards whom we would like to interview and how to choose those informants. In a case study, samples should be based on their appropriateness to the purpose of the investigation (Bryman & Bell, 2015). Eisenhardt (1989) emphasize that random selection of cases is often neither necessary nor preferable. Further, as the goal is to understand the selected cases in depth, both cases and individuals have to be chosen according to criteria relevant to the research.

Through contact with an individual working with logistics at Sykehuspartner HF we were able to identify two hospitals in the southeastern part of Norway with different SCs. Both hospitals are a part of South-Eastern Norway Regional Health Authority where it has been decided that all hospitals in the region are to implement and work Lean (Magnussen, Vrangbnd, & Saltman, 2009). The first hospital (H1) is a medium-sized hospital located in the Oslo area and is a part of OUH that is a large-sized hospital trust. The second (H2) is medium-sized and located in the eastern part of Norway.

Investigating two hospitals in its whole would be too complex and time-consuming for this master thesis. Thus, our contact person in Sykehuspartner HF proposed that we made contact with one ward at each hospital and worked our

way backwards in the SCs. By this, we have engaged in what resembles purposive snowball sampling (Bryman & Bell, 2015). The approach was sequential, which suggests that our sampling was an evolving process. Further, the snowball method is often considered feasible when the individuals in your sample are hard-to-reach populations (Noy, 2008). As we wanted to include interviews of managers, it was particularly important that we structured our request in a way that would most likely lead to a favorable outcome. Healey and Rawlinson (1993) advise following a dual approach where you make a phone call prior to sending an email or a letter. A few days later the inquiry is to be followed up with a second phone call. This is what we did, and it brought good results. However, even though everyone we contacted was eager to contribute, we had to follow up to actually book a date for a meeting. We expected no less as we were looking to talk to people with great responsibilities and particularly much on their plates.

We interviewed several people with various relations to the two respective hospital wards. Our aspiration is that this helped us achieve valuable information, both contrasting and/or similar. However, our research question regards the HSC and consequently the wards' suppliers were of interest. Considering the SC of materials from raw material to consumption, this thesis starts with the SC partners one step upstream from the hospital, i.e., the hospital-supplier interface. There are a great variety of supplies related to hospital operations, ranging from pen and paper to X-ray machines. Management of materials in healthcare typically involves two kinds of item clusters: drugs and medical items, subject to different regulations (Iannone et al., 2013). To not over-complicate along with cultivating the logistics related activities regarding materials at hospitals, we have scoped the focus to the flow of single-use medical items, instead of e.g. pharmaceuticals. The reason is threefold. First, many researchers have already studied pharmaceuticals at hospitals. Secondly, pharmaceuticals at hospitals are solely handled by pharmacists. Thirdly, studying pharmaceuticals would not give the same depth to the study as other aspects like strict regulations, security and politics, play a greater role than logistics (Khorasani et al., 2017; Krichanchai & MacCarthy, 2017; Kaakeh et al., 2011; Nabelsi & Gagnon, 2017). Consequently, we interviewed the respective wards' suppliers of single-use medical items.

Finally, we have included interviews of nurses at two reference hospitals (RH1 & RH2). These hospitals are also part of OUH, like H1. This was done to ensure that

we to some extent can generalize some of our findings. This is referred to as *moderatum generalization*, or *case-to-case transfer* (Bryman & Bell, 2015; Williams, 2000). The list of interviews is displayed below.

List of interviews

When	Who	Abbreviation	Where	Length (minutes)
31.01.19	Individual with a central position in logistics at OUH	Logistics staff (H1)	Telephone	45
13.03.19	Employee at ward 1 holding order responsibility	Order manager (ward 1)	Hospital 1 (Oslo)	75
22.04.19	Nurse 1 at ward 1	Nurse 1 (ward 1)		25
30.04.19	Individual with a central position in logistics at hospital 2	Logistics staff (H2)	Hospital 2 (Eastern Norway)	130
30.04.19	Service employee at hospital 2	Service employee (ward 2)		40
14.05.19	Manager of internal warehouse 1 at hospital 1	IW1	Hospital 1	45
14.05.19	Internal consultant at internal warehouse 2 at hospital 1	IW2		60
14.05.19	Nurse 2 at ward 1	Nurse 2 (ward 1)		15
16.05.19	CEO at Regional Distribution Center	RDC	Regional Distribution Center	60
16.05.19	Head of logistics at Regional Distribution Center	RDC		60
20.05.19	Nurse 3 at ward 1	Nurse 3 (ward 1)	Hospital 1	15
20.05.19	Nurse 4 at ward 1	Nurse 4 (ward 1)		15
22.05.19	Nurse 5 at ward 2	Nurse 5 (ward 2)	Telephone	25
27.05.19	Nurse 7 at RH1	Nurse 7 (RH1)	Telephone	45
30.05.19	Nurse 6 at ward 2	Nurse 6 (ward 2)	Telephone	30
01.06.19	Nurse 8 at RH2	Nurse 8 (RH2)	Telephone	35

Table 2: List of interviews

3.3 Data Collection

Qualitative research methodology was the departure of our research. However, using an embedded design is common when collecting either qualitative or quantitative data do not seem sufficient. It may happen either simultaneously,

sequential or both (Bryman & Bell, 2015; Creswell & Plano Clark, 2011). Moreover, Eisenhardt (1989) remarks that case studies typically combine various sources in data collection. Thus, the data collection in this master thesis is three-fold through literature, primary and secondary data. The main part of the data collection was through primary sources, and the majority through interviews. Additionally, we gathered supporting data from secondary sources. This was done to create a better picture of the complexity in our case, to gain more reliability in our data, and as an attempt to quantify qualitative things.

3.3.1 Literature

The literature search was done through online searches on various platforms with aspirations of previous research to gain an understanding of the relevant theory. The platforms accessible to us were Oria, the library platform of Aarhus University and Google Scholar. Papers were searched in these databases by numerous combinations of the following keywords linked to the three main parts of the literature review and the research question:

- Lean, Lean thinking/philosophy/methodology, healthcare, hospitals, benefits, drawbacks, failure, logistics, supply chain management, inventory, inventory management, material, supplies, information, flow.

To not miss out on relevant literature we searched with the use of asterisk, e.g. suppl*, to capture articles on both supply and supplies. Further, we considered both the British and the American way of writing English, e.g. healthcare versus health care. This combined made it more likely to capture the relevant articles we were looking for. Some articles of interest found in reference lists were not accessible to us but to friends enrolled in other schools. Thus, we also reviewed articles from the platform of Copenhagen Business School, the University of Agder and Kristiania University College.

Initially, we aimed at only including articles from highly ranked journals. Operations research for health care, international journal for quality in health care, health care management science, journal of healthcare quality and journal of healthcare management were highly ranked healthcare journals of particular interest in the literature search. However, this did not bring enough result, and we also wanted to include newer articles on the subject. Thus, most of the literature search were conducted by narrowing the search to articles published in the time

frame 2015 – 2019, were we considered the top thirty matches. Through these articles' reference lists we found interesting articles published before 2015. We prioritized the journals within healthcare, SCM and logistics.

3.3.2 Primary Data

The primary data collection in this thesis mainly concerns interviews with various individuals. All interviewees are in some way affected by the implementation of Lean thinking at the various wards. This includes the personnel in charge of logistics activities at the hospitals, those in charge of ordering and inventory at the wards along with nurses working at the respective wards. In addition, to gain a broader understanding of the material flow we also interviewed the main suppliers of single-use medical items.

Interviews

To comply with the new GDPR requirements, we applied to Norsk senter for forskningsdata (NSD) for permission to collect and publish data in our research. Our application was approved (consult appendix 10), subject to that the data were handled according to the GDPR regulations, and that the data were anonymized and not traceable to the informant. Thus, all our interviewees are referred to as “he” throughout the thesis. Further, the interview had to be voluntary and the informant needed to be aware of the opportunity to withdraw from the study until hand-in date. All interviewees signed a form (consult appendix 9) with information about the study and their rights before the interview and received a copy by e-mail or a hardcopy.

Before we began the interviews, we asked for permission to record the session. If recording was approved, we were increasingly able to be present in the conversation. In addition, we could be alert to the interviewee's body language throughout the entire interview, instead of focusing on taking notes. However, if the interviewee pointed to things or demonstrated something with gesticulations, we took notes of this during the interview. We also took some notes if a situation occurred that the recording could not capture. Finally, we made time for taking notes directly after the respective interviews such that immediate thoughts did not go missing.

Due to the context dependency of successful Lean implementation we wanted a flexibility to adapt to the responses during the interviews. We also wanted to ask many of the same questions linked to the three main parts of the literature review along with certain questions that could increase the purpose of the developed conceptual framework. For example, we asked the logistics staff at both hospitals; “What benefits can you identify from working Lean?” Thus, a semi-structured interview guide seemed appropriate as it provides a balance between standardization and flexibility (Kristoffersen et al., 2010). When developing the interview guides we anticipated that many of the interviewees had little knowledge about Lean. Consequently, we made questions based on more common language in order to get a good response. Moreover, we included several open questions. These were used as a tool to encourage the interviewees to elaborate on aspects they found expedient as well as increasing the possibility to capture aspects we had not anticipated. We began each interview by collecting both general and specific information about the interviewee, e.g. background, position and years in their respective position, to better contextualize their answers (Bryman & Bell, 2015). Further, we included questions directly linked to the respective empirical setting.

Using a semi-structured interview guide required us as interviewers to be able to adapt to the context, rephrase already prepared questions, change the sequence and weighting, and/or formulate new questions that substantiates our research question. The ultimate goal was to create an environment where we could attain valuable reflections by the informants. Therefore, we made sure to encourage the interviewee to share any other aspects they considered relevant that had not been covered when rounding up the interview. Further, by asking many of the same questions in all our interviews, the systemization and comparison of the answers were simplified, and eased the work with the analysis (Bryman & Bell, 2015; Kristoffersen et al., 2010). However, as we interviewed employees with various titles and responsibilities we adapted the interview guide to the respective position in the HSC. Attached in appendix 2 is the nurses interview guide. A sample of the questions asked in all other interviews is attached in appendix 1.

Additionally, we gathered some quantitative data during the interviews. This data mainly regarded time spent by nurses looking for supplies and stockout

frequencies at the wards. To date, there are no data on these topics from the chosen cases making this data collection a part of our primary data.

Observation

How a Lean-based strategy is realized, is highly context-dependent (Modig & Åhlström, 2014). Therefore, we purposely asked for the interviews to be held at the hospitals, so we could observe the workers “in action”. By this, we could capture valuable illustrations of how the wards and their respective warehouse facilities were organized. When something interesting came along, one of us immediately took note of the occurrence, and if this was not possible we did so immediately after the interview. However, Lean is a dynamic way of working by continuously improving routines and processes and what makes a Lean hospital can often not only be observed (Grabau, 2011). We therefore asked about their working-processes along with trying to observe some of these. Further, Buchanan (2001) states that by taking pictures during the interviews, the researchers will be better suited for developing a richer understanding of working-processes. Consequently, we took a lot of pictures on the various sites of the warehouse facilities and other interesting aspects during our visit. These are presented throughout the analysis and in appendix 7. It is worth noting that we were careful when taking pictures, meaning not including any personnel in the photos. This was done to comply with NSD in addition to ensuring that the photos were allowed.

3.3.3 Secondary Data

Secondary data refers to information gathered by secondary sources, e.g. cost reports conducted by the hospital itself. Most of this secondary data was collected during the interviews we conducted with employees who had access to this data. The data includes order frequencies, number of SKUs in inventory at the various warehouse facilities and deliveries on time in full. The quantitative data is used to provide depth to the analysis of our qualitative data and to create a more appropriate image of the complexity in the chosen cases. In addition, we looked at documents regarding the decision of implementing Lean at the hospitals, what it meant, and documents regarding the new distribution strategy by South-Eastern Norway Regional Health Authority. These were accessible to us online as our cases belong to the public sector.

3.4 Data Analysis

Data analysis is essentially a way for the researchers to link their process of making sense of the data with the research question, as well as the literature and theoretical concepts (Bryman & Bell, 2015, p. 13). We have gathered both primary and secondary data, and also qualitative and quantitative data. Creswell and Plano Clark (2011) provides recommended six analysis procedures: preparing the data for analysis, exploring the data, analyzing the data, representing the data, interpreting the results and finally validating the data and results. The application of these procedures varies regarding the type of data that is analyzed, and in the next sections we describe how we analyzed the collected data, while the study's validity is covered in section 3.5.

To prepare the data collected through the interviews we transcribed all the interviews. Transcribing can be rather time-consuming, and Bryman and Bell (2015) advises to allow for five to six hours of transcription for every hour of speech. It is essential that the transcription of the recordings is accurate, in order to be able to quote the interviewees correctly. In an interview, it can be essential to not only understand what people say, but also in what kind of way they say it. To capture this in text we used caps lock, exclamation points and underlining. In addition, transcribing interviews helped us correct our memory-bias and become attentive to aspects said during the interview that was not so clear during the interview.

While reading through the transcripts, we wrote some memos about the content and drafted some color codes corresponding with the conceptual framework, e.g. using similar shaded colors for barriers and another one for enablers. Coding is essentially about breaking data down to smaller components, or topics (Bryman & Bell, 2015). These codes were placed in the raw draft of our qualitative codebook. Next, we read through the transcriptions again. This time we created more codes and took notes as comments in the text, consequently beginning to analyze the data. Continuously throughout the whole process, we consulted the conceptual framework to see if and where the information belonged. In addition, we conferred the literature review to see whether the information was in line or contradicting with theory. Bryman and Bell (2015) suggest that you try to make as many codes as possible in this stage, so that was what we did. One challenge we faced was that some of our interviewees covered a lot of topics during “one

answer”. When this occurred, we marked the entire answer into the code that felt most appropriate, but commented the paragraph with the other codes and thoughts suitable. When all transcript was coded once, we reviewed the entire coding. During this time, we looked for duplicate codes that could be merged and codes that could be replaced with concepts from the literature review. The latter was conducted to generate more theoretical codes that could be linked to our literature review and research question. After a few rounds of coding, we tried to group the codes into broader themes or categories. In the search for themes we looked for repetitions, metaphors, similarities/differences, missing data and theory related material. This job was also reviewed a couple of times. Eventually we felt that we had found the “right” codes, and grouped them in a proper way so that our massive data were more manageable, and ready for the next procedure of data analysis.

Data analysis represents both a critical and difficult phase, with an immense volume of data (Eisenhardt, 1989; McCutcheon & Meredith, 1993). Consequently, as we had developed a conceptual framework, the analysis of the data was to some extent simplified. Further, it involves representing findings in discussions of the themes or categories. Thus, after the final grouping of codes and themes in the previous step, we started writing a representation of our findings. During this time, we sat together to be able to discuss the findings and create a better discussion in the text. It became natural to include interesting quotes from the interviews. We translated the quotes from Norwegian to English in the best way possible so that the gist was not lost. This resulted in translations that not always were verbatim, but we were careful with adjusting the statements in reasonable matters so that it remained recognizable. In addition to writing the discussion, we made visual models/figures/maps and tables to represent our findings. Some of these were made purely for our benefit to gain a picture of the events, and some were used to both clarify the findings, and to liven up the text. Finally, once the findings were down on paper the hard work began. To interpret our results we looked to both Bryman and Bell (2015) and Creswell and Plano Clark (2011) for guidance. Thus, the interpretation includes an assessment of how the research question(s) are answered through the collected and analyzed data, and how the findings relate to theory.

In between analyzing the qualitative data, we analyzed the quantitative data. The quantitative analysis was conducted to illustrate and provide depth to the understanding of how complex the context is. Further, the quantitative data was compared to the qualitative data in order to look for any similarities and/or contrasts. Bryman and Bell (2015) emphasize that there is always a risk that the qualitative and quantitative findings might be conflicting. When this occurred, we sent an email for clarification.

3.5 Quality Assessment

There are especially four factors to encounter regarding the research quality; reliability, validity, transferability and confirmability (Kristoffersen et al., 2010). Bryman and Bell (2015) also mentions replicability as a criterion for the quality evaluation of a research. In the following section, we discuss the study's reliability, validity and confirmability. In addition, we briefly discuss transferability and replicability. When assessing the quality of this study, it is important that we contemplate on various aspects that can limit the quality of the thesis and how we attempted to minimize these. To meet criteria, we utilized well-established tactics.

3.5.1 Reliability

When conducting research, trustworthiness is key. Hence, the reliability is of importance. Reliability concerns the degree to which a measurement of a concept is stable, namely the consistency of the paper (Bryman & Bell, 2015).

Conducting interviews, along with transcription and analysis of those interviews was rather time-consuming. However, it enabled us to gain in-depth knowledge and understanding, securing reliability. Further, we have interviewed several people with different positions/ranks at the two hospitals. This provided us with information all the way from the bottom to the top of the hierarchy at the two wards, increasing the reliability. We also made sure to consider all interviewees as equally accurate in what they told us and avoided favoring any interviewee or answers. In addition, we also made sure to understand the context the two wards are part of. Thus, the reliability was strengthened as we interviewed all their main suppliers.

External reliability

External reliability concerns to what degree the study can be replicated (Bryman & Bell, 2015). As Lean is dynamic (Modig & Åhlström, 2014), it may be hard to conduct a true replication of the study. This is emphasized by Bryman and Bell (2015), who state that external reliability is a difficult criterion to meet in qualitative research. In addition, the time spent by nurses is based on their own perceptions, it is not calculated. However, we attempt to provide detailed descriptions of the research's embodiment throughout the thesis to make it easier for others to evaluate the potential replicability. Moreover, we have included pictures, illustrations and thoughtful insights captured from our observations at the two wards and their respective suppliers. Further, although we have narrowed our scope to two wards and the flow of single-use medical items, many of the findings will most likely be partly or largely applicable for other material flows at different wards.

Internal reliability

Internal reliability regards whether or not the members conducting the study agree to what they see and hear (Bryman & Bell, 2015). To secure internal reliability and similar perceptions, we regarded objectivity as important. Objectivity was secured by always being two persons conducting the interviews along with listening to and interpreting the same data. Throughout the process, we constantly strived to maintain an objective and open mindset. Additionally, as the interview guide was semi-structured, the interviewees lead the way during the interviews. Thus, we attempted to not steer the direction of the interviews in a subjective and favorable manner. To further secure internal reliability, we always made time after the interviews, to discuss and interpret what we had learned and observed during the interview. This was utilized to elaborate whether or not we had similar perceptions. If these were contradicting we contacted the interviewees for clarification. In addition, we coded all of our transcribed data together.

3.5.2 Validity

Validity involves the accuracy of the measurement and the integrity of the research (Bryman & Bell, 2015). First, this study examines only research published in English and there may also be relevant insights stemming from papers published in other languages. However, the articles presented in the

literature review are from countries all over the globe. Thus, we perceive that the number of interesting articles overlooked is reduced greatly. Although a careful search approach was deployed, some papers from journals not indexed in the searched databases may have been overlooked.

When we located interesting quotes in the coded material, we made sure to check its context in the transcribed interview before including it in our analysis to secure the validity of the quote. Additionally, we were careful with the translation from Norwegian to English to not lose its essence. Moreover, we recorded the interviews in order to remove the issue of memory bias. Together, these efforts strengthen the validity of our research.

External validity

External validity parallels transferability, which relates to whether the findings of the closely studied phenomena can be generalized to another point in time or other contexts (Bryman & Bell, 2015). Lecompte and Goetz (1982) argue that using case studies with small samples can represent a problem for the external validity of a study. An attempt to mitigate against this was that we conducted reference interviews with two nurses who are also part of OUH. This secured greater accuracy in our data.

Another aspect to consider is that there is not a consensus regarding the definition of Lean, and Lean thinking may come in various interpretations. The lack of a universal definition may be reflected in the quality of the reported evidence (D'Andre Matteo et al., 2015). Thus, we chose the most suitable and including definition to serve as the bases for this study. Additionally, the term Lean is quite theoretical and for that reason it may not be used and/or replaced by a more mundane term. Thus, our interviewees could lack knowledge to the term Lean and collecting information regarding Lean could be inadequate. To cope with this, we asked in the beginning of the interview if they had any knowledge of Lean. If they did not we phrased the questions towards continuous improvements, rather than using the term Lean. We did not ask any of the interviewees directly about our research question, but tried to operationalize it and ask questions related to it. Moreover, as Lean regards efforts of continuous improvements it may be difficult to explain, both for the people who are doing it and for bystanders, because it often permeates all aspects of the organization. Consequently, we strived to ask

questions about how they cope with inefficiencies, and in general specific follow-up questions regarding their work processes and mindset.

Internal validity

Internal validity refers to whether or not there is a match between observations and developed theoretical ideas (Bryman & Bell, 2015). The internal validity of the study was strengthened by the fact that many of the interviews were located at the respective hospitals and their suppliers. All locations were visited at least once. Thus, we were able to observe the context and environment the interviewees operate in. This allowed us as researchers to ensure congruence between concepts and observations (Bryman & Bell, 2015). However, we have been conscious to include observations that deviates from the theory as well in order to not facilitate publication bias (Kristoffersen et al., 2010).

Using snowball sampling to find interviewees might influence the validity of the paper. Bryman and Bell (2015) argue that this way of sampling makes it very unlikely that the sample will be representative of the population. However, the study is organizational and not sensitive to individuals we have interviewed. Therefore, there would be no reason for the interviewees to tell anything but the general assumptions and truths. Thus, we regard the snowball sampling as not particularly weakening the internal validity. To further mitigate, we interviewed several nurses at ward 1, and added input through interviewing two nurses working at two different wards at two different hospitals. We also interviewed people at various stages in the SC providing a variety of interview objects.

In this chapter, we have reasoned the approach applied to answer our research question. Additionally, we have described the settings of the data collection to enable the reader to understand the data analysis and our interpretations of the results. Finally, we evaluated the quality of the research. The next chapter covers a case description, results and discussion.

4. Analysis and Discussion

The consecutive section regards analysis of the collected data from the two wards and their respective SCs regarding adaptation to Lean and inventory management. The two first chapters, 4.1 and 4.2, map the SCs and their context along with a presentation of Lean at the hospitals. The remaining chapters are more closely linked to the conceptual framework, where results/examples from the interviews and observations are analyzed and discussed in relation to theory. These are enablers, barriers, waste and value. Lastly, we analyze the benefits and drawbacks of Lean at the respective wards, with regards to time, quality and cost.

4.1 Mapping the Supply Chains

South-Eastern Norway Regional Health Authority (SENRHA) has decided that all hospitals in their region are to implement and work Lean (Magnussen et al., 2009). This implies that hospitals will rely on implementing Lean philosophy into their everyday operations in order to operate more efficiently. One of the initiatives with regards to this decision is that all hospitals are to move towards a regional distribution-logistics and implement a delivery of supplies called “active supply”. One of the hospitals we have studied has implemented this initiative, while one has not. In this section, the two respective SCs are presented after a brief introduction to the Lean initiative along with the context of the two cases.

4.1.1 The Cases in Their Context

SENRHA is the largest of four regional health authorities in Norway and consists of 11 hospital trusts, 5 private noncommercial hospitals and around 78 000 employees. The regional health authority was established 1st June 2007 and covers 57% of the total population in Norway (Helse Sør-Øst, 2019). The hospitals located in the southeastern part of Norway are affected by regulations set by the Norwegian Ministry of Health and Care Services and SENRHA, and decisions made by Sykehuspartner and Sykehusinnkjøp. Sykehuspartner delivers a regional economic- and logistics service (Sykehuspartner, 2019). Sykehusinnkjøp is responsible for implementing and managing local, regional and national procurement agreements (Helse Sør-Øst, 2018b). In sum, the hospitals are constrained by national agreements, regional agreements endorsed by SENRHA and lastly, local agreements that are made by the hospitals themselves. Consequently, the setup, with all these actors and regulations confirms what is

stated in the theory of HSCs being one of the most complex SCs there is (Dobrzykowski, 2019; Rais et al., 2018).

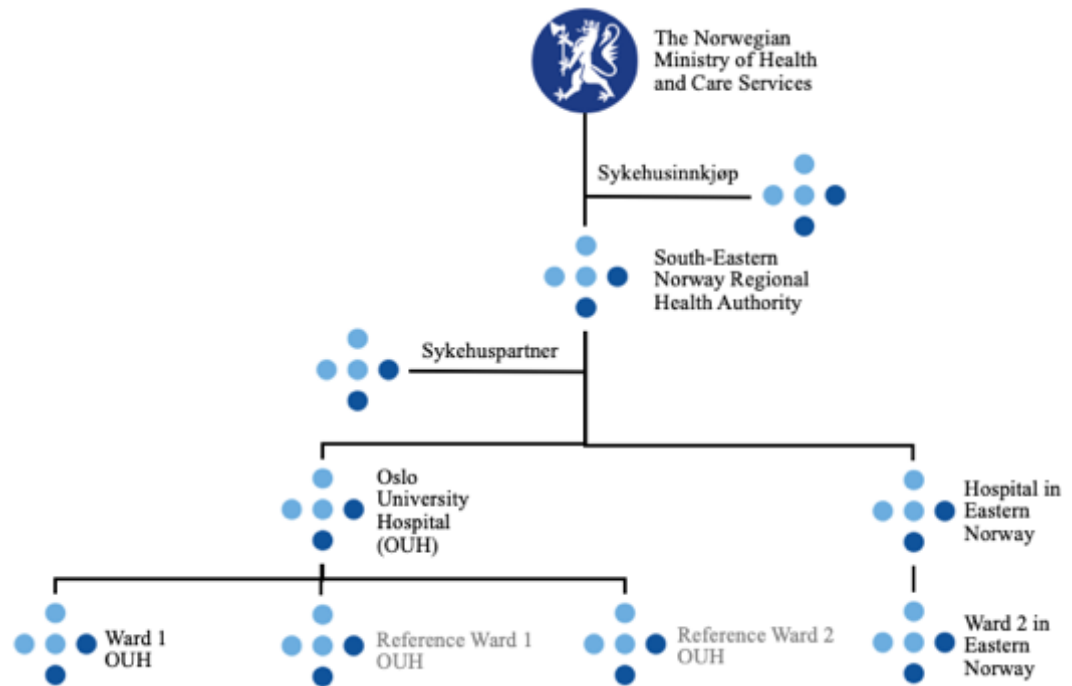


Illustration 4: The cases in their context; a simplified overview

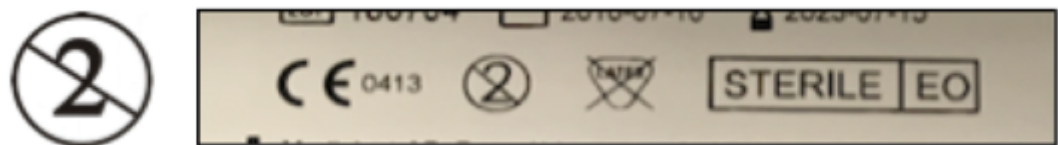
SENPHA is, amongst other things, responsible for administrating a common regional distribution-logistics (Helse Sør-Øst, 2018b). This implies that there will be one regional distribution center (RDC) that supplies the most frequently used material to all hospitals in the southeastern region of Norway. All internal warehouses located at the hospitals will be eliminated and distribution will happen directly from the RDC to the various hospital departments. This is enabled through the concept of “department packages”. Department packages concerns that the entire order from a respective department is packed and delivered in one cargo container. Thus, the receipt of goods at the hospitals can bring this cargo container directly to the department. The second initiative raised by SENPHA is called active supply. Active supply is an attempt to solve the excessive time and resources spent on manual tasks and processes in warehousing, and its high purchasing costs. The initiative entails a group of employees at the hospitals that takes full ownership of the material flow meaning the scanning, distribution, replenishment and maintenance at the departments stockrooms (Helse Sør-Øst, 2018a). At hospitals with internal warehouses these employees are also responsible for the picking and packing of orders. One of the goals with this initiative is to increase time spent by nurses on core activities. In addition, the initiative aims to contribute to reduce stockouts and dependency of key personnel

along with increasing inventory control. These are all common challenges in relation to inventory activities.

In sum, the regional distribution-logistics concept is an initiative by SENRHA made to achieve a more streamlined flow of materials along with a more optimal utilization of resources. By these goals, this initiative appear in line with the intention of the Lean concept (J. Womack & Jones, 2003). We investigate this during our analysis, but first we present the mapping of the two SCs, along with the more local Lean initiatives. Further, the initiative concerns all varieties of supplies that is delivered at the hospitals. However, as stated in our methodology chapter, we have scoped the study to single-use medical items. Thus, we provide an introduction to this type of medical item in the next section.

4.1.2 Single-Use Medical Items

Single-use medical items can also be referred to as “disposable products” (Bijvank, 2012) and “medical supplies” (Bélanger et al., 2018), and ranges from bandages to cannulas. Regardless of the term, a single-use medical item refers to a medical device that is used on one individual patient during a procedure, and then tossed (MHRA, 2018). The packages containing these medical items are marked with a symbol indicating that this particular device is not to be reprocessed and/or used by another patient.



Picture 1: Single-use medical item

The great variety in size, value and turnover of single-use medical items combined with the certain requirements of how these items are to be stored makes inventory management a prerequisite. Most of these items often require complete sterility. This implies that firstly, it is crucial that the item is wrapped in a way that prohibits any microorganisms to penetrate. Secondly, the storage unit has to be completely dry and cleared for dust at all times. Thirdly, any large temperature fluctuations should be avoided (Arbeitsgruppe for instrumentbehandling, 2004). Lastly, these items have an expiration date in terms of the guaranteed sterility.

4.1.3 The Supply Chain of Ward 1

The illustration (5) below replicates the SC of ward 1 at one of the medium-sized hospitals in Oslo (H1). Consult appendix 3 for an illustration of the extended SC. The ward houses 18 patient beds. At this ward, there are 9 nurses at work during the day, 4 during the evening and 3 during the night. Approximately 20 nurses are employed there in total. In addition, there are 4-5 employees with administrative/manager titles at the ward. One of the employees has 20% of his position dedicated to activities related to the ward's stockrooms. He is later referred to as the order manager at ward 1. This includes controlling, scanning, ordering and follow-ups. H1 has not yet fully implemented active supply and does not receive department packages from the RDC. The ward mainly orders single-use medical items from two internal warehouses and the RDC, where the RDC delivers supplies that are not in the assortment at the internal warehouses. In certain cases, where neither of the three warehouses supply that particular item, the order manager locates and order directly from another supplier. This resembles what Volland et al. (2017) refers to as a typical multi-echelon inventory system.

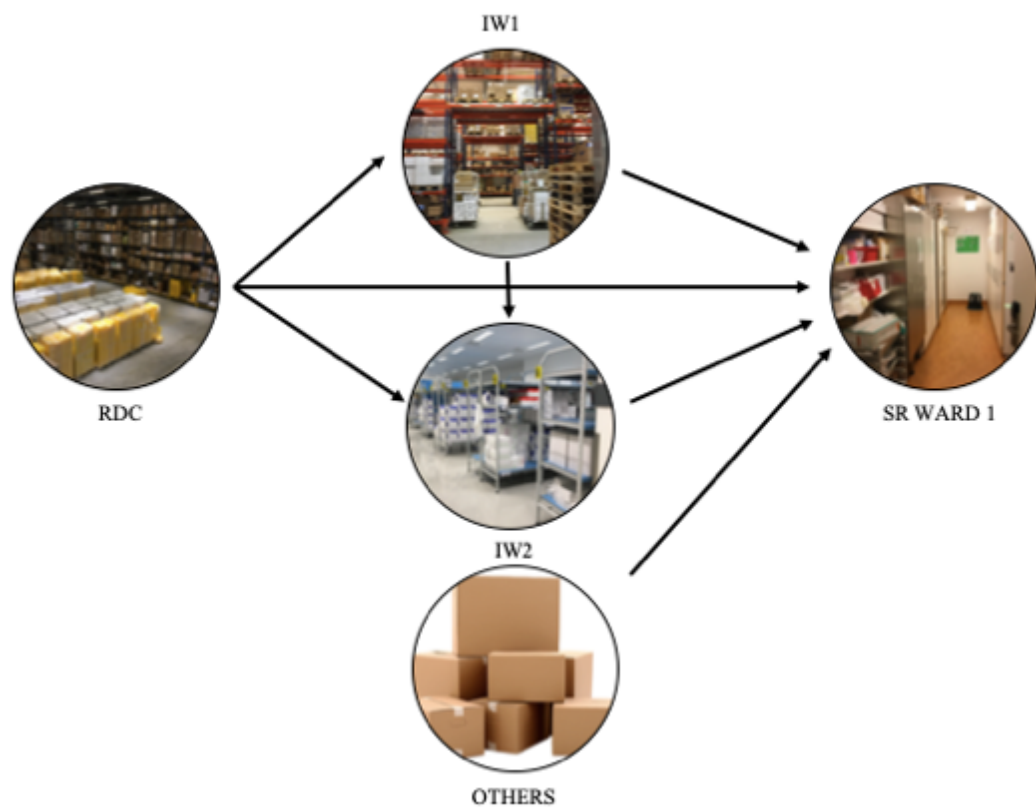


Illustration 5: The supply chain of ward 1 (H1)

The distribution of all orders placed by ward 1 to its various suppliers in 2018 is displayed below. These include all types of supplies, where other suppliers mostly

deliver non-single-use medical items, e.g. food and linen. The total order lines for ward 1 represents a small share of total order lines at H1.

Supplier	IW1	IW2	RDC	Others (58)	Total (61)
Order lines	414	369	357	399	1539
Pieces	68 680	5 850	106 474	73 971	254 975

Table 3: Distribution of orders made by ward 1 in 2018

At IW1 it is around 13 employees at work during their operating time, which excludes nights and weekends. At IW2 there are 9 employees. Both warehouses are rather large, located at the hospital and deliver single-use- and reusable medical items (Oslo Universitetssykehus, 2019). IW1 and IW2 are separated due to different sterility regulations. Both of the internal warehouses pick, pack, distribute and place the items in their respective location at the stockroom at ward 1. This amounts to around 50% of all ordered items, and resembles partial active supply. To be regarded as fully active supply, the employees from IW1 and IW2 would have to place orders as well. The order manager at ward 1 currently does this. In the case of supplies coming directly from the RDC or another supplier, the order will be registered at IW1, added a sticker and sent directly up to the ward. The transportation workers, who are independent from IW1, do this. Neither the warehouse or transportation workers place the remaining 50% of supplies in its locations. Thus, employees at the ward have to replenish these items themselves.

4.1.4 The Supply Chain of Ward 2

The illustration (6) below portrays the SC for ward 2 at a middle-sized hospital in the eastern part of Norway (H2). Consult appendix 4 for an illustration of the extended SC. The ward houses 29 patient beds. At the ward, there are 18 nurses during the day, 15 during the evening and 9 during the night. However, they are not all working with patients, so they amount to 36 nurses working with patients in total each day. This hospital has fully implemented active supply and receives supplies through department packages. Thus, the hospital applies what Volland et al. (2017) refers to as semi-direct delivery. Consequently, H2 does not have any internal warehouses like H1. This implies that all supplies at the hospital are located at the various stockrooms at each ward.

Each ward has one main stockroom and several smaller stockrooms. These smaller stockrooms are located close to the patient rooms, store around 50 unique items and are supposed to serve approximately nine beds. Thus, they are set up to

provide all the main medical equipment necessary for its respective area in order to secure efficient hospital flows. This idea is supported by Böhme et al. (2016), who emphasize the criticality of availability of medical items at the right time to ensure flow. Further, H2 operates with full-time workers, called service employees. They are responsible for handling all activities related to the inventory at the respective wards, including ordering and replenishment. There are four service employee teams covering one floor each, where 3-4 are working together on each team during a shift.

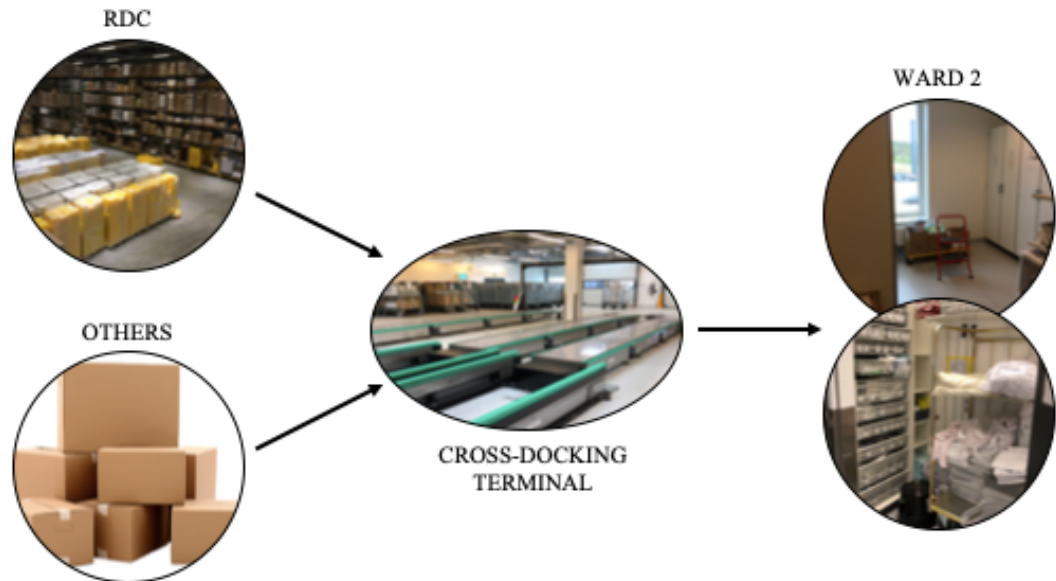


Illustration 6: The supply chain of ward 2 (H2)

H2 in general orders more than 85% of their supplies, in volume, from the RDC. This is also the case for the majority of the wards. All orders for the entire hospital are received on the ground level in a common area, where primary receipt of goods is conducted by scanning the package slips. Next, a specialized roll container is placed on a conveyor where a driving assignment is created. Since the majority of the roll containers contain goods for only one ward, they can be sent directly to the respective ward. However, to increase the fill rate in each container, two or more separate orders sometimes arrive in one roll container. These are separated at the primary goods receipt and then sent to each of their respective wards. The transportation is done by automated guided vehicles (AGV) until all received containers are distributed.

For the remaining 15% of received supplies, the primary goods receipt has their own small storage room. The items are kept here until H2 receives a roll container from the RDC ordered by the respective ward. The stored item(s) is then cross-

docked with its belonging roll container, before the AGVs drive the supplies up to the corresponding ward for secondary goods receipt. However, notified rush orders can be distributed immediately upon arrival. This is a good example of the facilitation of flexibility that Lord (2019) claims is at the core of being able to handle the complexity of HSCs.

From mapping the two SCs, we have identified that ward 1 and ward 2 are in two different SC designs. In addition, ward 2 has implemented Lean-initiatives made by SENRHA, while ward 1 has not. Consequently, it is likely that the two wards also will differ in their reflections, enablers and barriers of Lean. Before we continue the analysis and discussion, we would like to remind you of the various abbreviations of the interviewees:

H1: Hospital 1 (Part of OUH) Logistics staff (H1)	H2: Hospital 2 (Eastern Norway) Logistics staff (H2)
Ward 1 Order Manager Nurse 1-4	Ward 2 Service Employee Nurse 5-6
Delivery from: IW1: Internal Warehouse 1 IW2: Internal Warehouse 2 RDC: Regional Distribution Center	Delivery from: RDC: Regional Distribution Center
RH1: Reference Hospital 1 (Part of OUH) Nurse 7	RH2: Reference Hospital 2 (Part of OUH) Nurse 8

Table 4: Abbreviations and overview of interviews in the two SCs

4.2 Lean at the Hospitals

Based on SENRHA’s decision that all hospitals in their region are to implement and work Lean (Magnussen et al., 2009), both hospitals in this study are encouraged to do so. H1 is a part of OUH that has published several notes on their webpage about the Lean journey. This is not the case for H2 although they too are to work Lean. Thus, there is no general information about the implementation of Lean at H2. Consequently, this preceding section only covers Lean at OUH.

OUH decided to implement Lean in 2014 (Oslo Universitetssykehus, 2016a). Thus, all departments at the hospitals are to conduct improvement work with Lean as the methodology and strategy. When OUH uses the principles of Lean, it is to attain good systematics and practical tools in this work. The focus has been to continuously improve work processes and to facilitate the daily operations around the patient (Oslo Universitetssykehus, 2016b). The goal is to achieve greater quality at all stages and more efficient flow between the partial activities. OUH

stresses that this does not entail that the employees are to run faster than before. It is rather about removing unnecessary waiting, duplicating work and unnecessary variation and complexity to be able to concentrate about the valuable activities. OUH refers to this as “doing what we came for”.

OUH regard Lean as easy to understand, but not so easy to “do” (Oslo Universitetssykehus, 2016c). Furthermore, OUH acknowledge that it can be both time consuming and unaccustomed to collaborate across professional environments and treatment sites. Additionally, they acknowledge the challenge to change known routines in a hectic workday. Finally, OUH claim that all clinics has been involved in this type of improvement work since 2014. Conclusively, it is apparent that both OUH and SENRHA have an understanding and plan for Lean implementation. The plan appears to be in line with theory, both regarding its methodology and its intentional outcomes. Since OUH emphasize the need for leaders to motivate and create engagement around the importance of logistics and holistic work processes, the next section covers the two hospitals employees’ perceptions about the Lean implementation and journey.

4.2.1 Unconsciously Working Lean?

The logistics staff (H1) states that it is a decided strategy by SENRHA that all hospitals are to be Lean. He further claims that there are a lot of people working with the Lean methodology at the hospital, and that Lean is the holistic perspective of all improvement projects. This applies to both the departments and back office.

The order manager at ward 1 tells us that it must be 5 years since the management communicated the word Lean for the first time. Further, he claims that he has not reflected on what Lean really is. However, he is under the impression that it has something to do with blackboard meetings and the Green Cross initiative which they implemented the 1st of January 2019. Green Cross refers to daily assessments of the previous day’s risks and deviations to increase emphasis on improvement initiatives. This is in line with theory which emphasize that Lean healthcare is first of all to focus on continuous improvement (Toussaint & Berry, 2013). When we explained more about the Lean concept he immediately said that the ward is not 100% into Lean yet, but that they are in a process of becoming more and more Lean focused.

We asked the nurses at ward 1 whether they were informed that the hospital has implemented Lean philosophy. One of them replied “*Lean? And that is?*” In general, none of them had heard of Lean, neither as a concept, nor as a philosophy implemented at this hospital. This contradicts what the logistics staff at H1 claims. However, nurse 1 (ward 1) mentions that they talk about continuous improvements at the ward, mostly concerning reception of, and things centered around, the patients. He adds, “*but that’s because we have to*”, as they want things to go as efficient as possible to be done with their tasks in time. Nurse 3 (ward 1) agrees. Nurse 1 (ward 1) further claimed that they rarely talk about other improvement initiatives. On the contrary, nurse 2 (ward 1) had not heard of this improvement work at all.

In line with the response from the nurses at ward 1, the nurses we interviewed at ward 2 had not heard of the Lean concept either. They told us that this was new to them and asked whether this was decided for all hospitals. On the other hand, the logistics staff and a service employee at H2 mention during the interview that the hospital has been working with Lean for a long time. The logistics staff claims that Lean permeates all project stages and many of the project documents. He also adds that working Lean was considered when this hospital was constructed. However, during the last year and a half it has been “put more into system” and permeated to the bottom level of the organization, so it is more noticeable to the employees. He further states “*All our employees have been working after the principles of Lean, but perhaps have been unaware that this in fact is Lean. So, if you ask employees at this hospital if they work Lean they might say no because they do not know what it is, but they are still working by it*”. Continuing, he claims that if we were to ask the employees whether they were involved in continuous improvements at the hospital, they would say yes. However, it is disclosed through our interviews that this is not the case for either nurse 1 or 2 at ward 2.

Up till this point we have presented the two SCs, their context and mapped the degree of explicit knowledge of Lean at the two wards. In general, we found that the “ground workers” were unaware of Lean implementation, and the degree of knowledge concerning continuous improvement was varied. Consult appendix 5 for overview of all interviewed nurses. With that in mind, the investigation of the concepts’ impact on HSCs continues with mapping the enablers and barriers.

4.3 Enablers for Lean

The original literature regarding Lean does not provide a clear roadmap of what will enable implementation success at hospitals and what barriers might prevent it. However, the most frequently mentioned enablers and barriers of Lean are context, culture, management and information transparency. Some of the enablers identified through interviews and observation could fit into these four categories. However, in accordance to our research question, we only include data suitable in the discussion of improved SC and material flow throughout the analysis. Thus, to cover the enablers we found most prominent at the two wards, this section is divided into the following categories of enablers; systems, standardization, flexibility and communication. Although systems and communication arguably fit into the information transparency category, they are so prevailing that they are worthy of their own categories.

It is worth noting that the lack of an enabler can be viewed as a barrier, and the presence of a barrier can result in waste. In this analysis, these three elements of Lean are separated and only included where most appropriate. Moreover, Lean is a dynamic state and enablers and barriers can consequently be viewed from two standpoints: enablers/barriers for *implementing* Lean and enablers/barriers to *stay* Lean (J. Womack & Jones, 1996). Both types of these enablers/barriers are considered.

4.3.1 Systems

The RDC answered the following when we brought up Lean “*To me, Lean is bullshit. It is not about the words you use, it is about passion. It is all about how you make things work, not what word you use.*” He continues by explaining that in short, logistics is not working without systems. This was supported by the logistics staff (H1) who claimed that technical support is perhaps the most important aspect with regards to the flow of materials, namely the logistics system and ICT-systems. “*It is all connected, and you are not able to get a well-functioning flow of materials without technical solutions to back it*”.

At the RDC there are several technical solutions that facilitate efficient processes. One system places all incoming orders in a prioritized queue and produces optimal picking routes for the different types of deliveries; namely with and without department packages. The routes are optimized in terms of motion and

waiting, and every order is box-calculated to achieve a high fill rate in the boxes, containers and the trucks. This is possible because they have measures of volume and weight of all products, boxes, containers, pallets and trucks in their system. The pickers are then provided with a route with information about which load carrier they need. Additionally, when a ward, internal warehouse or service employee places an order to the RDC, they are able to see the product availability for the requested items. Thus, they immediately know if they will receive it, or if they have to find it elsewhere. This system relies on the high level of inventory control at the RDC and provides the order placers valuable information, which H. Andersen et al. (2014) stresses the importance of.

Another example is that all maintenance trolleys at H2 are installed with a tablet containing a customized program. This provides an overview of all rooms at the hospital and the respective assignments for the day. The cleaners can mark rooms they have cleaned, and keep track of when patients are leaving the hospital indicating that the room can now be cleaned. The implementation of this system was reasoned by wanting to increase efficiency in the facility management activities at the hospital as a result of elimination of non-value-adding activities such as checking a rooms' status several times. While this example is not linked to material flow it is an example that demonstrates initiatives that facilitate for smooth processes. This maintenance system and the systems at the RDC enable the employees to reduce time spent on wasteful activities, consequently enabling for Lean success (D'Andreamatteo et al., 2015; J. Womack & Jones, 2003).

4.3.2 Standardization

During our visit at ward 2 we looked at the main stockroom where we commented that it was very neat and orderly. The service employee then said: *“but that is Lean; securing, sort, systemize and standardize”*, which is correct according to theory (Graban, 2011; Modig & Åhlström, 2014). He followed up with several practical examples of standardization. First, he talked about their standardized working routines. The chore list is standardized for the entire hospital, they look the same but the content is somewhat variable. This facilitates the work of the service employee when they have a shift in a new ward, department or floor. Further, the chore list contains slot time for ordering and when the wards receive goods. The service employee at ward 2 refers to this as *“brilliant! We do not need to remember everything by heart or spend time looking it up in our systems”*.

Second, when the service employees at H2 are to replenish inventory they carry a list called “cabinet-list”. In this list, you have the article name of all preapproved items the ward may order and if and which given location it has in all the stockrooms at the ward. This provides them with the precise location of the item, and they can cross out for which of the smaller stockrooms that needs replenishment. The service employee at ward 2 adds *“this list makes it easier for e.g. temps, but also for us to do a more effective job without having to go back and forth many times, that is just a waste of time”*. However, for the list to serve its purpose it is a prerequisite that the service employees check the smaller stockrooms and restock these with items from the main stockroom before they place an order. Only then are they able to meet the correct order level.

The service employee further claims they have good routines for their tools, where they put things and how they should work systematically and in “the best way”. They consider training new employees to work in the same way as them as very important. To this, the logistics staff at H2 adds that this is something they work hard with. They would rather have 13 people working slightly wrong, but in the same way, than 13 people working completely different. The latter would make it impossible to locate the root cause. The service employee agrees and supports the claim that they work hard to work after the same principles. He adds *“it is a continuous process, it is something we work with all the time, it is something that never ends; improvement work”*.

In general, there are apparent many examples of standardization at H2. All stockrooms are set up the same way, they have the same information boards, chore lists etc. Besides the ordering system, examples of standardization are not apparent at H1, nor at RH1 and RH2. However, we found such examples at the internal warehouses at H1 and at the RDC. These concern, among others, routines for deviation handling and customer registration, inventory set up and replenishment. As time-sensitivity is high at hospitals, Torabi et al. (2018) claim that the necessity of performing 5S increases.

4.3.3 Flexibility

Although standardization is an important part of becoming Lean, so is flexibility. A partner from EY (2019, March) stated that among others, Lean in healthcare

regards increased requirements of flexibility and availability. These opposite enablers of Lean might seem like paradoxes. However, flexibility is encountered as an enabler as it facilitates continuous flow and ultimately availability of resources (Lord, 2019; Modig & Åhlström, 2014). Flexibility can regard routines, buffers, job rotations etc.

At both H1 and H2, the ones that are responsible for order placements are able to scan a product they notice needs to be replenished exactly when noticed, although the slot time is not until e.g. the next day at 9 am. This enables the responsible to scan immediately to ensure that it is ordered, instead of postponing and possibly forget. Additionally, if the need for a product is urgent, the order manager at ward 1 can place an urgent order in a different system than the scanning, called iProcurement (iProc). This system does not follow the fixed slot times and a ward can order directly from IW1 and IW2. Out of all orders at H1 97% are placed in the scanning system and 3% in iProc. IW2 state *“in an ideal world there would be no surprises, namely that all orders go through scanning. However, iProc facilitate flexibility and the most important for the hospital overall is to provide quality care”*. This kind of thinking is clearly in line with the aspect of Lean where the goal is to add value to the patient (Dobrzykowski, 2019; Rais et al., 2018).

Another example of flexibility at H2 is the department rotation of service employees. The logistics staff (H2) reasons this by *“this way they are equipped during vacations and other situations”*. In practice, this arrangement entails that all service employees in one team are equipped to step in at all departments in their respective area, and still conduct a good job, compared to if they had fixed work stations. The service employee at ward 2 states *“it simplifies things when we work in teams this way, and you get continuity, better overview and knowledge about all the smaller stockrooms, and wards, which makes it easier for us in case of sick leaves etc.”* This arrangement enables higher level of product availability at all wards and facilitates timely patient care. Ultimately, this could increase value for the patients (Dart, 2011; Graban, 2011; Khorasani et al., 2017).

Additionally, at the RDC there is an assigned on-call employee after hours (5 pm to 7 am), providing ward 2 with flexibility Lord (2019) states is a prerequisite for hospital wards. This is arranged so that hospitals can order supplies with a

guarantee of receiving the order within 4 hours. The product catalogue at the RDC is divided into five categories of criticality, and this rush order must entail products in category 1 or 2. The logistics staff (H2) mentions this opportunity, but does not stress that they have had to use it. The RDC claims that they have had 3 rush orders at night the last year and a half. Although this service has not been particularly utilized, it adds flexibility and could be vital during an operation at night. Further, approximately 1/3 of the assortment at the RDC is changing yearly due to new national and regional procurement agreements. This brings a lot of work for the RDC to phase in and out the respective products. To handle this, they make sure to keep the warehouse fill rate at 85%. Consequently, they have added the flexibility to bring in new products while phasing out existing products in stock.

4.3.4 Communication

During interviews and observation, we identified several examples of communication that enable continuous flow in both processes and material. These were both verbal and non-verbal, and some can also be regarded as information sharing/transparency. The non-verbal are presented first, followed by the verbal communication examples.

The RDC produce and distribute a daily report over orders that are backlogged every morning to all their customers. If the item is categorized as level 1 criticality they usually phone the customer to make sure they receive the message. IW2 can extract from the list made for OUH only what regards them and their customers (consult picture 2 below). In this list, they are able to identify who is missing what and they state that *“it is these things that are important to operate by”*. IW1 supports this statement. However, these lists are not available for the staff at the wards, and are thus not necessarily communicated. Both internal warehouses at H1 claim that they inform their affected customers through a phone call, but they also admit that the frequency could be increased. In order for this backlog list to serve as an enabler throughout the SC, it should be made available downstream to facilitate smooth information flow. While this may create the need for additional investments (beyond our knowledge), it would reduce the extra efforts for the internal warehouse staff. In addition, it would save time for the staff at the wards in terms of inquiries and wonderment.

XXHS - RESTORDRE - DETALJER							Rapportdato: 14.05.2019 09:12
							Side 1 av 4
Leveringsadresse: *120101							Dager
Ordrenummer:	Artikkel	Artikkelbeskrivelse	Lovet Dato	Mengde	Enhet	i rest	
6019726	1000236	Kompress nonwoven steril 10x10cm 4lags 2pk	14.05.2019	140	STK	0	
Leveringsadresse: *120103							Dager
Ordrenummer:	Artikkel	Artikkelbeskrivelse	Lovet Dato	Mengde	Enhet	i rest	
6019716	1000236	Kompress nonwoven steril 10x10cm 4lags 2pk	14.05.2019	280	STK	0	

Picture 2: Excerpt of daily report of backlog at IW2

All hospitals under SENRHA, including both wards in this study, use something called the “chip system” for control of how many and when to place orders. This entails that there are two specific chips linked to each item located in their cabinets. The idea is that when you reach a certain level of items in a drawer, one of the chips linked to the item have to be placed on a board in the room that indicates “must order” this item (consult picture 3 below). When the item is ordered by manual scanning, the chip is moved a few rows down on the board to “have ordered” and ultimately, when the order arrives and is placed in its belonging placement, the chip is moved back as well. This process resembles a Kanban system (Torabi et al., 2018; Trent, 2008).

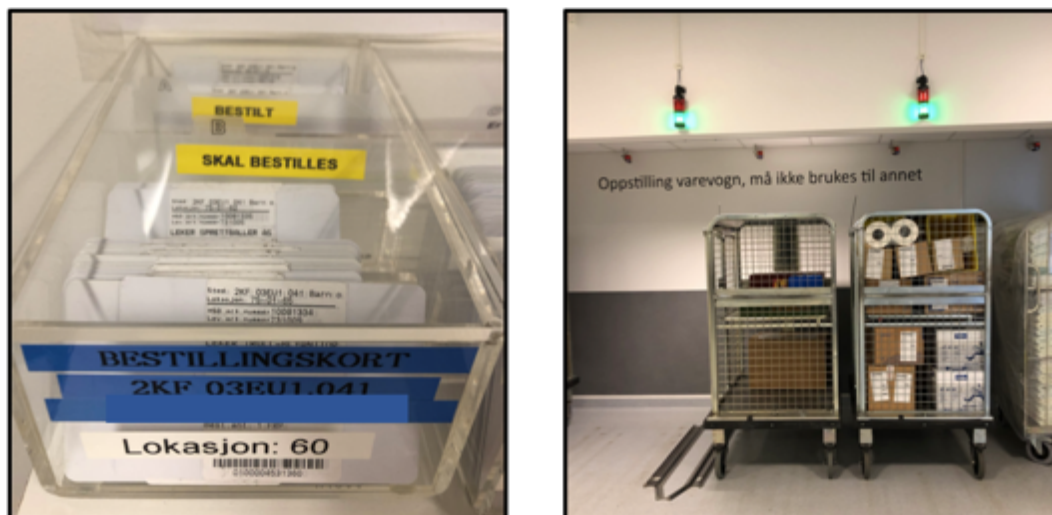


Picture 3: The chip system at ward 1 (H1) and ward 2 (H2)

When the stockroom responsible is aware of a backlog they are to place the respective chip on the top row of the ordering board, symbolizing that there is a backlog of that particular item. This practice is conducted at ward 2, but not at ward 1. The service employee at ward 2 claims that he checks the status of the backlogged items daily and informs the customers of the expected delivery date. The nurses at ward 2 have mixed opinions about this, but during the interviews we

disclosed that they have not experienced the need of a backlogged item. No such communication seems apparent at ward 1.

In addition to the chip system, ward 2 uses what they call “the cookie box” (displayed below). This box contains cards representing only the preapproved items the ward can order that does not have a fixed location in the stockrooms. Staff at the ward can move a needed item’s card to “must be ordered”. The service employee checks this box every day and after it is ordered the card is moved to “is ordered”. In this way, the employees at ward 2 know if the item is ordered. There is no such system at ward 1, meaning that the nurses have to find the order manager and express their need of this item with no simple system to check if it has been ordered. This is far from optimal for the nurses at ward 1 who express that their time to deliver quality patient care is already scarce.



Picture 4: “The cookie box” at ward 2; local receipt of goods at ward 2

Another non-verbal communication tool at ward 2 is parking lights in their local receipt of goods (displayed in the photo above). This enables the service employees to see when the goods have arrived even when they are far down the corridor. The service employee at ward 2 comments “*this is very beneficial for us because then we don’t have to go all the way over there to check several times. We already walk approximately 15 000 steps a day.*”

To communicate what the deliveries contain from the RDC they place tape in various colors on to the boxes. For example, boxes containing sterile items are marked with a red tape with the wording “sterile”. Another colored tape is used when the content of the box is mixed with the wording “mixed” and when it is a full box with the same non-sterile item the tape is blank/brown. Additionally, they

place colored sheets on the containers to communicate various messages to drivers and the receipt of goods at the hospitals. For example, if a box is partly outside the container it is marked with an orange sheet. If the container contains goods to two different departments it is marked with a red sheet. *“This is to communicate, and work better and more efficiently”*, states the RDC. These efforts of information sharing and communication facilitate for efficiency and responsiveness in the SC (Ageron et al., 2018; Hugos, 2018) which is a central part of SCM (Chopra & Meindl, 2016).

Blackboard meetings is a common tool associated with Lean methodology (Drotz & Poksinska, 2014; Modig & Åhlström, 2014). At H2 they conduct these on a regular basis at the various departments and wards. For instant, all service teams have a joint meeting every morning, followed by internal meetings within the team. These team meetings are repeated at 12.15 pm and 15.15 pm. The service employee at ward 2 tells us that their team is working continuously towards improvements, and that these weekly meetings enable that. Additionally, the logistics department at H2 conduct blackboard meetings where the many improvement suggestions are looked at in light of the concept they are working by, and consequences are considered before the change is implemented. By this, it is apparent that they have a holistic view in the continuous improvement work, which is emphasized as important to achieve success with Lean (D’Andreamatteo et al., 2015; Drotz & Poksinska, 2014). Moreover, the logistics staff (H2) states that in the case of an unforeseen event, the service teams always go through it afterwards to consider improvement initiatives. The service employee at ward 2 follows up with *“and we are very good at this”*. The logistics staff (H2) argues that in these situations they identify what went wrong compared to their routines and why. From there they manage and correct. As a result, the department are able to eliminate repetition of defects, which is an emphasized waste category in the Lean concept (Graban, 2011). Moreover, these meetings provide a platform for the employees to bring problems to attention where these are recognized as opportunities for improvement (Simon & Canacari, 2012; Toussaint & Berry, 2013). The frequency of these facilitate for continuity in the improvement work.

The order manager at ward 1 claims that the leader of the ward and himself have frequent meetings where they try to come up with measures to cope with reported deviations. However, he claims that they can still improve this work through

creating smarter measures that are more goal oriented and time constrained. The most important measures they come up with are brought up in the next personnel meeting with questions like “what do we wish to change”, “how can we do things better?” and “how do we perceive this is working now?” The order manager therefore states “*so, we are doing Lean, but without calling it that*”. While this appear to be a good initiative, the nurses argue that they only have personnel meetings once a month, where these things usually are down prioritized due to information regarding new patient groups etc.

Conclusively, we identified several enablers for successful Lean implementation. However, Leite et al. (2016) claim that while facilitating for enablers is important, so is combating the barriers.

4.4 Barriers for Lean

To achieve successful outcomes, barriers for success should be identified and broken down. However, some barriers cannot be coped with and must be accepted as they are. From the literature, four main barrier groups were identified; context, culture, management and information transparency. Although these are commonly encountered barriers, we have identified additional barriers through interviews and observations. From the two wards, the following barriers are the most “alarming” ones: physical, system, process and communication. Some of the identified barriers are not present at both wards.

4.4.1 Physical

Most hospitals are built for best possible patient care, not optimal logistics. In turn, this creates problems of achieving Lean delivery of materials. The RDC emphasize that even at the newest hospital buildings, where intralogistics is facilitated, it has not received the priority it deserves. This results in problems like insufficient space for keeping inventory. Interviews with the three main suppliers of H1 reveal that the buildings are not built with considerations to efficient logistics and flow. H1 consists of several building sections and culverts that connect these buildings. For an automated delivery of goods, like H2 operates with, these conditions are not optimal. The culverts are too small, fully stocked with old furniture and at some places the ventilation system would be in the way. “*The buildings were outdated already when they were new. So now, the capacity*

is full, all boundaries are blasted” (IW2). Consequently, H1 is to a large extent constrained by its construction, creating a barrier for Lean implementation (Hicks et al., 2015; Nabelsi & Gagnon, 2017). Moreover, Graban (2011) argues that waste is driven by the lack of proper design and the system itself. By this, it seems that H1 cannot achieve the true benefits of Lean implementation.

In addition to the construction challenges, the AGV containers entail some difficulties, both when it comes to maneuvering and storing them. *“The AGV containers are very bulky and gruesome to handle. We will have to do something about them” (RDC).* The RDC has various roll containers, and to compare, they are able to store 450 of one of the types, whilst they can only store 60 AGV containers. Another challenge is that it is not possible to place two AGV containers on top of each other in a truck. They are too tall, due to the size of the robots that have to roll under the containers to transport them internally at the hospital. In theory, one may fit 66 pallets in one truck, but there may only be 28 AGV containers. Additionally, the pallets to H1 have a higher fill rate. Consequently, while AGV enables flexible internal transportation, there are several challenges to implementing AGV at H1.

“When we deliver to the IW1 and IW2 at H1 today, we deliver pallets and cardboard boxes. While at H2, we deliver pieces” (RDC). Consequently, if H1 were to change to department packages the number of order lines to the RDC would explode (consult table below). One pallet ordered from IW1 or IW2 would transform into 4,3-4,5 order lines. This in turn demands for investments in automated solutions and additional storage space for picking the orders at the RDC. In addition, it would create the need for more storage space, possibly a fourth cargo container and more trips to H1 with lower fill rate.

RDC	H1	H2
No. of orders	16 080	12 457
% of total orders	16%	13%
No. order lines	44 616	165 660
% of total	8%	28%
Order lines pr. order	2.77	13.30
% of total invoiced amount	12%	7%
Unique articles ordered	2 011	1 797
Package level		
Consumer unit	0%	75%
Traded- /Dispatch Unit	100%	25%
Deliveries pr. day	37 pallets	35-70 AGV containers

Table 5: Comparison of deliveries from RDC to H1 and H2 in 2018

The choice of using AGV containers is an example of the consequences that occur when optimization of logistics activities is restricted to only the hospital itself (H2) rather than the SC as a whole (SENRHA). This can in turn increase costs and delay both general- and improvement projects. *“Much of the challenges at the hospitals, even the newest ones, are related to the flow of the material. They have not considered the flow from the RDC to the hospital, just the flow internally at the respective hospital”* (RDC). This illustrates an example of sub-optimization, which is the opposite of what the Lean concept suggest, namely a holistic view (D’Andreamatteo et al., 2015; Drotz & Poksinska, 2014).

Further, stockroom-location and -size can also be regarded as a barrier (Graban, 2011). Ward 1 has centralized inventory (Bélanger et al., 2018), with one main stockroom to meet the needs of the entire ward. The order manager at ward 1 explains that the sterile stockroom with single-use medical equipment has a rather good location, nearby the on-call room (consult illustration 7 below). Nurses at ward 1 point out that some of the patient rooms are located a bit far away from the sterile storage, but describes the current location as decent. *“It is all about planning for efficiency with what you got, so that you will not have to walk back and forth between the stockrooms and patient rooms. If we were to change the location of some rooms, then they would in turn be further away from something else”* (Nurse 1, ward 1). However, nurses at ward 1 express that the stockrooms for medicine and fluids are located too far away from the sterile stockroom. As they often use supplies from both rooms during a procedure, they find this somewhat problematic. These limitations in the construction of ward 1, creates wasted motion for the nurses. Consequently, they end up spending valuable time on non-value-adding activities. Theory suggests that an important part of Lean is to improve the workflows. In particular, the layout of the wards and the organization of supplies and equipment, can reduce these walking distances (Graban, 2011; Hicks et al., 2015).

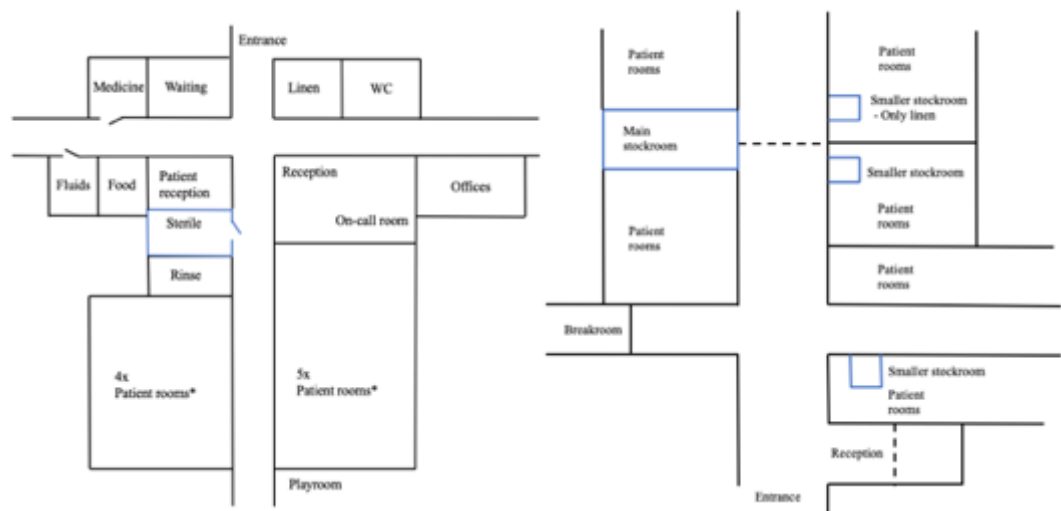


Illustration 7: Placement of stockroom at ward 1; Placement of stockroom at ward 2

Other stockrooms such as medicine and fluids at ward 2 are excluded in the illustration

* indicates that there are 2 patients per room

The order manager at ward 1 discloses that “*the sterile stockroom is the largest of all stockrooms at our ward and it is quite large compared to other wards at this hospital*”. However, all nurses we have interviewed at this ward express severe frustration of the stockroom size. They argue that it is particularly small, and nurse 1 (ward 1) states that “*there is almost no room for one, let alone two nurses, to get supplies at the same time.*” Nurse 1 and 2 point out the cabinets as a major problem, as you cannot have two opposing cabinet doors open at the same time, nor can another nurse walk past you when one cabinet door is open. Removing the cabinet doors would solve many of the problems. However, due to many of the products’ strict sterility rules, this is not possible. As there usually are 6-9 people working at the ward at the same time, this can easily cause problems and stressful situations. Nurse 4 (ward 1) proposes that a more quadratic stockroom would be more beneficial, and further states that the stockroom, as it is today, “*generates frustration*”.

Further, ward 2 is split into three various patient areas, with each of their own smaller stockroom. There is also a main stockroom (consult illustration 7 above). The most necessary equipment should be found in the smaller stockrooms. The service employee points to these as tremendously important for working Lean, especially if there are any hallway patients. Thus, ward 2 has more decentralized inventory (Crans, 2007), with increased availability of supplies, but often at a higher cost than a centralized stockroom-model. When interviewing the nurses at ward 2, we were told that they experience that for the most part the smaller

stockrooms are satisfying. However, they also express that the placement of the main storage is rather far away from one of the patient areas. They perceive this as time-consuming and further explain that it occasionally creates stressful situations. Nurse 5 (ward 2) further communicate that he does not know if there are any other placement that would have been more beneficial by the way the ward is constructed. Nurse 6 (ward 2) welcomes the idea of moving the main stockroom more in between the three patient areas.

The main stockroom at ward 2 is considerably larger than at ward 1. At one point during an interview, we are 6 people inside the main stockroom, without any feeling of being trapped. Further, both nurses at ward 2 are pleased with the size of their main stockroom. The service employee is certain that inventory control, keeping order and having good routines at the stockrooms can create a perception of more space even though it might in fact be a small room. Judging by the picture 5 below, this might be true for the stockroom at ward 2, but not so much for the stockroom at ward 1.



Picture 5: Stockroom ward 1; Main stockroom ward 2 and smaller stockroom ward 2

4.4.2 Systems

The chip system is present at both of the wards, but it is handled in a different manner. At ward 1 it is everyone's responsibility to move the chips. At ward 2 the service employee is responsible for checking the inventory levels of each medical item along with keeping track of the chips respective placement. Further, at ward 1, the chips are marked with a standardized order quantity, set by the ward. At ward 2, the chips have information about the reorder point and orders are thereby based on Kanban principles (Graban, 2011; Torabi et al., 2018).

From interviews with several individuals at the two wards, it seems like ward 1 is experiencing the chip system as a barrier, while ward 2 is not. The order manager at ward 1 expresses that the chip system is a good system in theory. However, it would have worked much better if they continuously updated their product catalogue and cabinets. *“We rarely set aside time for doing so, only about every other year, as there is so much else that takes priority over this. In addition, it does not increase motivation to know that the same product catalogue and cabinet placement you just updated will be outdated in 2 months”* (order manager, ward 1).

The order manager at ward 1 further highlights the importance of always moving the chips to the correct location in order to inform the other employees. *“Once I go through the stockroom, I collect around 20 more chips than what is placed on “must order”, that actually needs to be ordered* (order manager, ward 1)”. The nurses at ward 1 agree that the system is not followed up by themselves, nor the others working at the ward. Nurse 1 (ward 1) states that *“it might sound strange, but sometimes there is simply just not enough time for us nurses to be able to follow up on the chip system”*. He further explains that time is often crucial, and that in certain situations *“you just have to spend that time to run to another ward to gather the needed item”*. All nurses at ward 1 have expressed that they run, not walk, to get their needed supplies. Thus, time is scarce for the nurses at ward 1. However, this type of sub-optimization is likely to become a vicious circle. Under these circumstances it is not unlikely that the order manager at ward 1 does not realize that an item is out of stock. If so, unnecessary trips by nurses to borrow items from other wards will increase additionally.

An additional barrier with the chip system at ward 1 is that it is only one person, the order manager, who has control of the stockroom and ordering system. *“This is one of our greatest Achilles heel, and I have reported it many times. We are working on a solution here”* (order manager, ward 1). However, the order manager further states that *“we have had a lot of turnover, and to learn the ordering system is not the first thing you bother the new nurses with. They have more than enough with getting familiar with the patient group”*. On the contrary, ward 2 focus on rotating on who is ordering. This is an important measure to overcome the identified system barrier. Although ward 1 has experienced a lot of turnover, it is rather surprising to find that there is only one individual at the ward

that knows the ordering system. From our understanding, it only takes about 10 minutes to undertake this task. Nevertheless, the nurses rarely prioritize it, as they are too busy with their main objective, delivering patient care. Consequently, the repercussions are often 4-5 days without the needed item which in turn results in poorer patient care. However, it is also important to keep in mind that there are full-time workers at ward 2, dedicated to the same task(s) as a 20% employee at ward 1.

4.4.3 Processes

Lean processes are securing continuous flow and right capacity, along with emphasizing on doing things right and reduce waste (J. Womack & Jones, 2003). Additionally, Lean processes are patient focused and standardized (Cohen, 2018; Graban, 2011). Contradicting the theory, none of the two wards practice inventory control in a way that makes their inventory levels transparent. Hence, none of them have any overview of how many items that are in stock at any given time. By not exercising inventory control, the number of obsolete products is expected to increase. In addition, replenishment becomes reliant on manual ordering as a result of poor insights in inventory levels. Nurse 3 (ward 1) expresses astonishing: *“Do you have any idea of how much supplies we actually have to throw away due to lack of inventory control?”* Consequently, the lack of inventory control at both wards brings challenges that theory suggests leads to unnecessary inefficiencies (Bosire & Gandhi, 2012; Conner, 2016; Wang et al., 2015). More sophisticated inventory control systems like barcode scanning and RFID could be potential solutions by providing more effective SCM (Conner, 2016; Nabelsi & Gagnon, 2017).

Ward 1’s sterile stockroom is sorted based on procedures. They operate with posters on the cabinet doors to indicate what items that are in the respective cabinets. However, there is no continuous update on the posters and the order manager at ward 1 tells us that the posters that are on the cabinets now, do not match the actual items in the cabinets. *“The inventory changes with the patient group, and we are not able to update while the ward is open. Therefore, we can only update during holidays when we partner up with another ward”* (order manager, ward 1). He further explains that they have a list of all items and their respective location in stockroom, but this is not updated either. *“I don’t think any of us nurses have control of inventory. The items are just floating around at the*

stockroom. In addition, many items are stocked on top of the cabinets, or unpacked outside the stockroom, but people do not look anywhere else besides the actual location of the item” (nurse 1, ward 1). Further, nurse 7 (RH1) mentioned that they do not have posters on their cabinets at all, nor an alphabetical list, to locate supplies. He perceives this as a large burden for the ward, especially as they are highly dependent on this due to an abnormal number of temporary workers. In a study by Simon and Canacari (2012) they also found that especially temporary workers spend a lot of time searching for supplies, indicating the value of a better overview. This lack of transparency increases time spent on non-value-adding activities by nurses. Consequently, greater transparency in information should be emphasized in order to overcome this barrier and enhance efficiency. This is supported by Nabelsi and Gagnon (2017).

At ward 2 the inventory is sorted by its function, i.e. bandages are in one cabinet and catheters in another. The cabinets are marked with a rough chronological overview poster on the cabinet door, indicating what item that is in the cabinet along with its approximate placement. *“The system is decent, but some cabinets are just filled up with too many items, making it more complex to find the right item”* (nurse 6, ward 2). Ward 2 does not have an alphabetical list of all items in the stockroom and their corresponding location. Nurse 6 (ward 2) experiences that most of the time there is decent control of the stockrooms at the ward. Nurse 5 (ward 2) on the other hand, expresses that he experiences out-of-stock situations more often. *“I usually find the most used items, they are appropriately filled up. However, during weekends and holidays we experience that some items are emptied out. This can be very frustrating”*. By this, it seems like there are varying results at H2 from using service employees.



Picture 6: Cabinet at ward 1; Cabinet at ward 2

4.4.4 Communication

Nurse 5 (ward 2) expresses that the communication between the nurses and the service employees could have been greatly improved. He points out lack of information regarding change of suppliers for medical items, resulting in change of design, as the main source of frustration. *“Items are frequently changed, so I will never have full control of the stockroom”* (nurse 5, ward 2). He further adds that he does not have any information of when they receive inventory nor when the stockrooms are filled up. He wishes that this was communicated in a better way. On the contrary, nurse 6 (ward 2) perceives the communication between the service employees and the nurses as satisfying. *“I have not given it much thought, but it is really helpful that we can call them whenever we are out of stock”* (nurse 6, ward 2). This observation clearly reflects divergent opinions of the communication at ward 2. In this case the communication regards two individuals, thus it may very well be a result of the individual efforts put down by both the different service employees and the nurses.

At ward 1, the nurses are not aware of when they receive inventory either. When we asked nurse 1 (ward 1) he replied *“I have no idea, suddenly there are cardboard boxes outside of the stockroom”*. When we were at ward 1, one of the nurses working there came into the stockroom to look for a specific item. He then consulted the order manager asking if they had it. The order manager then replied *“no, but it is ordered. It was supposed to arrive today, but then I guess we will receive it with the next delivery”*. The nurses express that this leads to frustration. Nurse 2 at ward 1 emphasize, *“my perception is that it can take very long time before we receive an order”*. Sogand (2017) emphasize that Lean hospitals are based on information sharing and open communication between staff, suppliers and partners. From our observation at ward 1, it can seem like they are experiencing communication problems, not internally at the ward, but throughout their SC. Transparency in information is perceived to enhance SC efficiency, while lack of it may lead to higher buffer levels and an increasing amount of rush orders. This will in turn lead to increasing costs.

Further, although it is decided that both hospitals are to work Lean, many of the employees, especially the nurses, have not heard anything about it. This does not just regard the term Lean. During our interviews, we re-phrased it as working towards continuous improvements, but they were still not familiar with this

decision. This finding is supported by de Souza and Pidd (2011) who states that terminology and professional silos are common sources of implementation failure.

Moreover, a reoccurring finding at the two hospitals: H1 and H2, along with the two reference hospitals: RH1 and RH2, is the lack of a platform to bring up general improvement initiatives. Wild (2018) argue that communication is a key concept to enable Lean success. Further, Graban (2011) claim that flow is streamlined when communication across or between wards and departments are improved. By this, theory clearly indicates that such a platform is an enabler of successful Lean implementation. It could especially be beneficial to communicate across the various wards, to learn from one another. As of today, the only platform available to the nurses and employees at the various wards are monthly personnel meetings. These meetings normally involve learning about procedures and new patient groups, which are of major importance for the quality provided at the wards. Consequently, there are usually little time to discuss improvement initiatives, and perhaps more importantly, next to no time to actually do something about them.

Up until this point we have provided some of the examples of enablers and barriers revealed through interviews and observations in the two HSCs. These lay the foundation for implementing and staying Lean. Identifying the value-adding and non-value-adding activities is central in the continuation of the Lean journey. The majority lies in reducing or eliminating waste. Thus, the next chapter provides examples of waste identified at the two wards.

4.5 Waste

The Lean concept in a hospital setting proposes eight categories of waste; overproduction, waiting, transportation, overprocessing, motion, inventory, underutilization and defects (Graban, 2011; Khorasani et al., 2017; Nicholas, 2012; Noori, 2015a; Platchek & Kim, 2012). Eliminating, at least reducing, waste releases time to focus on the activities that adds value for the patient (J. Womack & Jones, 2003). Through interviews and observations, we have identified waste in the two HSCs. Some of these fit well into one of the eight categories, while some fit in several of them. In the following section, we discuss the four waste

categories that are most prominent through our interviews and observations; inventory, motion, underutilization and overprocessing.

4.5.1 Inventory

Out-of-stock situations results in waste through nurses looking for supplies that is not there at all. At ward 1, the nurses are responsible for locating either a substitute or the same item at another ward, which they describe as extremely stressful and time-consuming. At ward 2, the service employees are responsible and the nurses can call them if they cannot locate the needed item. Nurses at ward 1 express that they often experience out-of-stock situations (at least once or twice each week pr. nurse), while nurses at ward 2 express that they experience it sometimes (around once a month pr. nurse). This results in ward 1 on average experiencing out-of-stock situations 15 more times during a week. Out-of-stock situations contradicts the Lean philosophy, where delivery of quality patient care through keeping the right supplies and inventory available should be facilitated (Torabi et al., 2018).

Ward 1 receives single-use medical items twice each week, Mondays and Wednesdays. The nurses do not perceive this as frequent enough, and expresses a desire for a more even distribution throughout the week. Consequently, ward 1 may achieve higher level of product availability if they redistributed or increased delivery frequencies, as proposed by Persson (1995). Ward 2 receives single-use medical items twice a week as well. These delivery days are based on an analysis of historical data of the various departments' needs. The deliveries are mainly to replenish the main stockroom at the ward, while the smaller stockrooms should be filled up from the main stockroom every day. What is interesting here is that ward 2 experiences far less out-of-stock situations compared to ward 1, but they have the same amount of delivery days. This may indicate that the service employees at ward 2 exert greater inventory management which signals potentially large efficiency gains from utilizing service employees.

Out-of-stock situations can emerge from many various reasons. First of all, it could be a result of key personnel not being present, like the order manager at ward 1. Secondly, the item may not have been ordered at all. Either due to the chip being wrongly placed or that it was never moved to the board. Further, the order manager at ward 1 states "*Our stockroom is so small, that we often run out*

of certain supplies on Fridays. As the ward is open on weekends as well, we often have to borrow from other wards during the weekends". Consequently, out-of-stock situations may also occur from not ordering enough inventory due to capacity constraints. Thus, it appears that ward 1 would benefit from reviewing the par-levels to align demand and supply as suggested by Bosire and Gandhi (2012). Nurse 7 (RH1) made another interesting point when he elaborated on out-of-stock situations. He explained that they do not allocate enough place to the items that have high turnover rate. Their stockroom is approximately the same size as the one at ward 1. Hence, the problem might be that the items respective location is perceived to be too small compared to its consumption, given their delivery days. In line with theory, we see that waste is often driven by the lack of proper design and/or the system (Graban, 2011).

4.5.2 Motion

The nurses at ward 1 respond that they on average spend between 10-15 minutes every shift looking for supplies (consult appendix 5 for overview of time spent by all interviewed nurses). Nurse 1 (ward 1) further states that *"I do not think there is ever a shift where I do not spend time looking for supplies"*. If he is really unlucky one day, he could end up spending 1 hour looking for supplies. At ward 2, the nurses explain that time spent on looking for supplies is very dependent on the patients. They estimate that they do not use more than 5 minutes looking for supplies on average every shift. Waste of motion could be a result of a stockout situation (Noori, 2015b) as described in the previous section, or other scenarios elaborated in this section.

The logistics staff at H2 states that *"the nurses should never spend time looking for or worry if there are enough supplies. That is our, and the service employees' problem"*. However, the interview with nurse 5 (ward 2) reveals that the nurses do spend time looking for supplies. He expresses that both him and his colleagues on several occasions spend time looking at the smaller stockrooms only to find out that they have to go to the main stockroom. This frustration is shared with nurse 7 (RH1) who explains that they are supposed to have the most frequently used supplies at several POU locations, but that these are rarely filled up. First of all, the patient rooms are supposed to store certain items. In addition, they have trolleys with medical items in each end of the patient corridor. However, nurse 7

(RH1) states that *“It often happens that I walk past the main stockroom on my way to a patient room, discover that the necessary items are missing there, walk to a trolley to realize it is missing there too and end up having to walk back to the main stockroom again”*. Thus, waste of motion can be a result of not filling up POU locations. Theory suggests that increasing availability of supplies by decentralizing storage areas closer to POU is one way to increase time spent on direct patient care (Rosales et al., 2015). However, when the nurses are responsible for refilling POU locations, slack in doing so will result in negative repercussions for themselves and their colleagues. Consequently, while the idea is supported by theory, the examples above demonstrate that it may evolve into a greater burden if not followed up adequately.

Further, updates or renewal of products can lead to waste of motion as nurses might not know exactly where and what they are looking for. First off, as new patient groups arrive, there are new supplies added to the stockrooms. When these do not have a permanent location, it can be easy to just store them on top of cabinets or other random places. This in turn might lead the nurses to think that they are out-of-stock, when in reality, the items they are looking for is located in an adverse place. From visiting the two wards, we could observe that ward 1 had much supplies randomly located. Nurse 1 (ward 1) claims that *“The stockroom is so cramped, that we are almost not able to see what is stocked on top of the cabinets. It is therefore quite easy to forget to even look there”*. Secondly, when the supplier and design of a product changes and the nurses are not informed, they may spend excess time looking for supplies *“I have not received information about when these changes occur. This results in me spending much time looking for the supplies. Ultimately, I may end up thinking that we are out of stock, when the needed supply actually is in stock”* (nurse 6, ward 2). Once again, the importance of proper communication and information transparency is highlighted.

Poor visibility of supplies and their location may also lead to unnecessary time spent looking for supplies. Internally at the wards, this mostly concerns not updating the posters and alphabetical item list. Nurse 2 (ward 1) is clearly frustrated when he explains that *“the alphabetical list is so old that when you look up a specific item, it might be located a totally different place. Thus, we end up with delays by striving to find the right item”*. Further, at both ward 1 and ward 2, there is no information of inventory levels in their own nor other wards’

stockrooms. This can also be regarded as both a barrier and underutilization of the nurses at ward 1. Both wards have to either call or walk to other wards to check if they have the specific item in stock. However, while the nurses at ward 2 can ask service employees, the nurses at ward 1 have to do it themselves. In line with the proposal by Volland et al. (2017), ward 2 has relieved nurses from non-patient related activities to free up time for better patient care. Consequently, nurses at ward 1 would benefit greatly from such information as the current situation seems to create stressful and time-consuming scenarios, in addition to confusion of whether or not the item is actually in stock. However, the order manager at ward 1 does not believe that such a system will be prioritized. *“It is a fascinating thought, but I can tell you that it will never happen, ever. We will never get funding for this”*. While this might be very true, it contradicts the concept of Lean, which emphasize that hospitals should to focus more on reducing waste, than cutting costs (Graban, 2011).

From all scenarios mentioned above we see that, in line with theory, the presence of waste is not an indication of employees not working hard. Rather, it is waste caused by employees working too hard when combating the issues that interrupt the value-adding activities (Graban, 2011).

4.5.3 Underutilization

Nurses looking for supplies does not only lead to waste of motion, it also creates waste in terms of underutilization. Another example of underutilization is that nurses at ward 1 have to place approximately 50% of all received supplies in the various stockrooms. To compare, the service employees at ward 2 do this. This underutilization at ward 1 is further pinpointed through a job listing at one of the hospitals in Oslo. They were looking for a service employee at their internal warehouse where the tasks were among others scanning and replenishment at the department stockroom. The educational requirement of this position was that he/she had completed high school (Karrierestart, 2013). Hence, many of the activities the nurses have to do during their workday underutilize their competence. Nurse 1 (ward 1) states during the interview *“I feel that it is totally unnecessary for us nurses to spend time to locate and replenish equipment when there are patients waiting for care”*.

However, EY (2019, March) claims that behavior is the main reason for waste. The nurses at ward 1 plea that they do not have time to place supplies. This finding is supported in Fillingham (2007), where it is stated that nurses often feel that they are “too busy to do it”. Despite this, it may be that once they have this attitude, they will not do it if they actually have time. Nurse 8 (RH2) told us that the nurses there rarely bother to place received orders. Nevertheless, he sat aside time for it recently with a colleague during a night-shift. They were able to place 10 large cardboard boxes with supplies in their cabinets. These boxes had been standing in the hallway for several days, while many of shelves in their cabinets were empty.

4.5.4 Overprocessing

The design of the SC H1 is a part of is arguably more complex than beneficial. Bear with us during this explanation. Ward 1 orders some single-use medical items directly from the RDC and some from the internal warehouses. Additionally, both internal warehouses order majority of their single-use medical items from the RDC as well. For both warehouses, this amounts to approximately 80% of all orders in volume. It is regarding the remaining 20% it becomes increasingly complex. IW1 orders the remaining 20% from other suppliers. IW2 on the other hand, orders 50% of the remaining 20% from IW1. Consequently, some of the medical items ordered by ward 1 are transported from the RDC to IW1, from IW1 to IW2, and ultimately from IW2 to the ward.

	RDC	IW1	Others	No. suppliers
RDC	-	-	100%	92
IW1	80%	-	20%	36
IW2	80%	10%	10%	29

Table 6: Demonstration of the suppliers of IW1, IW2 and RDC (in volume)

This setup might impact the lead time for ward 1, depending on whether the needed supplies from the RDC is stocked at the internal warehouses. This we were not able to identify, but we did however identify that this setup produces waste in terms of overprocessing. Take the instance when ward 1 orders a product from IW2, who bought it from IW1 who again bought it from the RDC. This structure produces two additional orders and accounting, compared to the situation where ward 1 had ordered this product directly from RDC. Furthermore, this structure produces waste of transportation and possibly the waste category waiting. To compare, H2 has released NOK 35 million in tied up capital by

removing internal warehouses and cross-dock internally in addition to implementing service employees (Tekna, 2019). This underpins some of the advantages of semi-direct delivery compared to a multi-echelon system.

Next, not all items frequently used at ward 1 have their own chip. This results in additional work for the order manager, having to manually find and enter the product ID number. Moreover, if the ward receives a patient with special needs the order manager has to spend time locating the needed item(s) from suppliers worldwide. This entails searching the web in addition to calling suppliers in Norway to get them to become suppliers for that respective product. The order manager has to do this every now and then, and may spend several days/weeks on only getting this one product. It is not unlikely that another order manager at H1 does exactly the same thing for the same type of product, or that this product has been tried located/bought a few months ago without results. Consequently, several people are working on the same task resulting in overprocessing and lost time for other valuable activities.

Another example of overprocessing identified at both H1 and RH1 is the production of deviation reports by nurses at the wards that are not followed up. Consequently, effort is put down to produce solid reports for the desk drawer, which adds zero value for the patient. This contradicts with the Lean theory, as the main purpose is to find ways to increasingly create value for the end-customer, the patient (Dobrzykowski, 2019; Rais et al., 2018). Ultimately, this may feel like a hopeless situation for the nurses who are already experiencing time scarcity.

Throughout this section, we have identified several waste examples at the two wards. In order for Lean implementation to be successful, and to be able to stay Lean, these wastes should be eliminated or at least reduced (Toussaint & Berry, 2013; J. Womack & Jones, 2003). This will in turn increase value.

4.6 Value

Lean is a systematic quality improvement approach that bases on identifying and eliminating non-value-adding activities (Aherne & Whelton, 2010; H. Andersen & Rovik, 2015; Kaplan & Porter, 2011). Essentially, the concept is more devoted to removing the non-value-adding activities than to do more of the value-adding activities. However, many hospitals struggle to both identify and eliminate the

non-value-adding activities, i.e. waste. According to Kaplan and Porter (2011) increasing value regards eliminating processes that do not add value and improving the resource utilization. Additionally, value to the patient is mainly timely and quality healthcare. This served as the point of departure to identify examples of waste. In the previous section, we highlighted some examples of waste and their sources in the two HSCs. These were identified through interviews, observations and reflections upon the literature. This work may serve as a starting point of a VSM in the respective SCs, where the next step in the Lean journey is to reduce the identified waste and its root causes (Rother & Shook, 2003).

The waste identified in the categories overprocessing and motion serves as examples of processes that do not add value. For instance, the overprocessing of single-use medical items in the complex structure at H1 does not add value to the patient. Further, if the waste identified in the category underutilization were reduced, resource capacity utilization could be improved. For example, it does not add value to the patient that a nurse spends time locating supplies or handles inventory. Additionally, Kaplan and Porter (2011) claim that both outcomes and costs must be measured at the patient level to manage value. Thus, the waste category inventory is of relevance to reduce costs. Reducing these non-value-adding activities can provide more value to the patients through freed up time that can be used to provide more service and improve quality, while reducing efforts and costs.

It is important to recognize that benefits achieved through Lean rely upon continuous efforts to increase value through identifying and reducing waste. The continuity of the Lean journey may for some organizations be perceived as overwhelming (J. Womack & Jones, 2003). However, there are in turn several benefits that can be achieved if carried out.

4.7 Benefits and Drawbacks of Lean at Hospitals

Implementing Lean involves taking into use and adapting tools and techniques to the respective organization and its context (Graban, 2011). There are no specific drawbacks of implementing Lean identified by research. However, a general presumption is that if you neglect barriers and not facilitate for enablers, there is a

slim chance of successful Lean implementation. This in turn may create negative implications. Although there are no concrete drawbacks, implementing continuous improvement in activities at a hospital may lead the hospital to face some new challenges. These may not be directly linked to Lean implementation, but can rather be seen as a consequence or causality of working towards continuous improvements. Thus, we focus on the challenges we have observed at the two wards, and not pinpoint any drawbacks.

Theory suggests that there are many potential benefits from implementing Lean initiatives. Daultani et al. (2015) claim that since hospitals differ in type and size, the required efforts and potential Lean benefits are difficult to compare directly. The two hospitals, and their respective wards, are fundamentally different in many areas like size, building-age, professional communities and location. Thus, as frequently claimed by research, context is key to understand divergent outcomes of Lean implementation. Although there are no comparative measures developed, there is growing evidence that the Lean philosophy impacts quality, cost and time when applied in healthcare (Hallam & Contreras, 2018). Thus, this section is divided into these respective parts.

4.7.1 Time

The time benefit of Lean implementation refers to productivity enhancement and time-savings, as proposed by, amongst others, D'Andre Matteo et al. (2015). Thus, this section regards how these productivity enhancements and time-savings can be achieved or are influenced by the interactions between the various SC actors.

When we asked the logistics staff at H2 what he would say are the benefits achieved through working Lean he highlighted that working Lean provides a good overview of how the SC is constructed. He further claimed that they are probably very good at finding shortcomings and analyzing the problem areas. This is in line with the benefits proposed by Mazzocato et al. (2010). During the interview, he emphasized the importance of obtaining a mindset that considers the overall implications of the SC, not just worrying about the hospital-internal gains or consequences. An example of this was when he showed us a complete overview of incoming deliveries from the RDC. Delivery of goods was far bigger on Tuesdays and Fridays than the rest of the week. He explained that although he

predicts that much of the reason for this is that they do not deliver on weekends, this is something that he would now want to take a deeper look at in order to even out deliveries during the weekdays. Balancing the deliveries to H2 will in turn increase optimization at the RDC as well. This is underpinned by the RDC, who states “*in an ideal world, we would look at how many order lines we have to pick every week and distribute these evenly for each day*”. Theory suggests that working in such a way can contribute to break down the barriers between various silos. Resulting in productivity enhancement, which in turn could increase time-savings and improve patient satisfaction (Holden et al., 2015; Mazzocato et al., 2010).

The criteria for when each department at H2 should be able to order were first set by an extremely thorough analysis, down to item-level. Often, an organization might have been satisfied with doing “just” this. However, working Lean means continuous improvement and recognizing that there is always something that can be improved (J. Womack & Jones, 2003). Consequently, the example above is also a great example of focusing on continuous improvements on already well-developed processes.

On the contrary, the order manager at ward 1 expresses that he experiences challenges due to lack of continuous flow in the SC and presence of sub-optimization on each level. He argues for improvement in communication between the various parts of the SC as something he would see great value in. “*We should all be more understanding and attentive to the other parts of the SC*” (order manager, ward 1). This is in line with previous research which suggests that HSCs often are characterized by high fragmentation with an absence of coordination mechanisms between the chain members (e.g. Dobrzykowski, 2019; Rais et al., 2018). For ward 1, this especially concerns their delivery days. However, the order manager emphasize that he understands that changes may create additional work for the internal warehouses. He therefore proposes that they should have more collaboration-meetings and not just make decisions individually. On the other hand, both IW1 and IW2 argue that the problem is just as much about the wards not meeting the right ordering levels and allocating enough place for critical items at the stockrooms. “*We welcome any wishes from the departments, but the most important thing is the efficiency of the system. You cannot have an employee running with deliveries in each direction of the*

hospital' (IW1, H1). Thus, the benefits pinpointed for H2 above, do not seem to be present at H1. This appears to be a result of H2 being further along in the implementation process of Lean, compared to H1. The lack of a holistic view and communication at H1 may result in poorer productivity enhancements and increased time-pressure.

Another example regarding the time benefit at ward 2 is a result of utilizing service employees. Service employees are doing tasks that the nurses at other hospitals have to perform themselves, resulting in freed up time for nurses at H2 to spend on patient care. On average, this amounts to 10 minutes for each nurse every shift. Taking the number of nurses working at the two wards into consideration, this adds up to ward 1 spending at least 4 more hours than ward 2 on out-of-stock situations every week. In addition, the use of service employees reduces the waste of underutilization and motion in terms of looking for and replenishing supplies.

4.7.2 Quality

Quality as a benefit from successful Lean implementation mostly regards increased quality through fewer errors (e.g. Moraros et al., 2016), increased employee satisfaction (e.g. Dellve et al., 2015) and increased patient satisfaction (e.g. Aguilar-Escobar et al., 2015). Further, improved quality is pointed to as a general result of continuous improvement focus. We are not able to comment upon the patient satisfaction directly, however there are reasons to believe that patient satisfaction could be indirectly affected through increased employee satisfaction and increased quality in patient care.

Employee satisfaction is a result of many variables. In this section we consider increased employee satisfaction in light of the means for continuous improvement in logistics at the hospital, rather than through leadership and human resource management. Graban (2011) argues that elimination of waste both improves employee satisfaction and increases quality in patient care. This entails reduction of aforementioned activities that are considered as overprocessing or underutilization of the nurses' capacity, unnecessary motion and reduction of inventory waste, at the two wards.

Lean thinking encourages to always strive for improvements (J. Womack & Jones, 2003). A potential psychological drawback in this regard is the feeling of never being good enough. Due to the stressful working environments, and the lack of nurses in Norway, many nurses might feel insufficient in their job. The nurses are concerned with providing quality healthcare to all their patients, and consequently focusing on improvement initiatives on top of this might feel overwhelming. The logistics staff at H2 argues, *“this is the great sales argument for introducing service employees, nurses should only worry about serving the patient.”* The idea of having service employees is to remove the nurses’ worries about having enough or available supplies to provide patient care. Compared to ward 1 without service employees, the nurses at ward 2 have a less stressful working environment what concerns supplies. This in turn could be a factor for improved employee satisfaction at ward 2, and is reflected in the interviews on this aspect. Moreover, the nurses at ward 2 are more satisfied with the location of the stockrooms, their size, set-up and inventory than at ward 1. While nurses at ward 1 experience frustration with the availability of medical supplies, this frustration is not particularly mentionable at ward 2. In sum, the higher availability of single-use medical items at ward 2 facilitates improved quality patient care.

Further, Lean at its best involves *“employees keep raising the bar, ... and an attitude of continuous improvement becomes the driving force behind all work”* (Toussaint & Berry, 2013, p. 75). During the interview with the service employee at ward 2 it seemed apparent that this is a focus among the service employees. This was revealed as he stated that *“improvement work is a continuous process”* and *“my opinion is that all things can be improved, there is always something we can do better”*. This is in line with the claim by Mazzocato et al. (2010) that a benefit of Lean is staff engagement. Finally, the logistics staff at H2 stated *“in the end, it is always the patient we are working for, no matter what position you hold at this hospital, it is the patient that should be in focus”*.

4.7.3 Cost

Cost reductions are not the main goal of Lean, eliminating waste is. However, when non-value-adding activities are reduced, cost reductions tend to follow. Kaplan and Porter (2011) argue that the relevant costs to consider in this respect are total costs of all resources, namely clinical and administrative personnel, drugs

and other supplies, devices, space and equipment used during patient care. Continuously they claim “*A cruel fact of life is that total costs will not actually fall unless providers issue fewer and smaller paychecks, consume less (and less expensive) space, buy fewer supplies, and retire or dispose excess equipment*” (2011, p. 63). Consequently, Lean initiatives should bring cost reductions through, amongst others, less manufactured hours, less money tied up in inventory and/or through improved inventory management.

Through a better structure of the material flow at H1 cost reductions can occur. In the case when ward 1 orders an item from IW2, who bought it from IW1, who again bought it from RDC there are two additional buffers. This leads to more tied up capital in the SC, compared to if ward 1 had ordered this product directly from the RDC. Additionally, nurse 1, 3 and 4 at ward 1 and nurse 7 (RH1) argues that they keep items in inventory that they do not use often or enough of, to justify its place allocation in the stockrooms. This also leads to cash tied up in inventory for a longer period of time than necessary. Improvement initiatives regarding inventory management could solve this.

Further, when the order manager at ward 1 has some extra time, he tries to do a thorough tidying of the sterile stockroom. In the case where there is a lot of one item required by a patient with special needs that is no longer at the ward, he notifies other wards at the hospital through the intranet. This initiative demonstrates a mindset of waste reduction and arguably Lean thinking in general.

Before ending this section, we would like to add that if Lean initiatives are implemented halfhearted, it could result in added costs rather than cost savings. This also applies if many projects are only initiated before realizing that there is not enough capacity to enroll all projects. Unfortunately, this is the case for many organizations when embarking upon the Lean journey (J. Womack & Jones, 2003). This can play a role in people’s perception of the success rate of Lean.

5. Conclusion

As the two wards and their supply chains have been studied, the findings and ensuing analysis have revealed several shortcomings and possibilities for improvements. This concluding chapter provides recommendations as to how improvements can be achieved, both at the wards and in their respective supply chain. Further, it provides a presentation of the main findings and their theoretical and practical implications before a discussion with regards to the research question. Ultimately, interesting ideas for further research are elaborated.

5.1 Suggestions

Before presenting our suggestions, we would like to emphasize that while we have identified several shortcomings at the two wards there is no doubt that the nurses and employees endure heroic efforts every day. The purpose of our thesis is to identify areas of improvements and suggest solutions through the Lean concept in order to make their workday a bit less hectic. Here we present what we perceive to be the three most rewarding measures; one at ward 1, one at ward 2 and then one considering the context of both supply chains.

Our first suggestion is to reorganize the stockroom(s) at ward 1. The nurses express severe frustration over its lack of overview and untidiness. We suggest that they reorganize the setup, standardize the cabinets, adjust space allocation for several SKU and update the cabinet-list. This has not been done in two years, since there allegedly is no time to do so due to 24/7 operations at the ward. Thus, we suggest that during reorganizations they could take use of “emergency trolleys” at POU, containing the necessary supplies. This would ensure access to supplies while the stockroom is under reconstruction. If this is done, less supply will be placed on top of the cabinets. In addition, the most frequently used items will have allocated adequate space in the cabinets. This could in turn lead to less stockouts in light of the fixed delivery days from the internal warehouses. In addition, we suggest that par-levels of several SKUs are adjusted. The ward may take use of the EOQ model, and thus get the most out of their Kanban resembling system. In sum, the nurses will be increasingly able to find the necessary supplies, and its location. Further, we suggest that the nurses should be encouraged to ensure a FIFO procedure when they are replenishing the stockrooms. While we

recognize that this in practice could be difficult to follow up, it would reduce the current levels of obsolescence.

H2 facilitates for excel and Lean flow of materials and product availability in many ways. However, they come a bit short in permeating it all the way down their professional hierarchy. Therefore, our second suggestion is improved exploitation of the service employees at ward 2. The nurses at ward 2 express that they see great value in changing the content of the smaller stockrooms along with the setup at the main stockroom. From dialog with the service employee we experienced that their team is willing and seeking improvement suggestions from their customers, the employees at the respective wards. However, we did not recognize that the nurses' suggestions were presented to the leader of the ward, nor directly to the service employees. Consequently, the nurses are holding on to improvement initiatives that could be implemented if they were explicit to the service employees. We therefore suggest that there is communicated and encouraged to the nurses that the service employees welcome these suggestions, either directly from the nurses or by the leader of the ward.

The Lean initiative by SENRHA with department packages results in RDC possessing a substantial amount of information about the hospitals' order history. This is valuable information that should be encountered in the continuation of implementing department packages to all hospitals in the southeastern region. Thus, the third suggestion regards increased interactions with the RDC. They arguably hold so much information that they could engage in VMI for their clients. While this would require more manpower at the RDC, it would release nurses and other employees at the hospitals to more patient-oriented tasks and possibly lead to cost reductions as suggested by theory (Krichanchai & MacCarthy, 2017). However, deliveries from the RDC to the various hospitals vary from 20% to 90% of all SKUs. Consequently, there would still be necessary for some hospitals to devote nurses or employees to replenishment activities. Furthermore, since the patient needs at the many wards vary depending on the illness and its complexity, the RDC would rely on inputs from the wards in order to meet the patient needs. Thus, we propose an implementation of CMI where the RDC and the wards co-manage the inventory and replenishment, to cope with many of the current challenges related to the material flow.

Lastly, a general recommendation to all actors in the two respective SCs is to enhance their communication and increase their information transparency. While this may be trivial theoretically, it is observed to be rather difficult practically. Many of the valuable aspects of working Lean does not seem to have been permeated throughout the whole chain and internally at the hospitals as well. As Toussaint and Berry (2013) state; implementing Lean requires a major shift in roles where leaders must become teachers, mentors and facilitators. While this is claimed emphasized by both hospitals, the interviews with all of the nurses states otherwise. It was decided 11 years ago that all hospitals in the southeastern region of Norway was to implement and work Lean. We identified that the upstream actors were actively applying Lean thinking. However, none of the nurses we interviewed had heard anything about this and a minority of the nurses knew that they were supposed to work towards continuous improvements. This illustrates that the efforts of the upstream actors do not permeate to the end stage. Additionally, there also seem to be apparent some shortcomings in the communication and information transparency between the different SC actors. In order to secure a Lean flow of materials, this should be improved.

5.2 Practical Implications

From interviews and observations, we identified various types of waste at the two wards, and in their supply chains. However, we found more waste at ward 1, than in any other of the supply chain stages included in this study, implying the validity of the initiative raised by SENRHA. We also identified to a large degree what drove these non-value-adding activities. Among others, these were inventory that was not filled up after delivery of supplies, poor visibility of inventory levels along with its location and extra supplies randomly located. Additionally, at ward 1 the nurses are underutilized when they spend time receiving orders and replenish the stockrooms. When this situation occurs, the nurses attempt to complete the task as quickly as possible, resulting in a LIFO procedure. This in turn results in obsolescence because of the expiration dates on sterile medical items.

An important part of being Lean is to be proactive, with a holistic view. Through our analysis we discovered that upstream the SC there is a lot of focus on proactivity and planning, while downstream, at the wards, it is mostly fire-fighting. The biggest challenge to overcome is that one could never pause in a

hectic workday to do “important things” such as logistics, because the patient is always the most important. This combined with the root causes of waste as mentioned above, creates the big sales argument for service employees or other relieving positions.

A service employee dedicated only to the supply of medical items/materials could release so much time for the nurses/healthcare providers that:

1. The quality is likely to improve (the nurses are likely to produce more patient care, and less errors due to lower stress levels),
2. the satisfaction of both patients and employees is likely to improve, and
3. the total costs could go down (despite the costs of employing service employees their employment would reduce inventory costs (holding and obsolescence), and fewer errors/improved quality could reduce hospital days).

In addition, unnecessary time spent by nurses to locate supplies would decrease by at least 4 hours each week. Through utilizing service employees, the nurses may gain so much more time with the patients that the prognosis number of missing nurses in Norway can be reduced. This may not only result in nurses enjoying more time with their patients, but could also contribute to reduce burnouts. Both in terms of sick leaves and total burnout resulting in leaving the occupation for good. This could be highly valuable, as today, one of five nurses leaves their occupation within the ten first working years (Aftenposten, 2019).

5.3 Theoretical Implications

Implementing Lean at hospitals has received increasing attention in research. However, research regarding the implications it has on the flow of materials and product availability has been slim. This thesis has addressed the interactions between theory regarding Lean, inventory management and supply chain management at hospitals. Thus, contributed to filling the literature gap.

Through the literature review we disclosed the four most frequently mentioned enablers and barriers. These were context, culture, management and information transparency. During the analysis of the data we identified additional categories of enablers/barriers for successful Lean implementation in a HSC. We highlight the importance of systems, standardization, flexibility and communication as enablers

and physical, systems, processes and communication as barriers. While standardization is suggested as a useful tool when implementing Lean, we have found that it also can be regarded as an enabler to stay Lean. Moreover, flexibility is an important facilitator to responsiveness and quick turnarounds. Physical barriers are often set in stone, but should be thoroughly encountered when embarking upon the Lean journey. By this, we would like to emphasize the importance of the holistic view. Hence, not sub-optimizing when implementing improvement initiatives in the supply chain.

The application of Lean tools in healthcare is not agreed upon in literature. However, through our analysis we find great value in many of the suggested tools in Lean theory. Kanban appear to be useful in the work of ensuring continuous flow of materials. Blackboard meetings are valuable to create a platform to foster continuous improvement, thinking and solving. 5S appear applicable during the work of standardizing and simplifying processes. Lastly, VSM appear valuable in the work of identifying non-value-adding activities. Most importantly, we found that the tools should be applied in its entirety to truly have a meaningful effect.

Consequently, the construction of the conceptual framework based on previous literature can be supplemented with this study's findings. This includes additional categories of enablers/barriers, and implementation of tools in the Lean application (consult appendix 6). This new conceptual framework serves as a contribution to theory what concerns the link between the concept of Lean, inventory management and supply chain management at hospitals. Moreover, although this framework is constructed to investigate improvements in HSCs, it may be applicable to other service organizations as well as it covers the material flow and not specifically the service provided at hospitals. Additionally, while the study covers single-use medical items, our findings are likely to be applicable to other material flows at hospitals as well.

5.4 Research Question

In this thesis, we have analyzed how Lean can contribute to improve HSCs. The focus has been on identifying problem areas that may benefit from tools suggested in the Lean theory, or where Lean thinking in general can contribute to

improvements. What lay the foundation for such an analysis are the enablers and barriers present at the two wards.

To achieve successful implementation of Lean, the hospital supply chain must take the perspective of the patient and create holistic solutions, not improve sub-optimally without considering the context. The problem areas might be internal logistics, administrative processes or communication flow. Everything revolves around using the right competence, at the right place at the right time. The work of continuous improvement is closely linked to good planning of resources and good measurements of quality and process time. Our interpretation is that the initiatives by SENRHA regarding a RDC, department packages and active supply align with the foundation of Lean methodology. However, we find shortcomings in the matter of bringing the whole organization on board – from top to bottom. Through our investigation it appears that Lean thinking is to some degree applied in the lower levels in the hierarchy, and next to none-existent “at the floor”. However, Lean thinking requires a cultural change. This is one of the most frequent mentioned barriers in research on Lean, both in manufacturing and service organizations.

Perhaps the most prevailing challenge we identified during our study is that the “floor workers” are overloaded with tasks and assignments. This results in insufficient time to solve them all during the day, which in turn affects the direct patient care. Freed up time as a result of successful Lean implementation might not imply that they have more time to do other activities than direct patient care. It rather implies that they will have sufficient time to do their core-activity, or “do what they came for”.

Conclusively, we found that several tools suggested in the Lean concept are applicable to improve the material flow in the hospital supply chains, but also that more important than the choice and application of Lean tools is the mindset the concept suggest.

5.5 Limitations and Further Research

When studying the two wards in their different supply chains we found several examples of Lean related to logistics and material flow in the supply chain of ward 2. In comparison, we did not find remotely as many in the supply chain of

ward 1. The activities focusing on continuous improvements regarded issues such as deviations and sick leaves. However, this does not imply that logistics/material flow initiatives do not exist. H1 is a part of a big hospital trust where the logistics is more centralized. Additionally, there are future plans for these hospitals regarding restructuring and centralization. Consequently, it might be more facilitated for continuous improvement work in these new plans and buildings. This is out of scope for this study, but raises an interesting question.

Our approach to the research question was mostly qualitative. While we were interested in collecting quantitative data, this was challenging because the interviewees often did not have the numbers at hand. Consequently, the benefits time, quality and costs are based on interviewees' perceptions and our interpretations of possible causalities and what theory suggests overcoming the challenges could bring. Suggestions for further research is to have a quantitative approach in order to report true cost savings through improved inventory management and semi-direct deliveries contra multi-echelon systems.

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Appendices

Appendix 1: Interview Guide – Supply Chain Actors

Background

These questions will only be used to map the background/competencies of the interviewee, and will not be stated in the master thesis.

1. What role do you have at this department?
2. How long have you been working here?
3. What is your background? (Education and work experience)

Lean and continuous improvement

4. Have you been informed that this hospital is working towards being Lean?
 - a. If no, have you ever heard of the Lean concept?
 - i. If no again: then we explain in short what Lean is about.
 - b. If yes, elaborate what and how.
 - i. How was this decision communicated to you and the employees?
 - ii. What was the main focus as you understood it?
5. Do you have any perception of what Lean thinking means to you?
 - a. Is it your perception that the hospital is in fact working after the principles of Lean?
6. What are the benefits with Lean in your opinion?
7. What are the drawbacks with Lean in your opinion?
8. What do you do in regards to continuous improvement? Please elaborate

The ordering system

9. What ordering system are you using?
10. How do you place orders?
 - a. Are there standard replenishment orders?
 - b. Or is the order based on forecasting?
 - c. How many people are involved in the ordering process?
 - d. When do you order new supplies?
11. Who do you order from (external supplier)?
 - a. When do you receive the shipments (normally)?
 - i. Is this affecting your order frequency/size of orders?

- b. Do you have any restrictions regarding orders?
 - c. Are you experiencing “wrong shipments” (delays, defects, wrong products etc.)? – Explain.
 - i. If yes, how do you cope with this?
12. How do you receive orders from the various departments (internally at the hospital)?
13. Is it your perception that this way of ordering is optimal? Please elaborate
14. Based on the Lean concept – is it your perception that the routines of ordering is Lean?
- a. Why/why not?

Suppliers and customers

15. How many suppliers do you have?
16. How is the communication between you and them? Please elaborate
17. How many customers do you have?
18. How is the communication between you and them? Please elaborate
19. How is the information sharing regarding the order status between the various supply chain stages? Please elaborate
20. Is there a way for you find out what your customers/other warehouses have in stock? Please elaborate

Inventory management

21. Can you describe how inventory is handled here?
22. Where is the inventory kept in this department (single-use medical items)?
- a. Is it your opinion that this is a good location?
 - i. Why/why not?
 - ii. Do you have a suggestion for an optimal placement of this inventory?
23. How is the size of the warehouse?
24. How many SKUs do you have in stock?
25. Will you tell us about the availability of inventory?
- a. Is it your perception that you have control over the inventory at all times?
 - b. Do you experience mistakes in the inventory?
 - c. How is the availability of the inventory?

- iii. Are you often out of stock?
 - 1. If yes, why and how do you handle this?
- d. How is the overview of inventory at hand?
- 26. Are you familiar with that the length of inventory days is considered as a cost? “Money tied up in inventory”.
 - a. If yes, what do you do to ensure that the inventory circulates efficiently?
 - b. If no, do you have inventory in stock that is there for a long period of time (deadstock)?
- iv. Why? What kind of products are they?
- 27. Is it your perception that this way of handling inventory is optimal? Please elaborate
- 28. Based on the Lean concept – is it your perception that the handling of the inventory is Lean?
 - a. Why/why not?

Concluding questions

- 29. Is there anything else that you think is relevant in this matter that we have not covered already?
- 30. Is there anything you would like us to exclude from this interview in our master thesis?
- 31. If we experience a need to contact you again, is it possible to contact you for clarification or elaboration?
- 32. Do you have any questions to us?

Thank you for meeting us, we appreciate it greatly. Here is our contact information if you have any doubts.

Appendix 2: Interview Guide – Nurses

Background information

These questions will only be used to map the background/competencies of the interviewee, and will not be stated in the master thesis.

1. What role do you have at this ward?
2. How long have you been working here?
3. What is your background? (Education and work experience)

Lean and continuous improvement

4. Have you been informed that this hospital is working towards being Lean?
 - a. **If no**, have you ever heard of the Lean concept?
 - i. If no again: then we explain in short what Lean is about.
 - b. **If yes**, elaborate what and how.
 - i. How was this decision communicated to you and the employees?
 - ii. What was the main focus as you understood it?
5. Do you have any perception of what Lean thinking means to you?
 - a. Is it your perception that the hospital is in fact working after the principles of Lean?
6. What are the benefits with Lean in your opinion?
7. What are the drawbacks with Lean in your opinion?
8. Is there a focus of continuous improvement at this ward? Please elaborate

Inventory and supplies

9. Where is the inventory kept in this ward (single-use medical items)?
 - b. Is it your opinion that this is a good location? Why/why not?
 - c. Do you have a suggestion for an optimal placement of this inventory? Why?
10. How is the size of the inventory room?
 - a. How is the overview of inventory at hand?
 - b. How is the information sharing regarding the inventory at the ward?
11. Will you tell us about the availability of inventory?
 - e. Is it your perception that you have control over the inventory at all times? Why/why not?

- f. Do you experience mistakes in the inventory?
 - g. Is it your experience that the necessary supplies are available when needed?
 - i. Are you often out of stock?
 - 1. If yes, how often? And how do you handle this?
 - h. Is it your perception that you spend time looking for supplies?
 - ii. If yes, how do you do that?
 - iii. If yes, how much time do you think you spend per shift?
 - d. Is there a way for you find out what other wards have in stock?
 - i. If no, and yes to looking for supplies, do you believe that this would made your workday easier?
12. Who handles the ordering at this ward?
- a. How do you experience this arrangement?
13. Is it your perception that this way of handling inventory is optimal? Please elaborate
14. Based on the Lean concept – is it your perception that the inventory management is Lean?
- b. Why/why not?

Concluding questions

15. Is there anything else that you think is relevant in this matter that we have not covered already?
16. Is there anything you would like us to exclude from this interview in our master thesis?
17. If we experience a need to contact you again, is it possible to contact you for clarification or elaboration?
18. Do you have any questions to us?

Thank you for meeting us, we appreciate it greatly. Here is our contact information if you have any doubts.

Appendix 3: Extended Supply Chain Ward 1

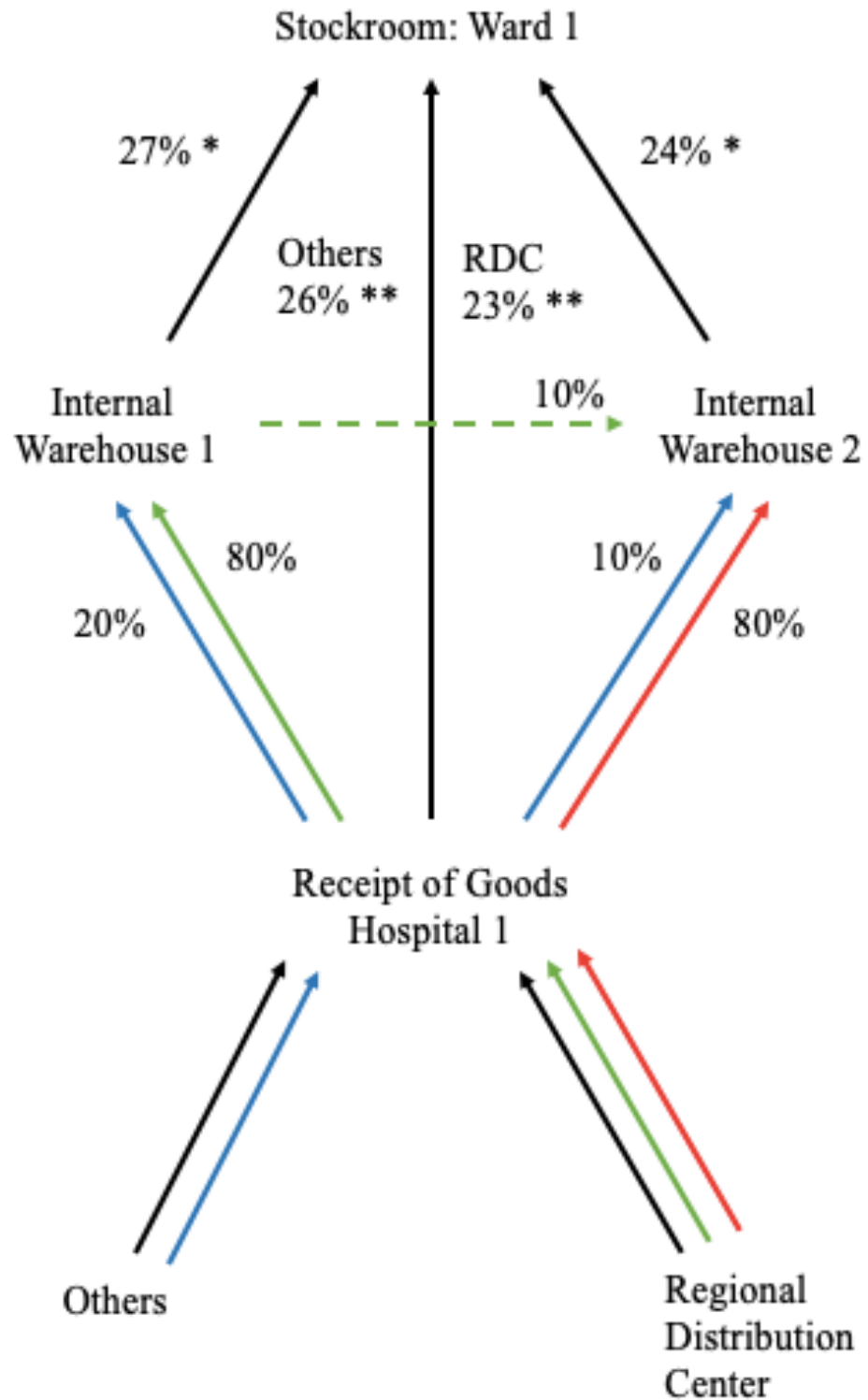


Illustration XX: Extended flow of materials from suppliers to stockroom hospital ward 1

* Placed at respective location in the stockroom by employees at ward 1

** Placed at respective location in the stockroom by employees at the internal warehouses

Appendix 4: Extended Supply Chain Ward 2

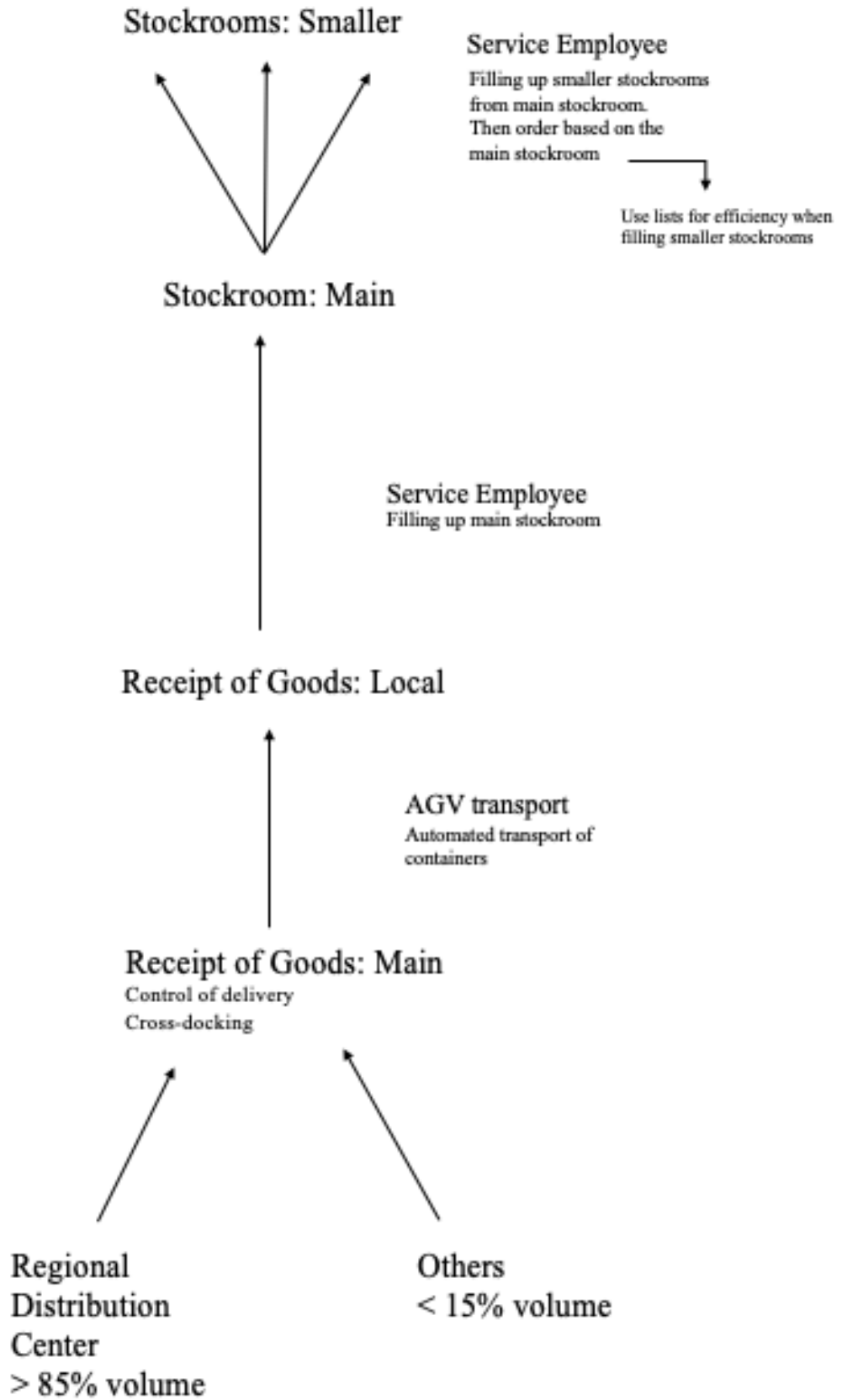
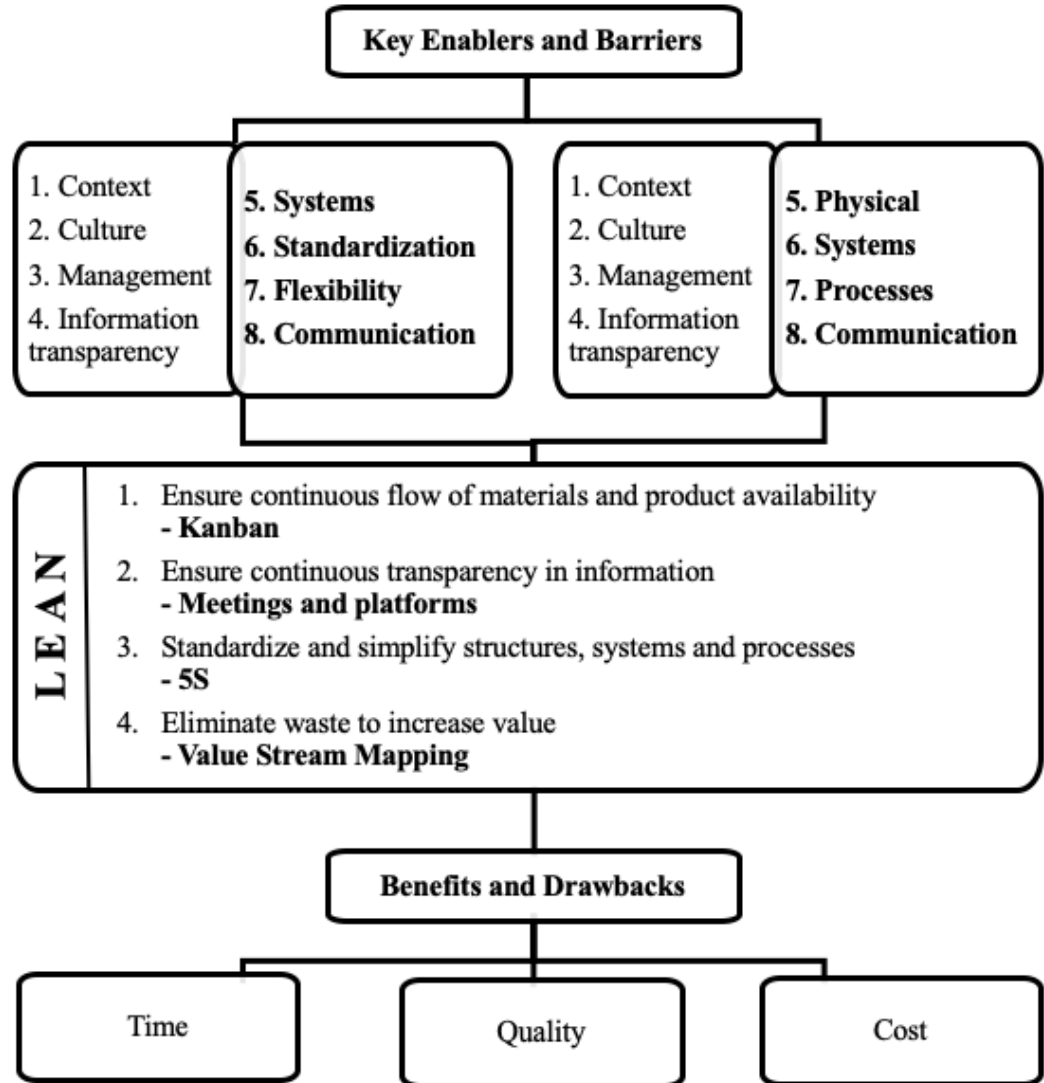


Illustration XX: Extended flow of materials from suppliers to the smaller stockrooms at hospital ward 2

Appendix 5: Summary-Table of Interviews with Nurses

Hospital	Hospital 1 Ward 1				Hospital 2 Ward 2		Reference Hospital 1	Reference Hospital 2
Alias	H1: Nurse 1	H1: Nurse 2	H1: Nurse 3	H1: Nurse 4	H2: Nurse 5	H2: Nurse 6	RH1: Nurse 7	RH2: Nurse 8
Employment	Permanent employee (80%)	Permanent employee (100%)	Permanent employee (100%)	Permanent employee (100%)	Permanent employee (50%) Temporarily employee (25%)	Permanent employee (75%) Temporarily employee (25%)	Permanent employee (80%)	Permanent employee (100%)
Length in position	10 months	10 months	10 months	24 months	24 months	12 months	24 months	20 months
Knowledge of Lean	None	None	None	None	None	None	Some	None
Perception of improvement focus	High	None	High	High	Some	Some	High	Some
Perception of time spent in average looking for supplies	Everything from 10 minutes to an hour every day. Never 0 minutes	10 minutes every day.	Everything from 5 to 20 minutes, perhaps every other day.	Everything from 5 to 20 minutes, perhaps every other day.	Do not spend much time looking, will stop looking after 2 minutes if it is an ordinary item.	5 minutes per month	5-15 minutes every day, depending on the distance to the stockroom with the supply	Approx. 10 minutes every day
(Perceived) result of looking for supplies	Stress, lost patient time, possibly overtime	Stress, frustration	Loss of valuable patient time	Loss of valuable patient time	Time-consuming, stress, especially when there is an emergency	Not mentionable	Stress, exhaustion	Stress, lost patient time, possibly overtime

Appendix 6: Extended Conceptual Framework



Appendix 7: Gallery

Hospital ward 1



Internal warehouse 1



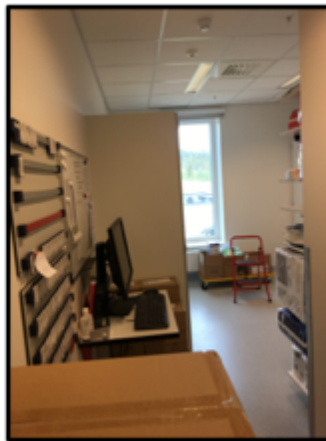
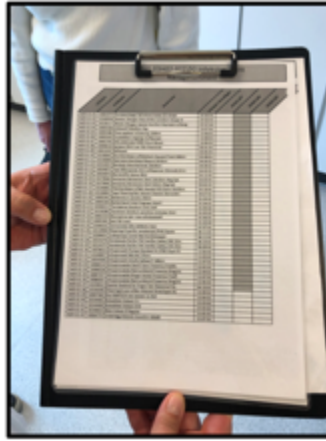
Internal warehouse 2



Hospital 2



Hospital ward 2



Regional Distribution Center



Pakningsnivåer

Pakningsnivåer som beror på de transporter som ska användas för alla transporter. Närvarande nivåer vidtar sig samordningen mellan anläggningarna.

DU
Dispatch unit
2-stak Transportpackning

TU
Trained unit
1-stak Lagerpackning

CU
Customer unit
2-stak Kundpackning

BU
Base unit
1-stak Grundpackning

Innhold
1-stak Innehåll

Kvalitetskontroll av leveranser

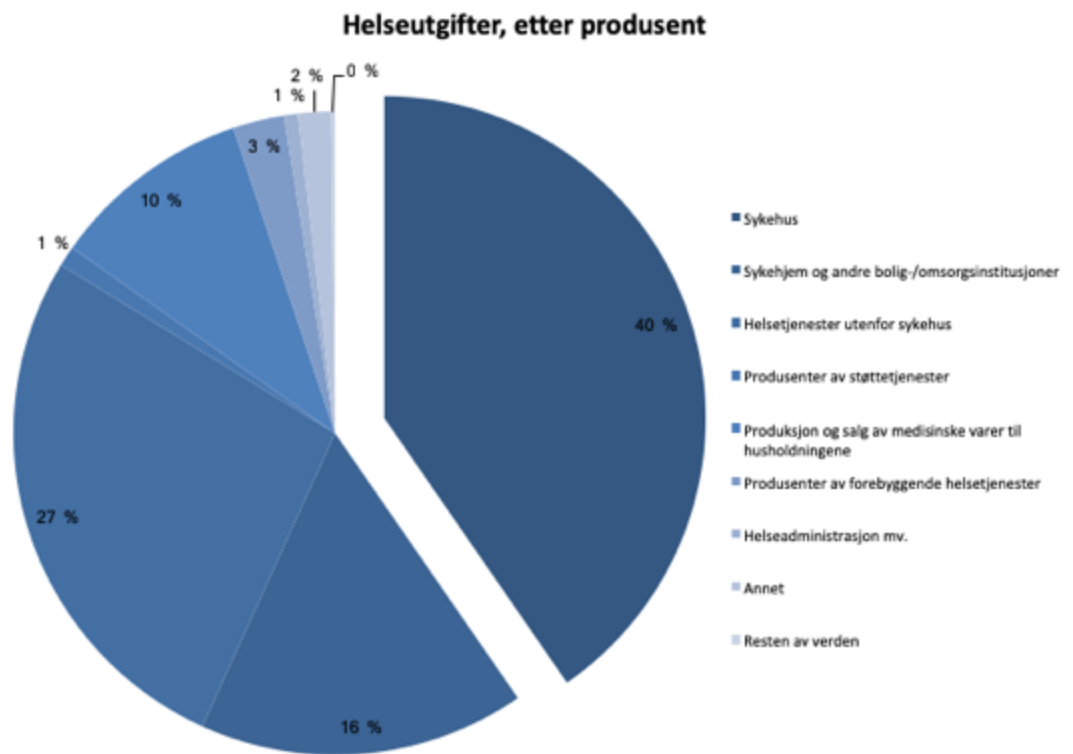
OK

VURDERES

IKKE OK



Appendix 8: Diagram of Healthcare Related Costs



Appendix 9: Information and Consent Form to Interviewees

Vil du delta i forskningsprosjektet ”Lean at hospitals”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å levere en masteroppgave hvor vi sikter på å kartlegge hvordan vareflyten ved norske sykehus er og knytte dette opp mot ”Lean philosophy at hospitals”. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Forskningsprosjektet er en masteroppgave ved Handelshøyskolen BI, innenfor profilen Logistics, Operations and Supply Chain Management, som skal ferdigstilles innen 01.07.2019.

Problemstillingen per 15.04.2019 er:

“How can Lean contribute to improve hospital supply chains?”

Mer spesifikt skal vi undersøke om vareflyten til og på avdelinger samsvarer med prinsippene i Lean da det utgjør en viktig del av Lean filosofien.

Hvem er ansvarlig for forskningsprosjektet?

Handelshøyskolen BI Oslo er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?

For å besvare vår problemstilling behøver vi informasjon fra nøkkelpersoner, typisk logistikkansvarlige, innkjøp- og bestillingsansvarlige og ansatte/sykepleiere ved de aktuelle avdelingene som har jobbet der mer enn et halvt år.

Hva innebærer det for deg å delta?

Hvis du velger å delta i prosjektet, innebærer det at du stiller til et intervju/samtale som vil ta deg ca. 60 minutter. Spørsmålene vil i all hovedsak gjelde generelle spørsmål om varelevering, vareflyt og tanker rundt Lean filosofien. Ut over dette ønsker vi å kartlegge følgende informasjon om deg:

1. Hvilken rolle har du på dette sykehuset/avdelingen?
2. Hvor lenge har du jobbet her?
3. Kan du fortelle litt om din utdanningsbakgrunn og/eller tidligere relevant arbeidserfaring?

Vi vil ta lydopptak og notater fra intervjuet. Dette lydopptaket vil slettes med en gang det er transkribert, og du kan få dette tilsendt for gjennomlesning om det er noe du ønsker fjernet.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg. Dette kan du gjøre ved å kontakte studentene per telefon eller mail. Dersom du ønsker å trekke deg, ber vi om at du gjør dette tidligst mulig.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrevet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

- Det er kun vi, to studenter, som vil ha tilgang til opplysningene du har gitt ved samtale.
- For å sikre at ingen uvedkommende får tilgang til personopplysningene (navnet og kontaktopplysningene dine) vil vi lagre datamaterialet kryptert.

Annet:

- Navn på databehandlere som skal samle inn, bearbeide, lagre data: Andrea Rishaug Bakken og Maren Sophie Solli
- Du som deltaker vil kunne bestemme om du vil gjenkjennes i publikasjonen. Type opplysninger som vil publiseres er da dagens stilling og noe om utdannings- og arbeidsbakgrunnen din dersom det oppleves som relevant. Du vil ikke bli omtalt ved verken navn, kjønn eller alder.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?

Prosjektet skal etter planen avsluttes 01.07.2019. Da vil alt av personopplysninger slettes. Lyddopptak avsluttes fortløpende etter transkribering. Transkriberingen slettes så snart analysen er fullført. Transkripsjonen vil senest slettes 01.07.2019.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Handelshøyskolen BI Oslo har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?

Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- En av studentene som skriver masteroppgaven; Andrea Bakken (450 555 09) eller Maren Sophie Solli (902 99 646)
- Alternativet vår veileder Marianne Jahre ved Handelshøyskolen BI. Mail: marianne.jahre@bi.no
- Vårt personvernombud: det er ikke etablert en slik institusjon ved Handelshøyskolen BI per 01.01.2019
- NSD – Norsk senter for forskningsdata AS, på epost (personvernombudet@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen

Andrea Bakken
Student

Maren Sophie Solli
Student

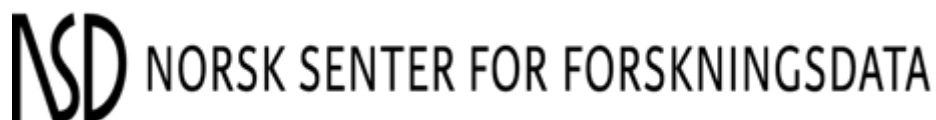
Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *Lean at hospitals*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- å delta i intervju
- at opplysninger om meg publiseres slik at jeg kan gjenkjennes (se: ”hva innebærer det for deg å delta?”)

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. 01.07.2019.

(Signert av prosjektdeltaker, dato)

Appendix 10: Approval from NSD**NSD sin vurdering****Prosjekttittel**

Lean i helsesektoren

Referansenummer

480261

Registrert

04.02.2019 av Andrea Bakken - Andrea.R.Bakken@student.bi.no

Behandlingsansvarlig institusjon

Handelshøyskolen BI / BI Oslo / Institutt for regnskap, revisjon og foretaksøkonomi

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Marianne Jahre, marianne.jahre@bi.no, tlf: 46410475

Type prosjekt

Studentprosjekt, masterstudium

Kontaktinformasjon, student

Andrea Bakken, andrearishaug@outlook.com, tlf: 45055509

Prosjektperiode

11.02.2019 - 01.07.2019

Status

08.02.2019 - Vurdert

Vurdering (1)**08.02.2019 - Vurdert**

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 08.02.2019. Behandlingen kan starte.

MELD ENDRINGER

Dersom behandlingen av personopplysninger endrer seg, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. På våre nettsider informerer vi om hvilke endringer som må meldes. Vent på svar før endringer gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET

Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 01.07.2019.

LOVLIG GRUNNLAG

Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER

NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke behandles til nye, uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER

Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER

NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Dersom du benytter en databehandler i prosjektet må behandlingen oppfylle kravene til bruk av databehandler, jf. art 28 og 29.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET

NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Tlf. Personverntjenester: 55 58 21 17 (tast 1)