Satakunnan ammattikorkeakoulu
Satakunta University of Applied Sciences

MARIA VIRTANEN

Developing direct delivery process in Oulu University Hospital

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Developing direct delivery process in Oulu University Hospital

Supervisor

Katri Kesti, Lecturer, MSc Eng

Abstract

Objective of this thesis is to develop direct delivery process in central warehouse of Oulu University Hospital using Lean management, in order to help the warehouse reach the service promise of 36 hour delivery time. The thesis work is part of larger development process in the warehouse.

The thesis process started by working as a direct delivery employee for two months. When the project begun, the process was mapped, described and timed in order to detect the waste. Open interviews with direct delivery employees were conducted to find out their perceptions and needs for the project. Supported by these interviews and Six Sigma 6M method, fishbone diagram was built to identify and categorize the waste. Efficiency of the direct delivery was inspected by getting information from the warehouse databases.

It was concluded, that warehouse has enough resources, but the process is leaking especially at the end part of the process, in printing and packing. To reduce the waste, some investments to new equipment would be needed. Possibility to make changes into software that the warehouse is using, should be also investigated.

Since the direct delivery is getting new workspace in the near future, it offers good potential to implement improvements and reorganize work in order to reduce waste.

As an end product the thesis maps the waste in the process and gives suggestions how to reduce it.

Keywords
logistics, hospital warehouse, direct delivery, lean, development, fishbone diagram

Images

CONTENTS

1 INTRODUCTION

Northern Ostrobothnia Hospital District (later PPSHP) provides health care services to its 29 member municipalities from two hospitals, Oulu University Hospital (later OYS) and Oulaskangas Hospital. It has almost 7000 employees and carries operational cost of 600 million euros per year. (PPSHP, 2020). OYS and the campus around it are going through significant changes. The hospital district has "OYS2030" project, and it aims to rebuild most of the campus by 2030. First constructions started in 2019. (OYS2030, 2021).

Alongside direct patient care, PPSHP has medical support services that are providing for example procurement, warehousing, pharmacy, and hospital logistics services to the hospital district (PPSHP intranet, 2021). The counterpart of the thesis is central warehouse of OYS.

The current hybrid warehouse handles 25 000 different products in year. 2 300 of them are located in the warehouse and rest are delivered as direct delivery products straight to the customer. Inbound handles roughly 60 pallets of deliveries daily, and outbound sends around 80 trolleys to its customers. (PPSHP and Dreambroker, 2018).

PPSHP has established direct delivery process to products which have low sales or high prices. These products are not kept in stock, they are ordered from suppliers when needed. The goods arrive from the supplier to the central warehouse, where they are received and sent directly to the customer. Delivery time takes longer than stock delivery. Direct deliveries account for most central warehouse sales, due to the value of the material. (Niemi, 2016).

It is not yet determined when the warehouse gets its new building, but it is included in OYS2030 project. Old warehouse was demolished 2017, forcing warehouse to move out of the hospital campus. The current warehouse is in temporary location which has been originally built for subcontractor of Nokia. Distance between hospital and the warehouse is 12km, which means roughly 15min drive in one direction.

2 RESEARCH

2.1 Research question and aims

Research question: How to make direct delivery process more efficient in hospital warehouse?

Research problem: What factors cause the ineffectiveness of direct delivery process?

Aim of the project: Improve the direct delivery process of the warehouse.

Sub-aims: Improve use of the available resources.
Get faster lead times in internal supply chain.
Find root causes to the bottlenecks in the direct delivery process.
Streamlining the work in direct delivery stations.
Find solutions to bottlenecks.
Give better quality of service for customers of the warehouse.
Improve patient care.

2.2 Research methods and outlines

The topic is built around problem that the warehouse has - ineffective processes that leads to broken service promise. To keep the research area and time manageable, the outlining was made to direct delivery process and internal customers, them being all the different departments of OYS.

In research, it is often debated if qualitative or quantitative method should be used. In their article Sogurno (2002) has summed up that these methods have different, but complementary role in research and its outcome. Rough way to separate these two is to see quantitative research as number-heavy research method and qualitative as research where data is not represented as numbers. Qualitative method can be seen as a process to understand social or human problem which is built on complex, holistic picture. When reporting outcomes, qualitative research gives detailed views of informants in their natural setting. (Sogurno, 2002).

Research method of the thesis is qualitative, even when there is quantitative data available and used on parts of the thesis. There has been done very little internal investigation regarding the inbound and direct delivery process as a whole, and its effectiveness in the warehouse of OYS. There are mostly assumptions based on perception of the direct delivery employees and their managers, why the process is taking so long. That is why root cause analysis was chosen as one of the approaches used in the thesis.

Information used in root cause analysis is collected by measuring time consumption of the direct delivery operations, interviewing the employees and pulling data from different software like Gemini (enterprise resource planning, later ERP), freight software Attune and data visualization program Microsoft Power BI. The analysis is also supported by Lean methodology, especially the methods to identify waste.

The work is outlined to the direct delivery process and internal customers (OYS), even when there are several other processes in the warehouse. Warehouse presents public sector, so it is mostly funded by taxpayers. Making the process more efficient, gives more value for this money. Because the warehouse services social- and healthcare, the patients are in receiving end of the process. Better support services mean better patient care.

There have not been resources to look the direct delivery process more closely yet, since the development project (Image 1) has started from picking. The planned hybrid picking system has not worked like anticipated, and this has delayed rest of the development project.

It is well known by both, direct delivery employees and the employer that there are several problems in the process. They haven’t recognized right tools to map and tackle them. That is why thesis work on the subject has been suggested.

At the moment problems manifest as a broken quality of service promise to a customer. This causes problems in patient care, since there is not always best possible or backup equipment available. In worst case scenario planned operations are cancelled when patient is already in hospital, but there are no right kind of materials available to treat them. (Savela & Valtanen, 2021).

2.3 Previous research related to the topic

Hospital logistics has been researched widely. Moons et.al. (2019) have done a literature study about measuring the logistics performance of internal hospital supply-chain. They highlight uniqueness of the supply-chain compared to other industries, importance of well-defined supply chain strategy, performance measurement and determining elements of an effective logistics in their research. Main focus of their research is on operating room environment. (Moons;Wayenbergh;& Pintelon, 2019).

Đapić et.al. (2015) have presented their case study about hospital logistics in 2nd Logistics International Conference, Serbia. They have researched different logistic flows in Serbia's clinical center CCS. The study gives more general view about hospital logistics, but they also highlight uniqueness of each hospital and importance of right key decisions. One of the key decisions is to determine if the items should be classified as direct delivery or stock items. (Đapić;Novaković;& Milenkov, 2015).

In his thesis Heino (2019) has developed the inbound operations and delivery tracking in Helsinki University Hospital (HUS). According to the thesis, there is no technology involved in the direct delivery process which makes their process unreliable. Heino has inspected direct delivery model from point of view of "drop shipping". He has listed positive effects of direct delivery as freeing up the storage space and not having managing costs in the warehouse since the items are stored by the seller. This way it is also possible to offer wider scale of items for the customers. Downside is reliability to the seller's warehouse, since the hospital can't control the inventories. He sees inoperative process having negative effect to imago of HUS logistics. (Heino, 2019).

Rivard-Royer et al. (2002) go through the direct delivery or "stockless" concept in their case study about hybrid stockless warehousing in health-care supply chains. History of the concept goes back to1980s, when distributors in US started to offer a new stockless method to their customers. They picked, packed and directly delivered products according to particular needs of their customers, in this case patient care units. In a decade this system was shifting towards hybrid stockless warehousing, since distributors wanted to optimize balance between their efforts and hospitals' inventory savings. (Rivard-Royer, 2002).

The health care sector supply chain is characterized by its complexity, which results from the multitude of different supplies and myriad distribution channels - supplies may come directly from the manufacturer or transit through a distributor. On the other hand, the complexity resides as well within the health care institutions. Hospitals must deploy their own logistics network for delivering supplies to the patient care. As a result, a major characteristic of hospital supply chain is the simultaneous presence of external and internal chain. Stockless material management was an attempt to integrate these two supply chains. (Rivard-Royer, 2002).

Benefits of direct delivery

1. Reduction of inventory
2. Distributors take some of the hospitals' central stores duties
3. Staff and workload reduction
4. Higher level of service (Rivard-Royer, 2002)

Zhi & Shaligram (2007) conducted interviews while investigating logistic activities in eight of Singapore's 29 hospitals. They used four basic distribution methods in their interview.

1. Direct delivery to medical unit for use
2. Direct delivery to medical unit's storage for later use
3. Direct delivery to central warehouses, then delivery to medical unit for use
4. Direct delivery to central warehouse and then delivery to unit's storages

(Zhi, 2007).

As a result of their interview, Zhi & Shaligrim (2007) found out that direct delivery to medical unit for use, was used only in one hospital. Most hospitals had formed a supply chain where deliveries were received to central warehouses for distribution to medical units. As office equipment aren't fast moving items, it was discussed if they should be delivered direct for the units to use. This would reduce cost of storage and handling. (Zhi, 2007).

Piuva (2015) has viewed operating room logistics of Oulu University Hospital in her pro gradu -study, implementing Lean. She briefly discusses direct delivery from the operating room's point of view and states "Reception of goods in central warehouse is one of the busiest spots in the hospital, since items are received daily in large volume and frequency. In practice this means several small packages which need lots of time and precision during the receiving process." (Piuva, 2015). Otherwise the description about warehouse is outdated, since warehouse has moved away from the campus after the study has been completed.

Myllylä (2018) has used Lean tool Value Stream Mapping (VMS) in improvement activities of operating room material logistic, in his Master's Thesis for Oulu University Hospital. He has concluded that waiting is most common waste in health care processes. Challenges in value stream were found in different phases of his analysis. Some challenges were clear in the phase where he interviewed stakeholders of the value stream, and some during the analysis. Some challenges were seen as part of the process and weren't recognized as a targets of development even when there was room for it. (Myllylä, 2018).

It seems there is no wide variety of research done from the direct delivery's point of view alone. It is handled as part of different stock management and delivery models. There is also term "drop shipping" which has lots of similarities with the direct delivery, but the idea is built for more commercial set ups like business to people (B2P) marketing rather than public sector logistics.

Meaning of the term "direct delivery" seems to vary at times. In international research it usually points to a supply chain where hospital warehouse is not involved at all. When in Finnish literature concerning hospital logistics, it is used to describe a process where items needed are not in the stock. They are ordered only based on the needs of the customer and are delivered to hospital warehouse first. Different hybrid warehousing and delivery models are used in international literature to describe similar supply chains.

3 LEAN

3.1 Basics of Lean approach

Lean is an operating principle and perspective for smooth flow and standardizing work. It has collaborative approach between management and employees to identify and minimize waste activities that do not create value for the customers or other stakeholders. Lean supports continuous improvement and has great transformative potential when viewing operations in different work environments. (McGovern, 2019).

The approach is used to improve existing processes in line with Lean's core principle of removing unnecessary parts and processes activities - waste. According to the principle, the parts of the process that do not produce value are additional and should be removed. Lean aims to produce more efficient processes and improve on processes benefits. (Dahlgraad, 2006).

Andersson et.al. (2020) argues in the article “Exploring perceptions of Lean in the public sector” that Lean can be seen as a tool or mindset, because Lean retains diverse, parallel and competing perspectives. In public services, Lean is seen as a tool, which places it to problematic position. Missing awareness of Lean as a systematic mindset, creates applications that have the appearance of Lean, but represent other mindsets of how best to organize work instead. (Andersson, 2020).

A prompt demand for Lean in healthcare operations is growing, because it’s systematic approach to improving quality, safety and efficiency. When implementing Lean to hospital warehouse setting, the performance metrics such as distance, time, cost, or space, should be defined in the beginning. Evaluation of the implementation should be measured using standard scorecards or audit tools. (Venkateswaran, 2011).

3.2 Definition of a process

The term process is used in several different senses. In general, the concept of process refers to change, evolution, or a series of consecutive activities that occur at between baseline and the final situation. Processes can be used to describe what kind of steps should be performed and in which order to achieve the desired result. Simplified, the process consists of activities resources and output. These parts of the process involve the performance that makes the process functionality can be compared. (Laamanen, 2009).

Processes are described at several different levels. The purpose is to model multi-stage processes and make them easier to understand, analyze and develop. A good process description includes things that are critical to the process and presents different inter-dependencies between phases. A good process description gives clear overview of the process and helps those working on it to understand their own their role in the process as a whole and in achieving the objectives. (Laamanen, 2009).

3.3 Bottlenecks

Bottleneck (Image 1.) is a point where an operation meets or exceeds the capacity of the production. In that case, enough units cannot be manufactured fast enough to keep the rest of the production schedule or other daily operations flowing at the same rate. This problem needs to be identified, because bottlenecks are very dangerous from production time point of view. The analysis from the time operations point of view is important, when improving the process with Lean management. (Wolniak, 2018).

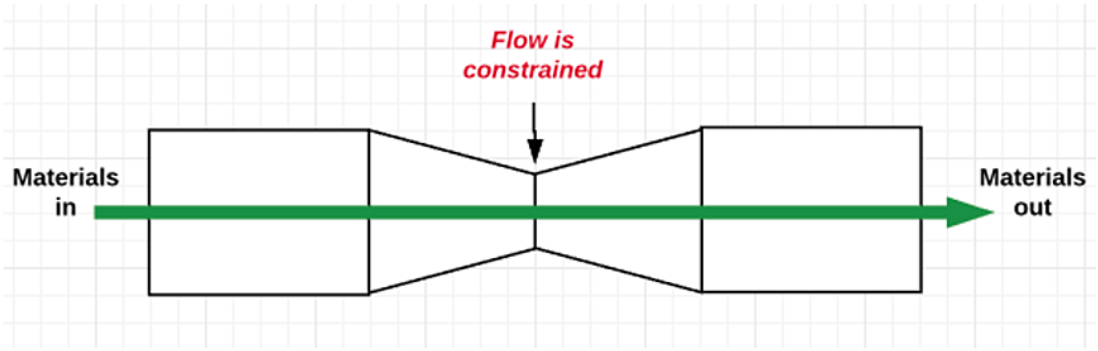


Image 1. Bottleneck. *(Anjoran, 2020).*

The processes in which the bottleneck phenomenon occurs have two typical features: queue is formed before the bottleneck and the post-process steps are not fully utilized because they have to wait for the previous process step to be completed, before the product or service can move forward. The bottleneck phenomenon is characterized by the fact that it cannot be removed, only be postponed. There are usually two types of causes of the bottleneck phenomenon: the steps in the process must be done in a certain order and variation within the process. (Modig, 2012).

3.4 Waste (Muda, Muri and Mura)

Smith (2014) talks about waste reduction by Lean in his article "Thinking Lean - Muda, Muri and Mura". Identifying and eliminating waste is one of the most talked about subjects when using lean methodology to solve company's performance defects. When looking things in big picture, reducing Mura and Muri helps to diminish Muda. (Smith, 2014).

Muda is most identified and known waste when discussing about Lean thinking. The idea is built around seven different wastes.

- **Defects** - product does not meet customers' expectation.
- **Extra processing** - nonvalue-adding steps are taken in the process.
- **Waiting** - process waits for materials, machines or manpower.
- **Transportation** - excess movement of product.
- **Inventory** - excess inventory caused by lack of pull in the production.
- **Personal motion** - motion waste of employees.
- **Overproduction** - producing more than the customer needs.

In some cases eight waste maybe added

- **Non-utilized workforce potential** - underuse of talent. (Smith, 2014)

Muri means overburden of people and processes, usually because the full potential is not used. That's why Muri is seen often to go hand in hand with 8th waste of Muda. One way to tackle this overburden is to standardize worker's tasks in order to gain more efficiency. Continuous improvement can also be hindered because of Muri, because overburden leads to situation where improvement ideas aren't shared with co-workers. Reduction of Muri is important, because Muri usually produces Muda. (Smith, 2014).

Mura can be defined as unevenness or inconsistency which created Muda. Way to deal with Mura is "heijunka" which can be also called "level loading". Aim of the heijunka is to make the process more predictable, since large variation in day-to-day demand makes it difficult to produce just in time. This allows individual employees to work more efficiently and reduces overburden. (Smith, 2014).

Relationship between these three categories can be seen clearly. Muda can be diminished by reducing Muri and Mura. "Overproduction is the most insidious form of Muda. If you have Mura in your system because you are not producing just-in-time -- you will be overproducing because your system is not working optimally. In fact, the existence of Mura in your system also causes Muri because work does not come through in smooth flow." Summarizes Smith (2014) at the end of his article. All three types of waste should be addressed, in order to get the best results. (Smith, 2014).

It is important to remember, that Lean activities can be categorized as value adding activity, necessary waste, and pure waste. When improving performance, value adding activity should be optimized, necessary waste minimized, and pure waste eliminated. (Hedman, 2010). Activities that don't bring value to customer are pure waste. Necessary waste is activity like keeping inventory and leftover materials from production. (Sakka, 2016).

3.5 Root cause analysis

Root cause analysis (later RCA) is a systematic process for identifying “root causes” of problems or events and responding to them. RCA is built on the idea that effective management requires more than “putting out fires” - they are prevented instead. Primary objective of using RCA is to analyze problems, in order to prevent their reoccurrence. RCA is performed most efficiently when accomplished over a systematic process with evidence backed up conclusions. (ABS Consulting, 2008).

Benefits of implementing RCA are for example:

- Identifying the causes of problems and barriers, so that permanent solutions could be recognized.
- Developing a rational approach to problem-solving, using data that already exists in the organization.
- Identifying current and future needs for improvement.

(ABS Consulting, 2008).

Root Cause Analysis is beneficial to businesses, but for some reason it is not used widely. Reasons may be in lack of resources or easy fixes that are used to bypass the problem. It should be remembered that RCA is not a solution to every situation. For example in events that occur rarely it is easier just fix the problem instead of using resources to make analysis. RCA should be targeted to problems that need permanent solution. Three easily identified cases where RCA is useful are

1. Big problems which have critical outcomes.
2. Incidents which don’t affect to the organization at the moment but may later cause serious problems. In this case the RCA is preventive action.
3. Large amount of similar incidents or problems.

(ABS Consulting, 2008).

In lean thinking there are different set of tools to execute root cause analysis. Most common being fishbone diagram, Pareto charts and “5 why” technique. These tools can be used individually or together. (Candy, 2018).

3.6 Fishbone diagram

Fishbone diagram (Image 2), also called Ishikawa, herringbone or cause and effect diagram is a visual way to demonstrate causes of a given effect in specific problem. It is best used when problem has several probable causes, and root cause needs to be identified. The diagram is good tool, when deciding what kind of data needs to be collected if further study of the problem is needed. (Hessing, 2016)

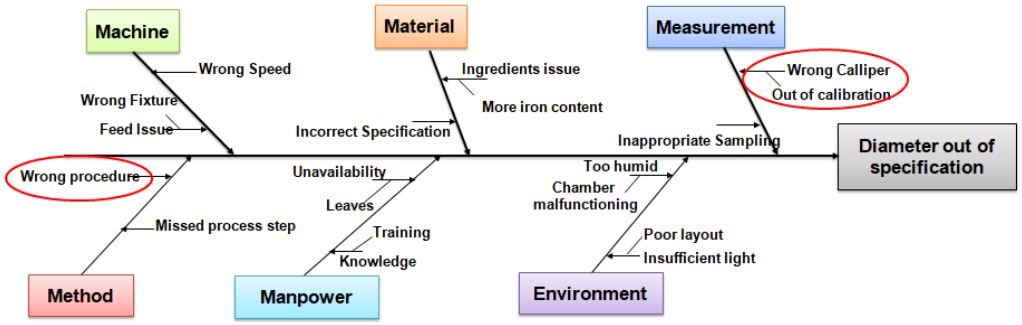


Image 2. Example of fishbone diagram. *(Hessing, 2016)*.

Fishbone diagram is easy to use, implement and understand. Other benefits are in its ability to foster teamwork and support brainstorming. The diagram focus on causes instead of jumping straight to solutions and leaving root cause to superficial level. (Hessing, 2016).

Steps of creating a fishbone diagram by (Hessing, 2016).

1. Identify the problem
2. Determine effect or problem
3. Identify major causes of the problem (6M)
    a. *Man/People* - Who is involved with the process?
    b. *Methods* - Policies, specific requirements, rules and procedures
    c. *Machines* - Equipment required to accomplish the task
    d. *Materials* - Raw materials, parts, perishable basic tools like pen, paper
    e. *Measurements* - Data generated and used in process
    f. *Milieu/Environment* - The working conditions like location, temperature, culture
4. Identify sub-causes
5. Analyze the diagram (Hessing, 2016)

3.7 5-whys technique

One of the most common ways to approach fishbone diagram, is Lean technique called 5-whys. The basis of this approach is to ask why five times whenever we find a problem. Repeating the why five times, nature of the problem as well as its solution becomes clear. (Card, 2017).

Card (2017) has taken critical view to 5-whys technique. He claims that problem with the technique is, that it oversimplifies the process of problem exploration to the point that it should not be used at all. It forces users down to a single analytical pathway with the problem, insists on a single root cause as the target for solutions and assumes that the 5^{th} why is fundamentally the most effective and efficient place to intervene. (Card, 2017).

Card (2017) also points out that more, or fewer, than five 'whys' may be required. It is also easy to approach the problem with biased view, which leads to a situation where different people get different results from the analysis of a same problem. He states that there is still place for 5-why technique, for example in accident investigation. (Card, 2017).

3.8 5S audits and Gemba walks

5s is meant to reduce waste and improve safety of the work environment by organizing the work environment, like summed up in Table 1. This is usually seen simply as cleaning, but 5s is built to help a workplace to remove unneeded items (sort), organize the items to improve efficiency and flow (straighten), clean the area in order to identify problems easily (shine), implement color coding and labels to have consistent areas and tools (standardize) and develop behaviors which keep the workplace organized (sustain). 5S audit is supported by audit form. (Richards, 2018).

Step Name	Japanese term	Explanation
Sort	Seiri (tidiness)	Remove unnecessary items from each area
Set In Order	Seiton (orderliness)	Organize and identify storage for efficient use
Shine	Seiso (cleanliness)	Clean and inspect regularly
Standardize	Seiketsu (standardization)	Incorporate 5S into standard operating procedures
Sustain	Shitsukse (discipline)	Assign responsibility, track progress, and continue the cycle

Table 1. The steps of 5S. (McFadden, 2021).

Gemba is Japanese word, meaning “the actual place”. Gemba walks are performed by managers of the workplace. It is a management technique that allows managers to stay in touch and observe everything that is going on in the place of work, connect team goals with strategy of the organization, instill discipline and hear employees. It gives opportunity for employees to talk to with the managers and address problems that are not solved. (Boca, 2015).

4 WAREHOUSE OPERATIONS

4.1 Warehouse processes

Receiving starts the warehouse process. When done properly, the warehouse should be able to verify that it has received the right product, in the right quantity, in the right condition, and at the right time. (Sunol, 2021). The most ideal way to receive products is via Advance Shipping Notice (ASN) from a supplier. If the delivery matches the ASN, then goods can be received to the system. Some systems allow goods to be received into inventory at this point, when other systems require the goods to be delivered to a specific stock location before inventory is updated. (Walker, 2018).

Put-away is the second warehouse process and means movement of goods from the receiving dock to the most optimal warehouse storage location (Sunol, 2021). Properly built ERP or Warehouse Management System (WMS) will note a put-away staff that stock is waiting to be transported to a storage location. Identification of goods and its stock location is usually done by scanning a barcode or manually. (Walker, 2018).

Picking is the process that collects products to fulfill customer orders (Sunol, 2021). When orders are received, it is common for them to be released either in ‘real-time’ or in ‘waves’. Real-time orders are downloaded as they are received. Orders are accumulated for specific picking times and transport routes are called ‘waves’. (Walker, 2018).

Packing process combines picked items in a sales order and prepares them for shipment. Main task of packing is to make sure that damages to the product are minimized. Packaging must be also light enough to control weight and packaging costs. (Sunol, 2021). Packaging phase also adds traceability to the shipment. (Walker, 2018).

Shipping or dispatching finalizes the warehouse process by starting the journey of goods from the warehouse to a customer. Shipping is considered successful only if the right order is sorted and loaded, dispatched to the right customer, travels through the right transit mode, is delivered safely and on time. (Sunol, 2021).

4.2 Measuring current performance

Measuring the process gives information about level of performance, how to add value and inspect which processes need to be simplified. Before change can be implemented in a supply chain, it needs to be known how well it is performing. (Sadler, 2007).

Harrison et al. (2007) suggests to ask three key questions, when measuring supply chain performance.

- How do we meet the customer's target?
- How good are we compared to the competition?
- Is our performance getting better or worse? (Harrison, 2019).

The result obtained from the performance measurements is a sum of several variables. That is why people have difficulties to relate the effects of their own actions to the results obtained. This makes development more challenging. (Laamanen, 2009).

When measuring the performance of processes, it can be broken down and focused on a specific part of certain activity. Laamanen (2009) uses as an example the division into time, boundaries, quantities, physical properties, and stakeholder's views. However, when measuring the performance of an organization's processes it is important to choose only a few indicators for the main task of the process, instead of choosing several non-relevant metrics. (Laamanen, 2009).

4.3 Central warehouse of Oulu University Hospital

The central warehouse handles the ordering of patient care supplies and general materials from the supplier, storing and shipping to customers according to orders. General supplies include i.e. office and cleaning supplies. Patient care supplies include a variety of disposable supplies and instruments needed to care for patients. (Niemi, 2016).

The most commonly used supplies are stored in pallets and shelfs. In stock deliveries, supplies are picked from stock according to customer orders. This ensures fast delivery and savings on items ordered on larger procurement lots. (Niemi, 2016).

5 DIRECT DELIVERY

5.1 Current situation

At the moment, efficiency and quality-goals of the direct delivery services do not meet. The goal is to have common items delivered to customers in 36 hours from inbound. Internal goal is to have fast track items delivered in 24 hours from inbound. In current situation, a common item may be waiting for five days before delivery. This is why warehouse has started a project (Image 3) to improve the inbound and direct delivery services. (Savela & Valtanen, 2021).

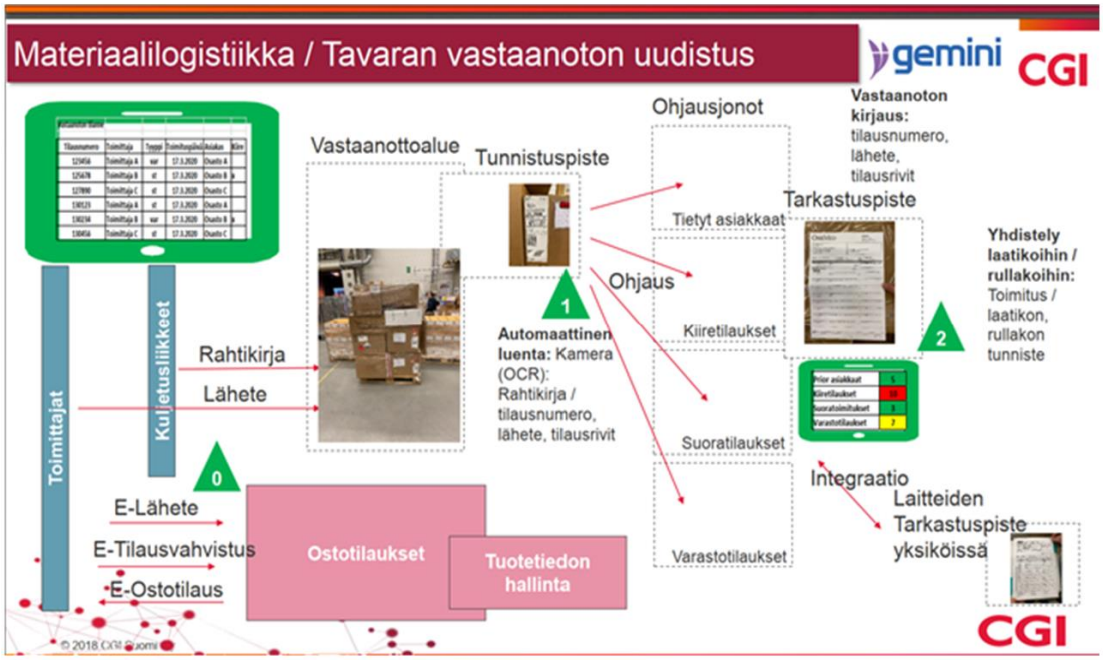


Image 3. Project plan chart. *(CGI Suomi, 2018).*

Direct delivery department is getting new workspace in the current location during autumn 2021, this makes timing of the thesis ideal. It is easier to take development needs under consideration in new space, since current work area has its own limits like height of the roof, closeness of the docks and long and narrow floor plan that leads to greater walking distances.

While the warehouse has good resources, they aren't being used effectively. There is more potential to improve timeliness of the deliveries, but right tools need to be identified.

5.2 Delivery setting

In direct delivery there are 10 different, pre-labelled collector trolleys for the items that are waiting for delivery to OYS. For example, K, L, N, S and AHT (G in map) like shown in Image 4. Naming of the trolleys is based on address system of the hospital like presented in Image 5. In addition, there is mixed trolley for places that do not have internal address or own trolley, and "private trolleys" for operative units that consume a lot of items in large amounts.

Image 4. Pre-Labelled collector trolleys.

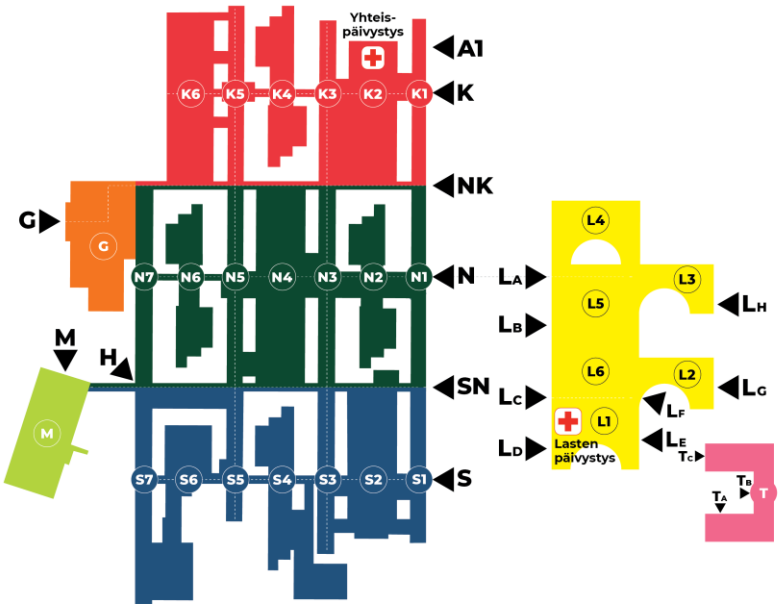


Image 5. Map of Oulu University Hospital. *(OYS, 2021).*

The trolleys are delivered from warehouse to hospital terminal at S-building (Image 3). Deliveries are sorted and shared between internal messengers and hospital logistics (hoitologistikko), depending on the destination. Hospital logistics unpack the items and deliver them to the shelf of the ordering unit. Pallet deliveries are rare, and they are usually delivered directly to the receiver by the delivery company driving between hospital and the warehouse. This kind of items are for example furniture and 200-liter barrels of detergent used by industrial washing machines in equipment maintenance and hospital kitchen. Truck delivery inside the hospital is also possible.

Outside customers are outlined from the thesis, but it is important to remember that OYS is not only customer of the warehouse and direct delivery. According to statistical data, 19.6% of the direct deliveries went to outside customers like health centers and schools in 2020 (PPSHP, Database , 2021). In the direct delivery process that OYS is using, receiving and delivery are done on the same sitting.

Successful receiving creates basis for effective activities in the warehouse and supply chain. Good skills in teamwork, item identification and avoiding mistakes are key skills when handling deliveries. Effective operation requires the ability to perform and manage work methods in accordance with the instructions. (Hokkanen & Virtanen, 2013)

5.3 Employee tasks

Direct deliveries are handled by team of 4-5 employees. Warehouse is open from 7am to 3pm during weekdays. Items are delivered to OYS in 9 departures during day by Delivery Company and hospitals own driver. First departure being 8:30am and last 4pm. Customers outside OYS have 1-2 deliveries in week.

Timetable (Image 6) in direct delivery shows different tasks and roles between the workers. These roles and tasks are rotated weekly and are tied to inbounded pallet types. Person working in receiving identifies deliveries and sorts them to their own pallets.

Employee / Week	22	23	24	25	26
VK	Urgent and mixed	OR	Mixed and recycling	Urgent and mixed	Supplier and cold packages
KH	OR	Mixed and recycling	Urgent and mixed	Supplier and cold packages	Urgent and mixed
TP	Mixed and recycling	Urgent and mixed	Supplier and cold packages	Urgent and mixed	ABSENT
MK	ABSENT	ABSENT	ABSENT	ABSENT	OR
EK	Warehouse inbound	Warehouse inbound	Warehouse inbound	Warehouse inbound	Warehouse inbound
RV	Urgent and mixed	Supplier and cold packages	Urgent and mixed	OR	Mixed and recycling
KM	Receiving	Receiving	Receiving	Receiving	Receiving
MV	Supplier and cold packages	Urgent and mixed	OR	Mixed and recycling	Urgent and mixed
JS	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT

Image 6. Example of timetable for people working with inbound and direct delivery. *(PPSHP, Shift Database, 2021).*

There are three different kind of inbounded pallets (Image 7):

- *Mixed pallets*. Pallet full of different sized parcels from different suppliers and delivery companies. It is common that one item or item type goes to one customer. One parcel may contain dozens of different items or only one item. Deliveries are opened and repacked. Items ready to be shipped are placed to collector trolleys or pallets which have assigned destination.
- *Supplier pallets*. Whole pallet comes from one supplier. There may be mixed cartons, but most of the time items are in factory packages and can be sent in those packages without need of unpacking and repacking. There are usually large amount of items going to one recipient, so in most of the cases they are sent out in their own trolleys or pallets.
- *Operating Room (OR) pallets*. Pallet with items that go to ORs. Aim is, that in delivery there is no excess packing material ("brown cardboard") sent in to the hospital with the items. Items are placed in plastic boxes that rotate between hospital and the warehouse. For example Central OR theaters 1-6 go to one box and 7-12 to another box. Boxes are loaded to their own trolley.

Image 7. Different pallet types queuing in front of the work stations.

Additional pre-assigned tasks include handling of cold packages and urgent requests, delivering full marked trolleys and pallets to shipping line, taking cardboards to the press machine and opening dock's door to delivery drivers.

Every employer needs to also take care of their personal workstation (Image 8) by taking out trash, resupplying items needed and filing the delivery lists of the day to their personal folders. In defect analysis cases, they work together with supervisors of the warehouse and customers to solve the situation. Usually, the communication is done via e-mails.

Image 8. Two workstations side by side.

5.4 Process description

5.4.1 Phases of the direct delivery process

Fetch a pallet	- Take empty pallet out and new pallet in - Prioritize most urgent pallet (first one in, first one out)
Choose package	- Take (small) packages to the workstation - Inspect for damage, address label and package list placing

Open	- Find package list, located in a pocket outside the package or inside package with the items - Take out fillings
Order number	- Identify internal order number from the package list - Circle the number with a pen - Type order number to Gemini and open order to the screen
Cross check	- Items, amounts and reference numbers (REF) - Package list - Gemini - Check internal messages from Gemini if available - Sign the delivery note with date and initials
Type info to Gemini	- Number of items received - Delivery note number from package list - Internal message if needed
Print	- “Make receiving” button in Gemini - Print out internal delivery note to paper - Print out address label if needed - Queue and fix label printer issues if needed
Pack	- Choose right type of delivery box or envelope - Insert item in the box and fillings if needed - Place internal delivery note to the box - Close the box with tape or attach delivery note to the item with film if box is not needed - Attach address label, write address on the box, or circle the delivery address from the delivery note - Place delivery to its collector trolley or pallet

Quality event note	- Made if there is package damage or there is deviation during cross checking - Create “quality event” note to the Gemini - Send e-mail to person who handles the defect analysis, describing the problem and important numbers tied to the delivery. For example, reference numbers, order numbers and delivery note number. - Place delivery note to a blue folder - Mark item with post-it note that has internal order number, date and your initials. Move item aside. - After the defect analysis is handled, resume with the process if possible

5.4.2 Process diagram

According to my perception and rough process description by Niemi (2016), direct delivery process was mapped (Image 9 / Appendix 6) at the beginning of this project. Each of the employees have their own, personal way to work. Most common way is to cross check all the items from one package at once, and after that repeat rest of the process as many times as needed. When the items are packed, all the deliveries are taken to the trolleys at once.

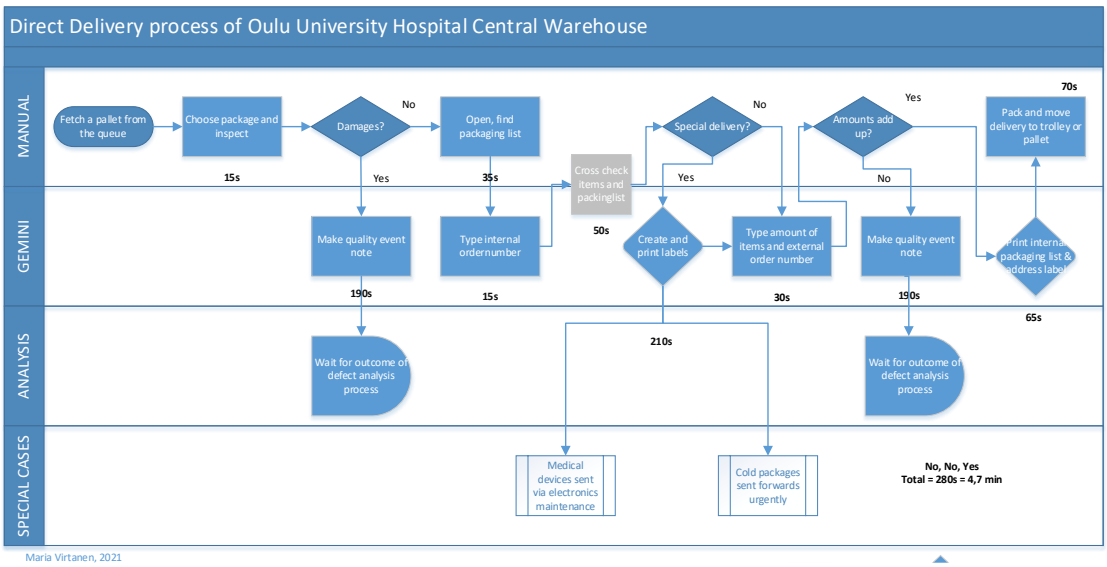


Image 9. Process map of direct delivery

5.4.3 Characteristics of different pallet types

Handling different pallet types have their own characteristics which leads employees having varying performance numbers depending on their task (Appendix 1). For example, work experience and walking distance from workstation to printer have shaped employee's way to manage their daily tasks.

OR pallets are fastest to go through, since most of the items don't require packing or printing address labels. Instead, items are placed to plastic transportation box with their delivery note. Smaller items like orthopedic screws, are placed to zip lock plastic bag with the delivery note, as a way to keep the order checking more manageable for the receiver. Because OR pallets are most urgent pallets and they are fast track items, person handling these items does not have other time-consuming tasks to handle.

Supplier pallets have usually the slowest items to manage. Commonly the packages are big or there are several smaller packages of same item, which need to be loaded to their own delivery trolley. Some parcels need to be unloaded in order to prevent sending the excess cardboards to the hospital. Handling one order line might take up to 15 minutes. It is also very common that part of the delivery goes to the warehouse, and direct delivery person sorts out their own items from the pallet first, before moving remaining items to the warehouse inbound.

Mixed pallets are usually handled by three people, since they are most common pallet type. The items may belong to external or internal customers. Size, amount of items and their types vary the most within the pallet types. Most of the items need to be repacked, resulting high time consumption.

6 IMPLEMENTATION OF LEAN TO THE DIRECT DELIVERY

6.1 Identifying value

Identifying value is the first step of Lean thinking. It needs to be described from the point of view of the customer, since it does not matter how good processes and materials there are, if customer does not feel it has value for them. That's why it is important to specify what the customer sees as value. (Sadler, 2007).

Even when the competition is not a huge factor in the warehouse, identifying value is still a base of the process. Customers, in this case all the different departments of OYS, still want value for the money they spend. For the direct delivery these values are for example service promises about delivery times, accuracy of the deliveries (right items to right place) and delivering undamaged items.

Logistics is most important support function in the hospital environment, since it affects to the availability of supplies. To build effective supply chain services, needs of customers should be identified. Optimizing logistic services provides added value into main goals of medical care. (Kriegel & Jehle, 2013).

6.2 Mapping the value stream

Value stream is group of operations, which are needed before product or service is ready to be sold for the customer. Visualizing these operations is called value stream mapping, and it is good tool when inspecting different types of waste. (Sadler, 2007).

The value stream mapping template (Image 10) was created in order to outline the whole process that direct delivery items go through. Material flow in and out of the warehouse is constant, but different materials tied to their pallet types have different lead times and value-added times (Appendix 1). In order to keep the focus of the thesis on the right tracks, mapping was done on estimated times and averages instead of getting accurate time measurements.

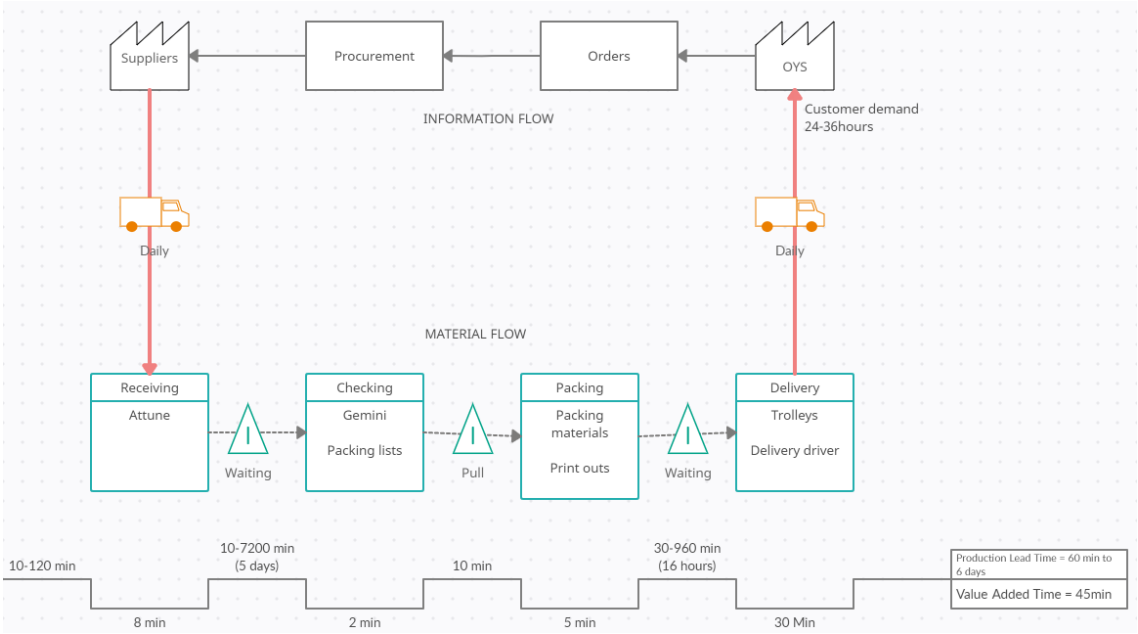


Image 10. Value Stream Mapping for direct delivery.

In the value steam map (Image 10.) bottlenecks are seen before and after the core process of direct delivery, checking and packing items. First bottle neck is visible as large number of pallets in queue. This queue might be several days long for OR and supplier pallets. After the core process is done, items ready to be delivered are waiting a delivery at second queue in collector trolley.

First bottleneck can be minimized by developing the core direct delivery process. Second bottleneck can be also helped with better efficiency. More efficient process fills up the trolleys quicker, which means they can be sent forwards at faster rate. Filled up trolley waits for the delivery from 15 minutes to 1.5 hours during opening hours of the warehouse. There is 18.5-hour gap between deliveries, when the warehouse is closed since first delivery leaves 8:30am and last call for direct delivery trolleys leaves 1pm. Last ride for urgent packages leaves 4pm.

6.3 Creating the flow

The flow is created when operations are moved away from process that contains waiting or queueing in different phases and between them. Flow requires focus on the specific order, ignoring the traditional restrictions of the operations, and changing work practices to eliminate backflows, scrap and stoppages of all sorts so that the design, order and manufacturing of the specific product can proceed uninterrupted. (Sadler, 2007).

Several tools were used to detect the waste in the direct delivery. First the process was mapped, described and timed as accurately as possible (Image 9). After that, the fishbone diagram (Image 11 / Appendix 7) and 6M was used together to identify and categorize the waste.

The fishbone diagram demonstrates that especially machines, materials and milieu caused waste. Malfunctioning and overloaded printing operations play a big role in waste, followed by amount of walking needed during the process and noisy environment. It was also noted that several packages were sent to same place during the same day, which causes unnecessary repetition of the process.

When using 5-whys technique to support fishbone diagram, in many cases root causes tend to go into causes that can't be reached with this thesis. They are tied to the limitations of budget, Gemini's administration and building. If we look for example noise and echo in Milieu. Why there is noise and echo? The working space is next to the loading docks. 2nd Why? There is no room for direct delivery elsewhere? 3rd Why? The space is designed for different kind of warehousing. 4th Why? This is temporary space. 5th Why? The warehouse gets brand new building in OYS2030 project. Instead it should be investigated, how the problem can be eased in the current situation. Noise cancellation headphones are offered by the employer. Another way could be coating the metallic flap of the dock with rubber.

Discussion with direct delivery staff was used to back up the findings. Three main issues the staff mentioned were 1) noise and echo of the work space which can't be

shut out even with anti-noise headsets, 2) issues related to printing such as dysfunctional label printer, queuing at printer, typing username and password when taking a copy and long walking distance to printers from certain work stations and 3) Issues related to Gemini such as unnecessary information the program provides and amount of clicks while closing different pop-up windows during receiving.

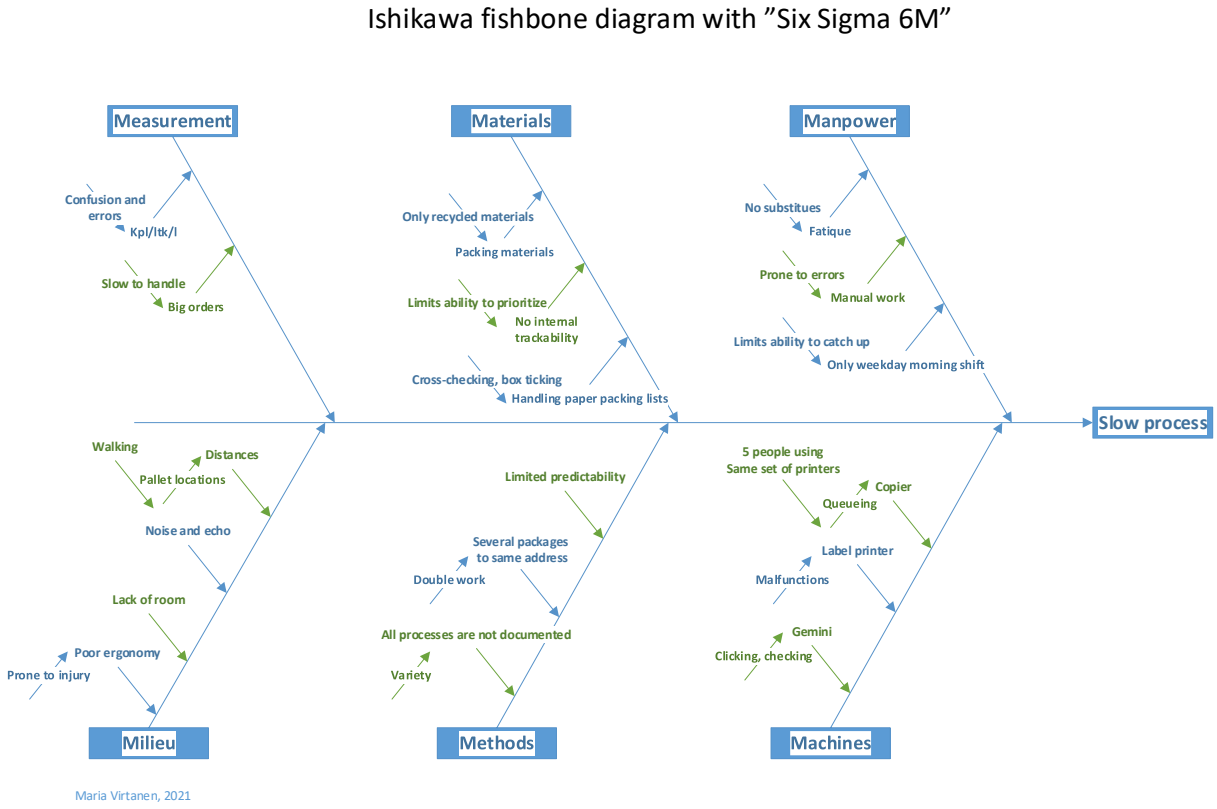


Image 11. Fishbone diagram of direct delivery.

6.4 Establishing pull

When talking about pull, it means that process is ongoing only when needed. This is based on customer needs - what do they want and when. In practice it means the customer is pulling the products and services as they need them, instead of pushing products to the customer despites their needs. (Sadler, 2007).

The queue system has been already implemented to direct delivery. The workflow is enough to present a pull, since stream of incoming items is steady during most of the day and every pallet and parcel there is on the queue, needs to be handled and there is

no minimum queue time for them. Therefor overproducing the end product - items ready to be shipped, is not an issue.

6.5 Continuous improvement

The final goal of lean management is to constantly improve every process. When you add in transparency, allowing all supply chain stakeholders to see everything along the chain, it is easy to discover better ways to create value. (Sadler, 2007).

At the moment main event to propose improvements has been during different team meetings. Benchmarking, finding new research regarding direct delivery and visits to other warehouses and expos have been identified as a way to find new ideas. 5S audits and Gemba walks are good way to maintain the new developments and seek things that need more improvement, and they have significant influence on organization activity (Boca, 2015).

7 RESULTS

7.1 Findings and analysis

7.1.1 Measuring process time consumption

It is clear that there was need for closer look of the direct delivery process. The root cause analysis and information gathered from different databases (Appendix 1-2) gives the evidence, that resources are sufficient, but there are leaks in the process.

Measuring operations was challenging, and it was hard to get definite times because of varying number of lines per delivery, personal work approaches and different characteristics of pallet types. How to perform the measuring and analyzing the results, was discussed on several occasions with warehouse management.

Measuring was done on five separate days, on four different employees (A-D) with different work histories in the direct delivery. Average of those measurements has been calculated and presented in Table 2. It can be seen from the table, that employees B and C have several years of experience from direct delivery, so they work faster. Supplier pallet was excluded from the time measurements, after discussion with warehouse management, because there is no standard type of delivery for that pallet type, and it is accepted that handling them takes a lot of time.

	Choose	Open	Identify	Crosscheck	Type	Print	Pack	Total
Mix / A	22	24	23	49	30	57	71	275
Mix / B	16	35	19	34	26	55	55	240
OR / C	7	34	9	49	32	91	43	265
OR / D	9	51	9	77	46	47	102	341
Average	14	36	15	52	33	62	68	280
Rounding to process chart	15	35	15	50	30	65	70	280

Table 2. Results of measuring time consumption.

It was concluded that average time for handling one delivery takes 280 seconds (4.7 minutes) from choosing the package from the pallet to a point the employee is ready to start the process again. Most time-consuming duties were in the end of the process; printing and packing (Image 12).

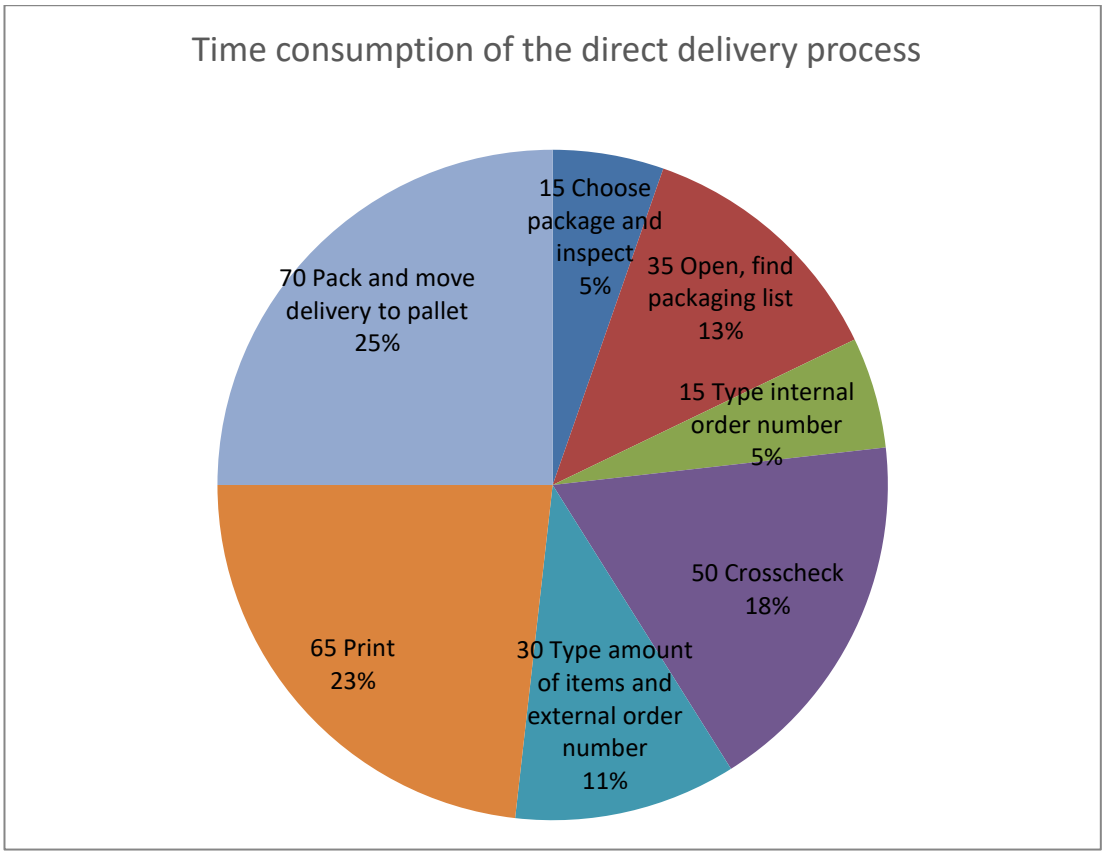


Image 12. Time consumption of the direct delivery process.

Measuring the time consumption included activities like time spent queuing at the printer or asking advice from a colleague. One delivery has average of 2.3 lines (Appendix 1). If we exclude lunch and coffee break from the workhours (7h 20min = 440 hours = 26 400 s), one person should handle (26 400s / 280s = 94) 94 deliveries or (94 x 2.3 = 216) 216 lines in one shift. Meaning 470 deliveries or 1080 lines in week. (PPSHP, Database , 2021).

Because of the additional tasks, special cases and time spent to colleague support, this is not possible. Even for experienced employee's weekly efficiency varies a lot, depending on pallet type they are handling. Highest number of lines handled in 2021 so far is 1046 lines in week by experienced employee working with OR pallet.

Accomplishing the measurements was a great chance to inspect how the work is done. Despite the challenges, this gave a good idea about the process leaks. It was easy to conclude, that end part of the process consumes time more than acceptable, and it requires action from the management.

7.1.2 Interviews with the direct delivery staff

Discussion with the direct delivery staff supported these findings. They felt that printing operations are most time consuming and also frustrating part of the process. Label printer is not functioning correctly, which leads to the situation where everyone needs to pay attention that they remove the label correctly or the printer malfunctions. Because several people are printing their packing lists to same set of printers, printing work gets mixed, and this causes waiting on the printer. Usually, one person takes the stack of lists and separates them for the people who are queueing for their print outs.

It was also stated that people aren't satisfied to the programs they are using.

- To get receiving and printing done for one line, it may require as much as 16 clicks in the program.
- Direct delivery personnel receive a lot of information that is meant for procurement, and this causes most of the excess clicks.
- In some parts employees need to check texts from the field that is shared with procurement. Information is written by procurement personnel or is picked from the order information typed by the customer. Separate field for direct delivery would eliminate these unnecessary clicks.
- Program lacks automation in the printing process. In the current situation the employee needs to print each package list individually and after the printing, each list needs to be closed individually. Even when they do the receiving for several deliveries at one click.
- The program also gives notice about typos in the receiving after the program has registered it. If the notice would be given before registration, correction would take only few seconds, but in the current situation the employee needs to make more time-consuming corrections to billing information.

Work environment is seen as a vast stress factor, by the employees, and they feel that this stress affects to their efficiency. Closeness of the docks causes temperature issues and noise pollution when the trucks are loaded and unloaded. Tight workspace is also limiting the efficiency. Handling paper packaging lists is seen old fashioned and time consuming amongst the employees.

Quality of work in reception of goods was seen to have influence to the effectivity. When the pallets are sorted out and built correctly, it increases efficiency. It is easier to find deliveries that have multiple parcels and well-built parcel towers are safe to handle.

7.1.3 5-why analysis of bottlenecks

After finding the biggest bottlenecks - packing and printing, 5 why analysis was made of them (Appendix 4 & 5) to find the root causes. It came true, what Card (2017) pointed out in his article regarding problems of this technique. There were several causes to these problems and following only one path of "whys" would not give good overall picture of the situation.

It is clear that the root cause may be found before the 5th "why" or five questions are not enough to find answers. In printing issues (Appendix 4) 5 whys was not enough to reach satisfying answer to problems caused by software. It would be impossible to find those answers without more knowledge about the procurement process and limitations of the software. In the other hand with printer problem root cause was found in 3rd why, but how to make justification to get the second set of printers can be found from 5th why.

Common factors in the two different analyses were savings and circumstances where working space and tools used are not adjusted to the needs of the direct delivery. Some of these factors are tolerable, because new space for the warehouse is being built in the future. Findings of this work should be used as one aspect, when planning operations in the new building and optimizing work in there.

7.1.4 Results of root cause analysis

Problem	Root cause	Solution
Slow printing process	Policies created for patient care are used in warehouse. This has affected to number of printers installed to direct delivery.	Request an exemption from IT-services to get another set of printers, since need for them is greater compared to patient care units.
	Gemini is slow to use because the number of clicks needed to make the receiving. The software is not fine-tuned to warehouse needs.	Request amends to Gemini from software developers. Assign strategy and budget to the process.
Slow packing process	Finding suitable packing materials is time consuming.	Purchase of tools which make the process more efficient and uniform.
	Long walking distance between different operations, i.e., outbound pallets and getting supplies from warehouse.	Reorganization of current operations to more time efficient. Warehouse layout planning in new workspace and OYS2030 hospital.

Table 3. Results of root cause analysis.

5-why analysis was used to find root causes of the waste in printing and packing, like shown in Table 3.

7.1.5 Other factors to consider

It is clear, that direct delivery is very vulnerable to disruptions. There is not much back up available if someone gets sick or there is peak in deliveries. In addition, the station has lost three long term, reliable employees during past year. When browsing personal efficiency data, it is evident and understandable that long term employees are more efficient than new employees.

Another noticeable factor is, that the warehouse management is not in control of the whole delivery process, even when they take responsibility of it. Control ends when the delivery leaves the warehouse. Like seen in realization data (Appendix 2), items that are handled during the evening are waiting overnight in the warehouse, because there is no more deliveries leaving to the hospital.

The logistics in hospital have their own timetables for their delivery rounds, so even if the delivery would leave later, there would not be personnel to transport it to the receiver. For this reason, revision of the service promise would be reasonable.

Not having reliable documentation of errors is an issue, which prevents side by side comparison of accuracy and efficiency. Therefore, one important piece is missing, when trying to define “sweet spot” in the production and calculating the sigma. When efficiency rises above certain spot, occurrence of errors tends to increase.

7.2 Solutions and improvements

7.2.1 Implemented changes

First measure to keep up flow, was eliminating the waste that came from material filling. Before the changes everyone was filling their own stations when they ran out of materials. This meant looking for the material from the shelves which are located in opposite side of the warehouse and making internal purchase for the materials. Finding the actual item is based on memory or to a search from Gemini database.

To make the change, a list of most common used items (Appendix 3) was made. The list includes item name, identification number that is needed in internal order and shelf place. From now on, every Monday morning, one employee goes and fetches the items that are running out to a direct delivery refill shelf and handles the internal order. They also fill up paper to the printer, no matter if it is empty, since printer running out of paper paralyzes the whole direct delivery until the printer is refilled. This task is added to the timetable.

Another measure taken in waste tackling was to inspect basic tools used and find out if they need replacement or update. Such as tape cutters, knifes and staplers. One broken electric table has been also replaced. Also, another set of printers has been requested from the IT services.

In order to maintain pull on slower days, the timetable was modified slightly. In the modification the tasks for each person were prioritized. If there is a case where the employer does not have their assigned pallet type to handle, they have clear instruction what to do while waiting for the primary work to be available.

7.2.2 Equipment and software

Since the direct delivery is getting new workspace during the autumn, it offers good potential to implement improvements and reorganize work. To tackle end of the process problems, it is evident that some investments to new equipment would improve the situation a lot. Adding another pair of printers would shorten walking distances between printer and personal workstation. It would also unravel the queueing problem on the printer. In the current situation 4-6 people are using the same set of printers.

WaveWrap® packing machine (Image 13) could be solution for some of the packing problems. Packing does not need filling or taping, and it excludes finding a fitting package from recycled ones from the process. (Boxon, 2021).

Image 13. Wavewrap®. (Boxon, 2021).

Cyklop® half-automatic pallet wrapper (Image 14) would speed up and improve ergonomics of outbound pallet handling (Cyklop, 2019). Both of these equipment would benefit also pickers of the warehouse.

Image 14. Cyklop®. *(Cyklop, 2019)*.

Changes to Gemini would be beneficial, but in the end, they are in hands of CGI who maintains the software. Some changes have been requested prior this project but declined by the company. Reducing the clicks and adding automation to the printing, would remove significant amount of the waste.

7.2.3 Changes in activities

Current training for new direct delivery employees lacks a structure. Kuismanen (2015) concluded in her thesis that training is in key role, when improving effectiveness of a warehouse. This was shown in both, the results of customer questionnaire and employee interviews. From employee's point of view, the biggest need was in software training. Customers hoped that the employees would have better knowledge about product groups they are handling. This would improve customer service and cut errors in the process. Also, customers were eager to get more training about the order placing software. (Kuismanen, 2015).

To motivate the continuous improvement training, the work process and environment needs attention from supervisors and use of Lean tools. 5S audits and Gemba walks are tools related to Lean. In her article about these two management tools, Boca (2015) states that "The job of a manager is to manage, and one cannot manage if they are not engaged in the work and with the people who do the work." (Boca, 2015). 5S and Gemba should be implemented to the routines of warehouse management.

López-Fresno (2012) sums up Lean principles in her article. She states that employees can be strong allies and supports employee involvement in development process. One benefit of Lean in her article is, that it implies all employees to continuous improvement. (López-Fresno, 2012). Work-counselling is widely used concept in Finland. It is an established work method that promotes work-related learning and develops the organization's operations. (Riitaoja, 2008). This tool would be ideal to build and maintain culture continuous improvement.

Hospital district has their own rewarding system called “Säpäkkä”, to improve motivation of the employees (Pohjois-Pohjanmaan Sairaanhoitopiiri, 2021). It allows supervisors to give monetary reward for employees who perform well. Säpäkkä has been used in some cases, but its suitability to reward well performing employees should be reconsidered.

7.3 Further research

If the warehouse management ends up test using the WaveWrap® packing machine, efficiency, actual costs within customer and employee satisfaction should be looked up more closely. In addition, it could be beneficial to benchmark the companies that already use the machine.

To soften the disturbance sensitivity could benefit from research and analyze of bullwhip effect regarding the direct delivery. At the moment there is data available to forecast peaks in the deliveries, but it is not analyzed.

Building form and standardization for 5S audits and Gemba walks to support environment of continuous improvement. 5s Gemba walks would enhance communication between management and employees. 5S audits would support inspecting safety issues and help dividing the responsibility about safety with warehouse employees. In 5S audits, use of template is recommended. Creating this template would be good topic for thesis work.

Synchronizing the internal supply chain between direct delivery and schedule of hospital logistics like internal transportation and hospital logistics who unload the boxes to shelfs, would need a closer look. Good synchronization would help to improve the lead times of the internal supply chain. At the moment different operators are creating their own timetables independently.

8 CONCLUSIONS

The direct delivery project has been interesting and helped me develop my own skills in project management and independent work. Working in reception and as a direct delivery employee prior the project gave me a good view to the basic work in the warehouse, which helped me a lot while working with the thesis. It also gave me a chance to connect with the direct delivery employees, and this trust gained had only positive impacts while accomplishing the interviews and measurements.

Direct delivery employees and warehouse management are very keen to develop their work environment, and they were actively taking part to the project by bringing up the issues they have noticed and discussing about possible solutions. They also welcomed the "outside view" and educational knowledge that the thesis work gave to the project.

Detecting and eliminating waste was in main role, when pursuing answers to the research question and aims. These improvements were aiming to shorten the lead time in direct delivery, so that the equipment needed in the patient care would be better available. This improves patient care, by enabling more consistent treatment when all items needed are in stock all the time. Health care professionals are this way able to seek best solution for the individual they are treating for example in case on wound care.

Being part of big, public organization has casted its limitations to the warehouse operations and direct delivery. The budgets are tight, and some things get lost into organizational rules which work in patient care environment but are not fit to the warehouse. Despite these limitations, there is lots of opportunities to develop the process. Even the limitations are bendable if there are enough arguments to support the change.

For example, root cause for the printing problem was found from these rules. The hospital district has a tool to calculate need of printers and every unit gets printers based on these calculations. National trend in patient care is to have "paperless hospital", so need of printers is decreasing. This tool is viable to most part of the hospital, but not to warehouse because the process does not support electronic packing lists yet. Getting

another set of printers to direct delivery required an application with heavy set of arguments, why the hospital district should make exception in this case. Since there was valid reasons to make this exception, second printer was granted.

Internal and external supply chains are connected by direct delivery. It is clear that both chains affect their work and that's why the cooperation with these stakeholders should be reinforced in order to develop the whole process. Root causes for certain problems can be solved only by teaming up with suppliers and customers.
It would be important to recognize key players from the stakeholders. This way right people would communicate with each other, when development needs are noticed.

For example, most common mistakes happen because of inconsistent understanding concerning order unit. Warehouse is handling order unit as single pieces or items, but customer may order, or supplier deliver the item as packages. Liquid products like detergent may be handled in litres or as one canister no matter how many litres of liquid the canister has. These misunderstandings employ procurement and warehouse management on daily basis.

The name direct delivery has also been discussed, is it representational enough for the internal customer. Part of the workload comes from the orders, which could be fulfilled from warehouse's shelf products. It has been thought by the customers, that "direct delivery" is some kind of fast route to get items. The false idea has been formed at least partly because the order software does not guide the customer enough when choosing the delivery type. Inventory management problems caused by the pandemic has heightened the situation.

The pandemic has also caused limitations to work rotation between warehouse and hospital logistics. Rotation would give understanding of the internal supply chain for its counterparts. This will open new doors to develop the whole process to serve the end customers - patients better. To achieve this, culture of continuous improvement and open communication should be maintained and supported. The new team leader position established and filled in warehouse management during the spring 2021, has been a good investment from the point of view process development.

REFERENCES

ABS Consulting. (2008). *Root Cause Analysis Handbook: A Guide to Efficient and Effectice Incident investigation.* Brookfield: Rothstein Associates Inc.

Andersson, G. e. (2020). Exploring perceptions of Lean in the public sector. *Public Money & Management*, p. https://doi.org/10.1080/09540962.2020.1847454.

Anjoran, R. (2020, June 10). *How to Avoid Production Bottlenecks with Lean Methods and Tools*. Retrieved from https://www.cmc-consultants.com/blog/how-to-avoid-bottlenecks-in-production-with-lean-methods-and-tools

Boca, G. D. (2015). The Gemba Walk – A Tool For Management and Leadership. *Ovidius" University Annals, Economic Sciences Series, Volume XV, Issue 1 /2015*, 450-456.

Boxon. (2021, July 13). *WAVEWRAP® -pakkaus säästää luontoa ja rahaa*. Retrieved from https://www.boxon.fi/ajankohtaista/wavewrap-pakkaus/

Candy, L. (2018, October 29). *Lean Tools for Root Cause Analysis: Fix your Processes for Good with this Resource Guide*. Retrieved from Leanopedia: https://leanopedia.com/lean-tools-for-root-cause-analysis/

Card, A. (2017). The problem with '5 whys' . *BMJ Quality & Safety 2017;26:*, 671-677.

CGI Suomi. (2018). Materiaalilogistiikka / Tavaran vastaanoton uudistus. Pohjois-Pohjanmaan Sairaanhoitopiiri.

Cyklop. (2019). *Puoliautomaattinen Käärintäkone: CSM 50*. Retrieved from https://cyklop.fi/tuotteet/puoliautomaattinen-kaarintakone-csm-50/

Dahlgraad, J. &.-P. (2006). Lean production, six sigma quality, TQM and company culture. *The TQM Magazine. Vol. 18, nro 3.*, 263-281.

Đapić, A. Đ., Novaković, Ž., & Milenkov, P. (2015). Hospial Logistics. *LOGIC - 2nd Logistic International Conference.* Belgrade: University of Belgrade, Faculty of Transport and Traffic Engineering, Serbia .

Harrison, A. e. (2019). *Logistics Management and Strategy* . Harlow: Pearson Education Limited.

Hedman, R. &. (2010). *Master Thesis: Reducing lead time and increasing productivity at a mail order distribution center Analyses and improvements of reverse logistic processes.* Göteborg: Chalmers University of Technology.

Heino, J. (2019). *Tavaran vastaanoton uudistaminen ja toimitusten seuranta. HUS Logistiikka.* Mikkeli: South-Eastern Finland University of Applied Sciences.

Hessing, T. (2016, January). *Six Sigma Study Guide*. Retrieved from Cause and Effect Diagram (aka Ishikawa, Fishbone): https://sixsigmastudyguide.com/cause-effect-diagram-aka-ishikawa-fishbone-herringbone-fishikawa/

Hokkanen, S., & Virtanen, S. (2013). Varastonhoitajan käsikirja. Tallinna: Sho Business Development Oy.

Kriegel, J., & Jehle, F. e. (2013). Advanced services in hospital logistics in the German health service sector. *Logistics Research, Vol. 6*, 47-56.

Kuismanen, L. (2015). *Varaston sisäinen tehokkuus: Outokummun Tornion tehtaat.* Tornio: Lapin Ammattikorkeakoulu.

Laamanen, K. (2009). *Johda liiketoimintaa prosessien verkkona: ideasta käytäntöön.* Helsinki: Laatukeskus.

López-Fresno, P. (2012). *Contribution of Lean Management to Excellence.* Retrieved from Nang Yan Business Journal 1.1: https://www.sciendo.com/article/10.2478/nybj-2014-0013

McFadden, B. (2021, July 20). *What is the 5S system?* Retrieved from https://www.graphicproducts.com/articles/what-is-5s/

McGovern, K. (2019). *A Public-Sector Journey to Lean: Fighting Muda in Times of Muri.* New York: Taylor & Francis.

Modig, N. &. (2012). *This is Lean.* London: Rheologica Publishing.

Moons, K., Wayenbergh, G., & Pintelon, L. (2019). Measuring the logistics performance of internal hospital supply chains – A literature study. *Omega, Volume 82,* 205-217.

Myllylä, M. (2018). *Diplomityö: Leikkaussalin materiaalivirran kehittäminen arvovirtakartoituksella.* Oulu: University of Oulu.

Niemi, P. (2016). *Tukipalvelukeskuksen logistiikkasuunnitelma.* Oulu: Pohjois-Pohjanmaan Sairaahoitopiiri.

OYS. (2021, June). *Toimipaikat*. Retrieved from Kartta: https://www.ppshp.fi/Toimipaikat/Sijaintitiedot/Pages/default.aspx

OYS2030. (2021, May 5th). *Rakennamme uutta sairaalaa*. Retrieved from https://oys2030.fi/rakennamme-uutta-sairaalaa/

Piuva, M. (2015). *Pro Gradu tutkielma: Leikkausosaston tarvikkeiden materiaaliprosessit.* Oulu: University of Oulu.

Pohjois-Pohjanmaan Sairaanhoitopiiri. (2021, Apri 29). Henkilöasiainkäsikirja. Oulu.

PPSHP. (2020, May 5th). *Pohjois-Pohjanmaan Sairaanhoitopiiri*. Retrieved from Hospital District: https://www.ppshp.fi/en/Hospital-District/Pages/default.aspx

PPSHP and Dreambroker. (2018). *Video presentation of central warehouse*. Retrieved from https://dreambroker.com/channel/4fmu4rmk/pe3p4vjm

PPSHP intranet. (2021, May 4th). *Hankinta, varasto ja kuljetus*. Retrieved from https://intra.oysnet.ppshp.fi/Palvelutoiminnat/Sivut/Hankintavarastojakuljetus.aspx

PPSHP, Database . (2021, June 28). Oulu.

PPSHP, Shift Database. (2021, June 28). Oulu.

Richards, G. (2018). *Warehouse Management: A complete guide to improving efficiency and minimizing costs in the modern warehouse. 3rd Edition.* London: Kogan Page Limited.

Riitaoja, M. M. (2008). *Pro Gradu tutkielma: Työnohjaus ja toiminnalliset menetelmät.* Jyväskylä: University of Jyväskylä.

Rivard-Royer, H. &. (2002). Hybrid Stockless: a case study. Lessons for health-care supply chain integration. *International Journal of Operations & Production Management. Vol22, No. 4.*, 412-424.

Sadler, I. (2007). *Logistics and Supply Chain Integration.* Los Angeles: SAGE Publications.

Sakka, F. e. (2016). Integrating Lean into Modular Construction: A Detailed Case Study of Company X. *Proc. 24th Ann. Conf. of the Int'l. Group for Lean Construction* (pp. 23-32). Boston: The International Group for Lean Construction.

Savela, T., & Valtanen, H. (2021, March). Strategia, Logistiikkapalvelut. Oulu: Pohjois-Pohjanmaan Sairaanhoitopiiri.

Smith, S. (2014, February). Thinking Lean - Muda, Muri and Mura. *ASQ Six Sigma Forum Magazine; 13, 2*, pp. 36-37.

Sogurno, O. (2002). Selecting a quantitative or qualitative research methodology: An experience. *Educational Research Quarterly, vol 26, issue 1*, 3-10.

Sunol, H. (2021, March 24). *6 Primary Warehouse Processes & How to Optimize Them*. Retrieved from https://articles.cyzerg.com/warehouse-processes-how-to-optimize-them

Walker, M. (2018). Spotlight on the 7 key warehouse processes. *MHD Supply Chain Solutions, Vol. 48, No. 1, Feb 2018.*, 20-22.

Venkateswaran, S. (2011). *Master's thesis: Implementing lean in healthcare warehouse operations - evaluation of 5S best practice.* Louisiana: Louisiana State University and Agricultural and Mechanical College.

Wolniak, R. (2018). Identification of bottlenecks and analysis of the state before applying lean management. *12th International Conference Quality Production Improvement – QPI 2018.* https://doi.org/10.1051/matecconf/201818301001.

Zhi, X. P. (2007). Logistics in hospitals: a case study of some Singapore hospitals. *Leadership in Health Services. Vol 20, issue 3.* , 195-207.

APPENDIX 1 Direct delivery efficiency 2021

Week	Supplier	Mixed	OR	Others	Order line	Internal	External	External %	Receiv-ing	Average of lines in receiving
1					896	721	175	24 %	363	2,5
2					2039	1580	459	29 %	857	2,4
3					2202	1616	406	25 %	836	2,6
4					2547	2021	526	26 %	1007	2,5
5	434	1049	893	422	2798	2342	456	19 %	1260	2,2
6	578	997	850	475	2900	2214	686	31 %	1158	2,5
7	302	1133	679	306	2420	2017	403	20 %	1003	2,4
8	270	750	435	458	1913	1563	350	22 %	850	2,3
9	381	950	767	354	2452	2106	346	16 %	1019	2,4
10	222	818	693	304	2037	1653	384	23 %	880	2,3
11	300	764	697	305	2066	1706	360	21 %	887	2,3
12	223	1112	711	493	2539	2053	486	24 %	1144	2,2
13	452	819	833	413	2517	2016	501	25 %	1255	2,0
14	236	1361	537	287	2421	1928	493	26 %	1065	2,3
15	226	1021	652	421	2320	1916	404	21 %	1079	2,2
16	307	1118	604	358	2387	1921	466	24 %	1018	2,3
17	478	1146	601	318	2543	2035	508	25 %	1069	2,4
18	366	1056	697	353	2472	2035	437	21 %	1135	2,2
19	238	606	664	725	2233	1824	409	22 %	852	2,6
20	374	1187	726	778	3065	2503	562	22 %	1214	2,5
21	309	1083	682	279	2353	1936	417	22 %	1089	2,2
22	304	918	914	417	2553	2183	369	17 %	1001	2,6
23	369	1305	762	398	2834	2288	516	23 %	1255	2,3
24	351	1221	618	340	2530	2013	516	26 %	1237	2,0
Average	336	1021	701	410	2377	1925	443	23 %	1022	2,3
3 employee average		**340**								

APPENDIX 2 Realization of direct deliveries from one company, 8 months period

Order number	Registered to Attune	Receiving	day:h:min	Next delivery at OYS	d:h:min	Lines
2027070	08/07/2020 09:43	08/07/2020 11:26	00:01:43	08/07/2020 11:55	00:02:11	7
	08/07/2020 11:30	08/07/2020 12:21	00:00:50	08/07/2020 13:25	00:01:54	
2027167	09/07/2020 09:41	09/07/2020 10:11	00:00:30	09/07/2020 10:55	00:01:14	5
	09/07/2020 13:59	10/07/2020 07:33	00:17:34	10/07/2020 09:00	00:19:00	
	09/07/2020 13:59	14/07/2020 07:45	04:17:46	14/07/2020 09:00	04:19:00	
2028981	03/08/2020 06:48	03/08/2020 09:06	00:02:17	03/08/2020 10:25	00:03:36	9
	03/08/2020 11:22	03/08/2020 12:14	00:00:51	03/08/2020 13:25	00:02:02	
2029565	10/08/2020 09:42	11/08/2020 09:10	00:23:27	11/08/2020 10:25	01:00:42	6
	10/08/2020 13:52	11/08/2020 07:50	00:17:58	11/08/2020 09:00	00:19:07	
	14/08/2020 12:46	14/08/2020 14:35	00:01:48	15/08/2020 09:00	00:20:13	
2030156	17/08/2020 07:09	18/08/2020 08:11	01:01:02	18/08/2020 10:25	01:03:15	18
	17/08/2020 07:11	18/08/2020 08:09	01:00:58	18/08/2020 10:25	01:03:13	
	17/08/2020 07:11	21/08/2020 14:09	04:06:57	22/08/2020 09:00	05:01:48	
2031175	27/08/2020 09:14	27/08/2020 09:44	00:00:29	27/08/2020 10:25	00:01:10	9
	27/08/2020 09:14	28/08/2020 07:03	00:21:48	28/08/2020 09:00	00:23:45	
	01/09/2020 11:05	02/09/2020 10:49	00:23:43	02/09/2020 11:55	01:00:49	
2032500	10/09/2020 09:12	10/09/2020 11:50	00:02:37	10/09/2020 13:25	00:04:12	1
2033000	16/09/2020 09:22	16/09/2020 13:36	00:04:14	17/09/2020 09:00	00:23:37	15
	21/09/2020 14:01	22/09/2020 07:37	00:17:36	22/09/2020 09:00	00:18:58	
	05/11/2020 09:52	06/11/2020 07:46	00:21:54	06/11/2020 09:00	00:23:07	
2034840	06/10/2020 11:19	06/10/2020 12:09	00:00:49	06/10/2020 13:25	00:02:05	1
2036320	19/10/2020 09:46	19/10/2020 10:34	00:00:48	19/10/2020 11:55	00:02:08	3
2037422	02/11/2020 07:55	03/11/2020 10:11	01:02:15	03/11/2020 10:55	01:02:59	13
	03/11/2020 07:13	04/11/2020 08:30	01:01:16	04/11/2020 09:00	01:01:46	
	03/11/2020 07:14	04/11/2020 08:12	01:00:57	04/11/2020 09:00	01:01:45	

2039761	24/11/2020 09:33	24/11/2020 13:37	00:04:04	25/11/2020 09:00	00:23:26	8
2040957	04/12/2020 10:22	04/12/2020 14:08	00:03:46	05/12/2020 09:00	00:22:37	9
2041204	08/12/2020 12:56	09/12/2020 10:10	00:21:14	09/12/2020 10:55	00:21:58	18
	09/12/2020 13:30	10/12/2020 09:39	00:20:09	10/12/2020 10:25	00:20:54	
	30/12/2020 11:18	30/12/2020 13:52	00:02:33	31/12/2020 09:00	00:21:41	
21002111	07/01/2021 10:01	08/01/2021 07:39	00:21:38	08/01/2021 09:00	00:22:58	3
	07/01/2021 12:18	08/01/2021 07:01	00:18:42	08/01/2021 09:00	00:20:41	
2100623	13/01/2021 09:22	13/01/2021 10:46	00:01:23	13/01/2021 11:55	00:02:32	15
	13/01/2021 09:23	13/01/2021 11:42	00:02:19	13/01/2021 13:25	00:04:01	
	13/01/2021 11:46	14/01/2021 07:23	00:19:37	14/01/2021 09:00	00:21:13	
	13/01/2021 11:46	13/01/2021 13:47	00:02:01	14/01/2021 09:00	00:21:13	
2101778	25/01/2021 11:27	25/01/2021 13:28	00:02:00	26/01/2021 09:00	00:21:32	13
	29/01/2021 11:04	31/01/2021 07:49	01:20:44	31/01/2021 09:00	01:21:55	
	08/02/2021 13:51	09/02/2021 09:05	00:19:14	09/02/2021 10:25	00:20:33	
	08/02/2021 13:51	09/02/2021 08:18	00:18:26	09/02/2021 09:00	00:19:08	
2101811	26/02/2021 11:58	01/03/2021 09:56	02:21:58	01/03/2021 10:25	02:22:26	7
	01/03/2021 10:34	01/03/2021 14:03	00:03:28	02/03/2021 09:00	00:22:25	
		42 receivings		Average	00:23:35	160 lines

Time from inbound to hospital terminal

26 %	Same day	(internal fast track goal)	
45 %	Next 24h	< 0:24:00	
19 %	Next 36h	< 1:12:00	
10 %	Does not meet the promise		>1:12:00
where	50 %	3 days or more	> 3:00:00

Last direct delivery leaves 13:15, at OYS 13:40

APPENDIX 3

ST Kulutustavara

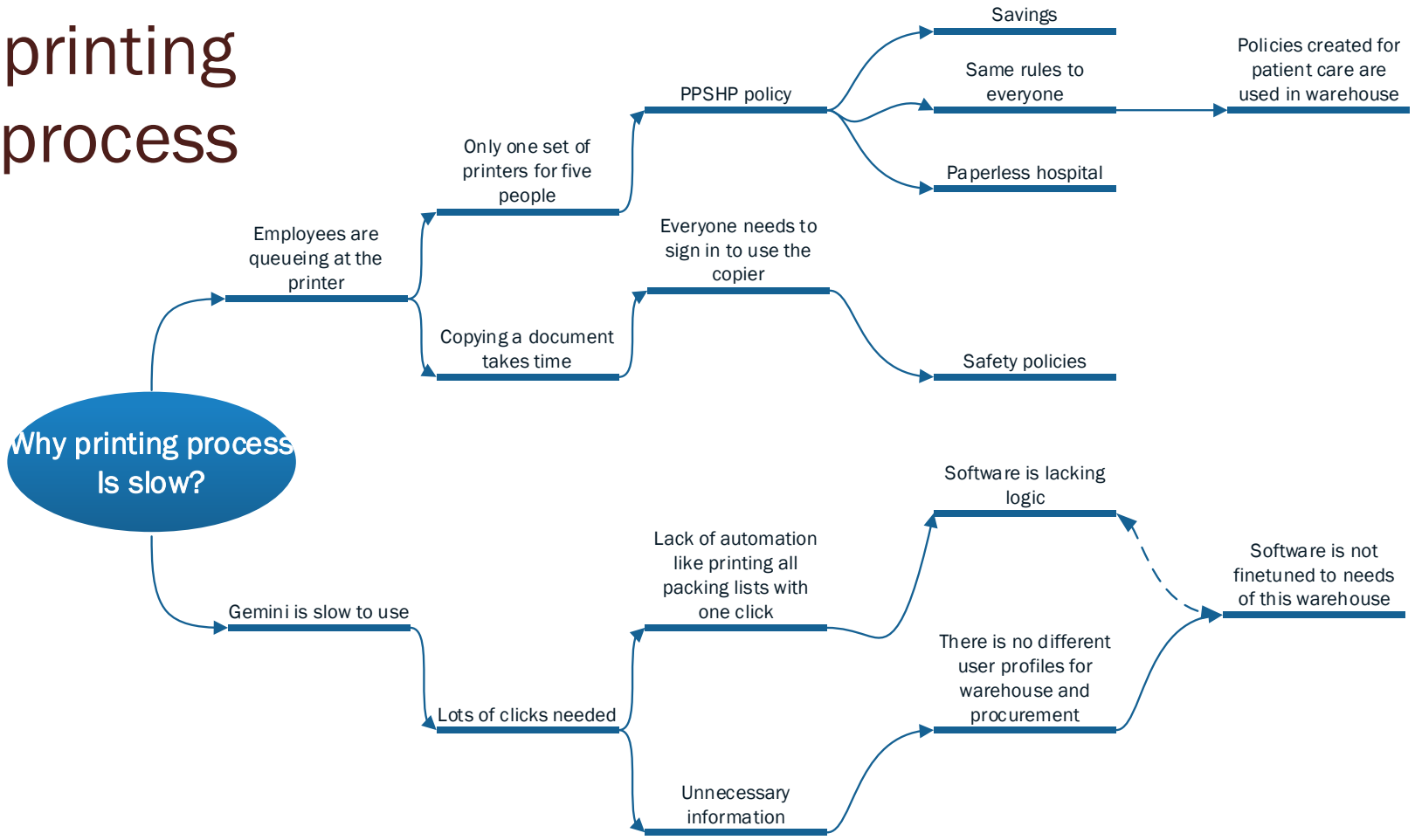
Nimi	Varastopaikka	Sailab	Tarve
Klemmari	T203B	21092	
Kopiopaperi	B105	05778	
Korjausnauha	U105A	17271	
Kumilenkki 60 x 1,5mm	T207D	17029	
Kumilenkki 90 x 1,5 mm	T208D	05823	
Kuulakärkikynä, punainen	U101A	17753	
Kuulakärkikynä, sininen	U101B	07804	
Lavakelmu, rulla (iso!)	U301C	16055	
Mapin välilehdet, 1-31	U201B	11384	
Mapit	A2-01	värin mukaan	
Mattopuukko	U503B	13383	
Mattopuukon terä, 9mm	U503B	13379	
Muistilappu, iso	T201A	09769	
Muistilappu, pieni	T201B	10994	
Muovitasku, kirkas	T104A	05834	
Nitoja 24/6	T202A	05857	
Nitojan niitit 24/6	T202B	05824	
Näytön puhdistusliina	T205C	12475	
Patteri AA	R111A	LR06	
Patteri AAA	R111B	LR03	
Sakset, askartelu	R107D	05954	
Sakset, yleiskäyttö	R107C	06318	
Tarratulostimen tarra	U303C	11410	
Tarratulostimen väri	U304D	17199	
Teippikone pakkausteipille	T208C	17131	
Teippirulla, kirkas	T207B	08558	
Teippirulla, ruskea	T208B	08557	
Tussi, musta ohut	U103C	08553	
Tussi, musta paksu (Textmark)	U104C	11396	
Yliviivauskynät	U104B	värin mukaan	

Muista tehdä sisäinen ostotilaus ottamistasi tavaroista!

<u>Erillisellä tilauksella</u>
Kutistekelmu, pieni rulla
Hanskat

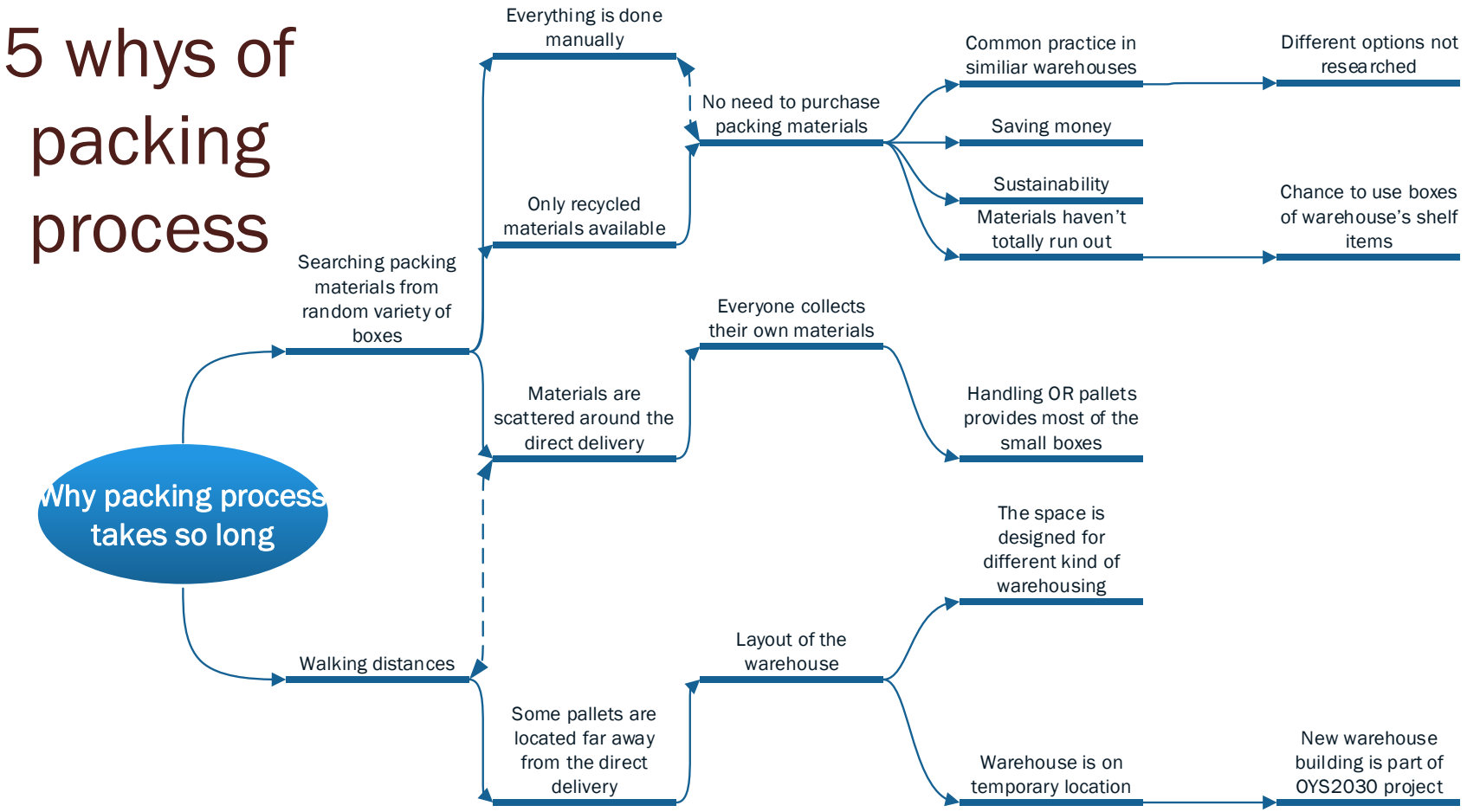
APPENDIX 4

5 whys of printing process



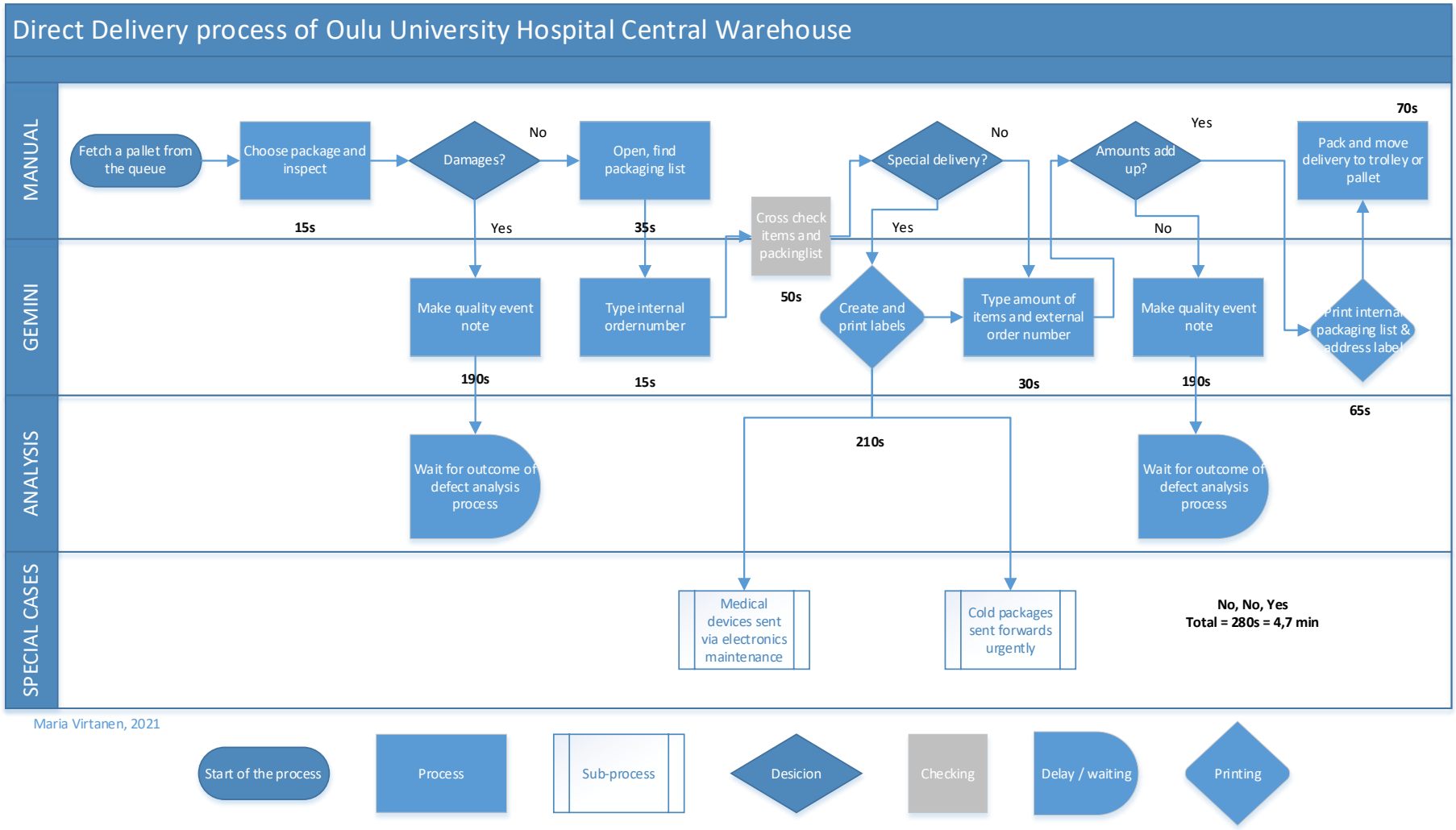
Maria Virtanen 2021

APPENDIX 5



Maria Virtanen 2021

APPENDIX 6


Direct Delivery process of Oulu University Hospital Central Warehouse
MANUAL
GEMINI
ANALYSIS
SPECIAL CASES
Fetch a pallet from the queue
Choose package and inspect
15s
Damages?
No
Yes
Open, find packaging list
35s
Make quality event note
190s
Type internal ordernumber
15s
Wait for outcome of defect analysis process
Cross check items and packinglist
50s
Special delivery?
No
Yes
Create and print labels
210s
Type amount of items and external order number
30s
Amounts add up?
Yes
No
Make quality event note
190s
Wait for outcome of defect analysis process
Pack and move delivery to trolley or pallet
70s
Print internal packaging list & address label
65s
Medical devices sent via electronics maintenance
Cold packages sent forwards urgently
No, No, Yes
Total = 280s = 4,7 min
Maria Virtanen, 2021
Start of the process
Process
Sub-process
Desicion
Checking
Delay / waiting
Printing

APPENDIX 7

Ishikawa fishbone diagram with ”Six Sigma 6M”