



# Master's degree thesis

**LOG950 Logistics**

**A case study investigating Norwegian hospital  
resilience using the AURA framework.**

Øyvind Rinde Rusaanes

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## **Preface**

This thesis is the final written assignment in the master program Master of science in logistics at Molde University Collage. The author was at an exchange semester in France during other students chose their specialty. Therefore, this authors specialty is mixed between advanced supply chain from when the author returned to Norway, and industrial performance from France. The advanced supply chain specialty from Norway focuses on qualitative aspects involved in management of supply chains. Industrial performance focuses on how to optimize the performance within the company, with the help of tools such as lean, total productive maintenance (TPM) and professional interactions between companies. Especially the knowledge from Molde university provided knowledge to analysis this topic.

The topic of choice is challenging, because it is an industry which recently where under enormous pressure due to the pandemic. The author has some, but limited experience in the field; however, this experience provided some insights in how to construct the interviews. Furthermore, this experience made it easier to find interview subjects.

The author would like to thank everyone involved. First and foremost, the author wants to thank the interview subjects and their leader for approving the author interviewing his employees. The interview subjects were of outmost importance a highly valuable to this study, as they shared their knowledge and perspectives in the field.

The author is thankful for everyone who has read and commented on the manuscript during the process of writing this thesis.

## **Abstract**

The purpose of this study is to contribute towards the literature on healthcare resilience and its implications. With an investigating perspective, the purpose is to examine how consumers in a Norwegian health enterprise practices resilience and potential new solutions to the problems. This study investigates existing plans and sourcing practices which can further be developed to increase resilience.

To investigate healthcare resilience with both a national and a health enterprise view, this is done through semi-structured interviews with six responders in different fields. This study recruited its responders through utilization of the snowball method. Research design consists of a qualitative approach as a data collection method.

Today hospital resilience is practiced to a certain extent in Norwegian health enterprises. Hospital Procurement and their purchasing agreements lack sufficient resilience in the award criteria. This practice stops the hospitals from achieving resilience to a level where the further action is within the health enterprises' jurisdiction. Most of the Norwegian health enterprises uses these purchasing agreements to buy medical consumables from a regional supply center where suppliers deliver their products. At this location there are some resilience assets in place, like security stocks. However, health enterprises and hospitals themselves have few such actions in place, and this thesis investigates how consumers inside hospitals and managers practice resilience in their department. Their practice is mapped and placed into the AURA-framework.

## Abbreviations

Under follows a list of abbreviations

Abbreviation	Norwegian word	Full English word or definition
PPE	Smittevernsutstyr	Personal protective equipment
ICU	Intensivavdeling	Intensive care unit
Unit	Spesialavdeling	Used to describe specialized ward, such as ICU and surgery
Ward	Sengepost	Hospitals bed associated with a specific unit
Department	En avdeling, hvilken som helst, inkludert støtteavdelinger	Used to describe one or more wards and units. Also used to describe support elements
PVC	Perifær venekanyle	peripheral venous cannula
HNT	Helse Nord-Trøndelag (HNT)	The health enterprise North-Trøndelag
Health enterprise	Helseforetak	Juridical and economical organization of two or more hospitals.
Hospital procurement	Sykehusinnkjøp HF	The national hospital procurement agency
Medical consumables	Medsinisk forbruksutstyr	Medical equipment used once.

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# 1 Introduction

Norwegian hospital supply chain resilience was severely challenged during the Covid-19 pandemic. Norwegian hospitals lacked essential equipment, like PPE (personal protective equipment), to be able to take care of the anticipated large influx of patients. Patient safety relies on the hospital's resilient supply chain. The resilience of Norwegian hospital supply chain is based on their capability to source necessary and strategic medical consumables. Resilience in Norwegian hospital supply chains is built through the cooperation between Hospital procurement (Sykehusinnkjøp), regional supply centers, each hospital (local) logistics department and the clinics, units and wards where the patients are treated.

After the Covid-19 pandemic healthcare resilience has received a lot of attention. However, this study is case studies, from countries with another organization of hospitals than Norway and therefore they can contribute limited relevance to this study (Læg Reid, Opedal, and Stigen 2003). Furthermore, hospital supply chains have received somewhat more attention than hospital resilience. The Active Usage of Resilience Assets (AURA) framework is a newly developed resilience assessment framework (Ivanov 2022a). The framework is developed for production companies with basis of the assets "Plan", "source", "make", "deliver", and "return" is coherent with the dynamics of healthcare supply chain. The AURA-framework is found relevant as theoretical foundation for this study and forms the outspring for the research questions. There is a lack of published knowledge about Norwegian hospital resilience assessments and the use of any framework to do this, and in particular the perspectives on hospital resilience from the perspectives of nurses and logistics department personnel. Therefore, the objective of this study is to investigate hospital supply chain resilience in one Norwegian regional hospital by the perspectives of nurses and logistics personnel and leader.

## 1.1 Literature introduction

Resilience is defined to be an organization's capability to withstand disruptions in their supply chain (Ivanov 2022a). Resilience is particularly important in healthcare. Generally, in the Western world, hospitals have many challenges (Ageron, Benzidia, and Bourlakis 2018; Wieser 2011). However, hospitals operating in different countries have different

challenges. There have been comparative studies on resilience in different countries, where developed countries have better resilience than developing countries (Kritchanchai, Hoer, and Engelseth 2018). Productivity and customer satisfaction increased when the logistics management outsourced hospitals or pharmacies their logistics to a private provider (Chen, Hsu, and Lee 2019). On the more operational level, multiple studies are published on how lean can be implemented in hospitals to increase productivity (Alemsan and Tortorella 2022). Hospitals could benefit not only through the application of lean in their process but also through digitalized logistics processes, especially the patient's information (Beaulieu and Bentahar 2021). Digitalization could help hospitals in their effort to modernize their procedures. Hence, they are closer to the level of other enterprises in other sectors, especially the logistics and data need to be patient centric (Roy, Prasanna Venkatesan, and Goh 2021). This makes the hospitals more patient-centric, which digitalization could contribute to; digitalization could significantly improve the hospital's resilience and profitability (Rehman and Ali 2022). Hospitals efficiency would benefit from implementing IoT (internet of things) technologies into their operations (de Vass, Shee, and Miah 2021). Another way to increase hospital resilience is by applying centralized purchasing groups, which would help generate new ideas and improve profitability and resilience (Patrucco, Luzzini, and Ronchi 2016). However, recently, the hospital systems in many countries were/ and are still under immense pressure to ensure the availability of critical strategic materials during a pandemic. In Scotland, they implemented a series of different local actions to battle the enormous strain pandemic put on their supply chain (Scala and Lindsay 2021). Hospitals in different countries acted differently on the shortage of the pandemic posts (Vecchi, Cusumano, and Boyer 2020).

I have been unable to find studies investigating consumer practice where nurses and logistics personnel are interviewed, in relation to hospital supply chain resilience in Norway.

## **1.2 Motivation**

The motivation for writing this thesis comes from the researcher's familiarity with the field of study. The researcher worked in a logistics department during the Covid-19 pandemic and experienced some of the challenges, without finding any theory about the phenomenon in scientific literature. Also, Norwegian hospitals has during some time, transitioned from healthcare logistics to healthcare supply chain models. Especially during the pandemic, the researchers interest in resilience in relation to healthcare supply chain models contributed to motivation for this thesis focus.

## **1.3 Aim**

This case study aims to investigate hospital supply chain resilience in one Norwegian health enterprise by the perspectives of nurses, logistics personnel and logistics leader using the AURA framework assets as a theoretical lens.

### **Research question:**

How is hospital supply chain resilience influenced by consumer practice, as described by nurses, logistics personnel and leader?

### **Sub questions:**

- 1: How do leaders, logistics personnel and nurses describe their consumer practice?
- 2: How do these practices influence hospital supply chain resilience?

## 2 Literature review

The first part of this proposal is first to summarize the existing literature about supply chain management, strategic goods, resilience, healthcare supply chain management, patient centric healthcare supply chain, risk and resilience in healthcare supply chains, enhancing resilience in healthcare supply chains and some studies on healthcare resilience.

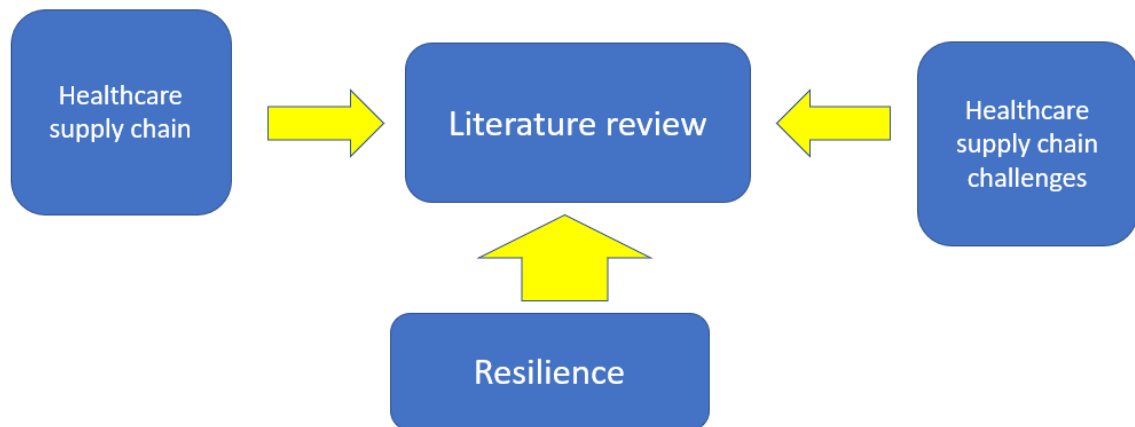


Figure 1: Components of the literature review

Figure one shows the different parts which this literature analysis consists of. First supply chain is defined and thereafter. healthcare supply chain needs to be defined. Thereafter the challenges of healthcare supply chain are presented and finally resilience is presented, both in the view of healthcare resilience and through both resilience framework and finding the strategic products.

### 2.1 Supply chain management

First and foremost, it is essential to define which area of science we operate in, and this study is within the field of supply chain management. Supply chain management could be described as a network of organizations, both upstream and downstream, in creating value for an end customer (Mentzer et al. 2001). Supply chain management represents the entire cooperation between chains rather than companies or departments.

Integration is a critical key for companies' growth in competitive environments. There are several disciplines within supply chain management, such as optimization, procurement, and operations, to name a few. Operations are the process of the flow within the organization or throughout the chain. The supply chain seeks to find the best possible relationship between the lowest cost and ensuring the availability of goods or services

moved throughout the chain or the organization. This is the purpose of supply chains, to fulfil customer needs (Lambert and Cooper 2000). The power to fulfil essential customer demands regardless of which sector the organization operates, healthcare, military or commercial sector. An example is retail because today's customers demand food delivered to them from all corners of the world. The retail sector has a high degree of digitalization throughout the process, such as the Internet of Things. Examples of the retail industries technologies could be Radio-Frequency Identification such as sensors, tags, wearables, GPS telematics, actuators, medical devices, vehicles, drones, smartphones, and machines, to name a few of the retail industry's utilization of new technologies (de Vass, Shee, and Miah 2021). Other supply chains, such as healthcare logistics lag other industries (Beaulieu and Bentahar 2021). This topic will be examined more closely in the following paragraphs, but first strategic goods and resilience will be defined.

## 2.2 Strategic goods

One of the first rules to find what articles are more important for the organization than other goods is the pareto principle. The Pareto principle is also called the 80/20 principle, because usually twenty percent of goods sold stands for eighty percent of the profit (Bynhildsvoll 2018). During the 1980`ies companies wanted another better way to properly address the growing trend of purchasing the materials they need instead of making them themselves. However, some products are more important than other(Kraljic 1983).

In 1983 Peter Kraljic published an article called “Purchasing must become Supply chain Management” in Harvard Business review (Kraljic 1983). This marked an important change for purchasing. In that article Kraljic presented a new view to classify the purchasing portfolio. The classification is based on the procurement's economical value and the supply risk. This figure is presented in figure two below.

	Supply risk	
Procurements economical value	Leverage items	Strategic items
	Non-critical items	Bottleneck items

Figure 2: Kraljic Matrix. Source: P. Kraljic 1983

The categorization is non-critical items, bottleneck items, leverage items and strategic items. Non-critical items are items of less economic value and low supply risk, meaning they are easy to find supplier of them in the market. Non-critical items are usually components which are easy to manufacture, like pens. Bottleneck items have a low economical value, but a high supply risk. Bottleneck items have less economical value than both heavy weight and strategic items, but they have a high supply risk. The products are often needed in limited numbers, but when they don't arrive, they pose a high risk for the company. Leverage products are products of high economic value, but low supply risk. Typical raw materials which can be. These products are easy to find from other suppliers, and they are often bought in huge quantities. Strategical items have both a high economic value and a high supply risk, which are typical components which are very important for the company to have access to. These strategic items could be developed together with the supplier of these items (Bynhildsvoll 2018). Where the different products are in the matrix also dictates which strategy the company chooses to go for in the relationship with this supplier (Bynhildsvoll 2018).

## **2.3 Resilience**

Modern supply chains are increasingly globalized. Therefore, there are more risks posing modern supply chain than previous supply chains due to longer distances and manufacturing locations involved. Modern supply chain needs capabilities and assets to recover quickly if disruptions occur in a supply chain, or in other words be resilient (Ivanov 2022b). Resilient supply chains may be presented through the AURA-framework (Ivanov 2022a). The AURA-framework builds on three other frameworks: low-certainty needed (LCN) supply chain, reconfigurable supply chain (RSC) and Visible supply chain (VSC). The low certainty needed supply chain is based on the capability of being ready to change, which uses supplier or own production to change their supply chain upon disruption. Reconfigurable supply chains (RSC) are a framework where suppliers and their backwards supply chain can reconfigure their supply chain to produce other products when such needs arise. The third framework is Viable supply chain (VSC) which is based upon the idea of the firms need to survive and maintain business during a disruption rather than bounce back to pre-disruption levels. Businesses with fewer products in their portfolio have an easier time recovering because they tend to have a better overview of their supply

chain. Combine all three and the fundament for the AURA framework is laid, or Active usage of resilient assets (Ivanov 2022a).

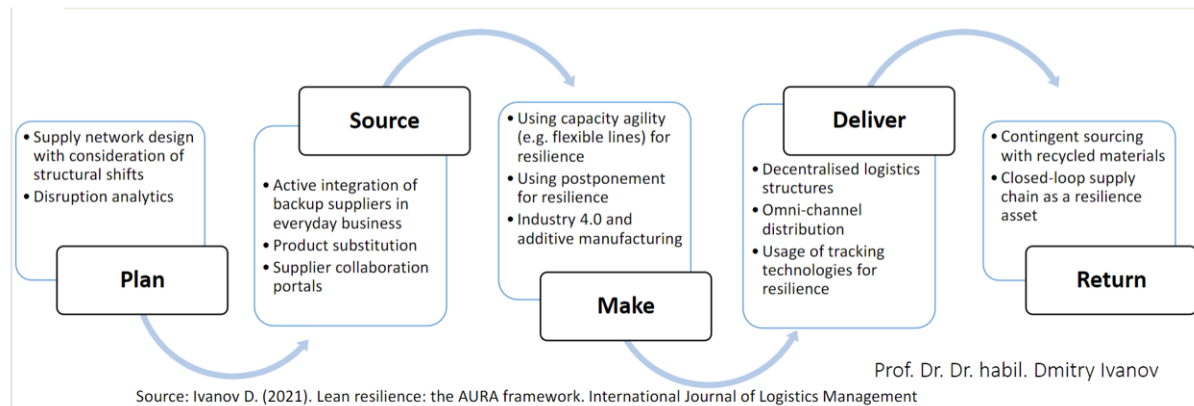


Figure 3: The AURA framework (Ivanov 2022a)

The AURA-framework comprises of five different assets needed for an organization to be resilient. The first area of resilient organization is that the organization needs to a plan in place. Plans are used to have a structured approach toward supply chain disruptions. The plans are made in advance and are placed into motion when the disruption happens, based upon disruption analysis. These plans should also be implemented in the supply chain with decisions such as making or buying the product and dual or multiple sourcing the product. For the supply chain to be truly resilient each product should have at least two suppliers. This practice could also function as a regulating tool, where the buyer could punish one supplier by buying more from their competitors when the supplier acts inappropriate. However dual and multiple sourcing arise concerns around data protection. These plans are shown in the second area, the source dimension.

The “source” dimension is an area where some of the plans come to fruition by showing the organization's agility and visibility. Agility is an important ability when disruption occurs, which could be achieved through the implementation of backup suppliers in everyday business. By doing this the organization is either dual or multiple sourcing and thereby already familiarize themselves with the supplier. Another important way to achieve agility is through the implementation of product substitution, which is the practice of using another product than what is originally needed in order to sustain business during a period of disruptions. Although implementing backup suppliers into everyday business and product substitution are important elements and can help the organization to be more resilient, viability is probably even more relevant. One way of increasing the organization's viability is through supplier cooperation portals, which could be in the form of a common



ERP-system. For organizations to decrease the distress during disruptions, establishing efficient and sustainable cooperation with their supplier through easily accessible channels are important. Better cooperation with suppliers leads us over to how the supply affects production, which is covered by the make area of the AURA-framework (Ivanov 2022a). After successful implementation of source assets into the organization there is a need to improve the production process resilience. Among the organizations capabilities to have resilient production process are utilize capacity agility, which means implementing flexible production lines. Another capability is the usage of postponement which means postponing the final assembly of a product in such a way the semi-manufactured product could be used to produce a variety of products. Both flexible production lines and postponement are tools within the industry 4.0 wave of manufacturing practices and technology, which would deliver the best product to the customer (Ivanov 2022a).

The second last area is the “deliver” area of the AURA-framework. For the organization to deliver their products to their market in a more resilient manner they should decentralize logistics structure, utilize tracking technology and use more than one distribution channel. Then the supply to the market can withstand disruptions too (Ivanov 2022a). The next, and last dimension is the return dimension where the life cycle of the product is closed.

The last dimension is the return dimension where the organization needs to source recycled materials, which also reduces the ripple effect throughout the chain. The organization becomes more environmentally friendly and has a short journey from materials to the production line. This closed loop is also a resilience asset (Ivanov 2022a).

The five dimensions of the AURA-framework are presented above. The use of AURA-framework is one way for an organization to become more resilient. By using these five dimensions they will be able to assess supply chain resilience, illuminate weaknesses and by addressing these become more resilient by reducing the impact disruptions would have on their operations. However, the AURA-framework is developed in the context of private manufacturing companies and has not been used in healthcare resilience assessment according to the literature. The next pages will define healthcare supply chain.

## **2.4 Patient-centric healthcare supply chain.**

When it comes to healthcare supply chains, there are two different approaches. The external supply chain has a material-based focus, while the internal logistics focus is patient-centric. An excellent functional internal logistics service is instrumental for hospitals to provide the best care for the patient. This is especially important due to medical advancement, more demanding patients, new governmental regulations and, in some countries, pressure from insurance issuers to provide the best possible care, and logistics have to play a part in this. The difference between internal logistics and the external supply chain is visible through academic research. Internal logistics are dealt with by disciplines such as optimization, and the external supply chain is researched through holistic studies. How these two approaches can be integrated with patient-centric perspective has yet to be made clear, as there is a gap in the literature regarding this topic (Roy, Prasanna Venkatesan, and Goh 2021).

Other articles provide strategies such as standardization for healthcare logistics. According to research literature there are multiple problems within hospital supply chains, such as poor inventory management at Malaysian hospitals and a lack of standardization of drugs in Thailand (Kritchanchai, Hoer, and Engelseth 2018). Both of these problems affect the patient. Furthermore, the literature finds hospital supply chains need instruments measuring their efficiency (Kritchanchai, Hoer, and Engelseth 2018). To improve efficiencies in developing countries, such as Thailand and Malaysia, hospitals could benefit significantly from centralizing their purchasing together with other hospitals (Kritchanchai, Hoer, and Engelseth 2018). Both Norway and Scotland have done this. However, the developed countries have another problem: they are often located far from their suppliers. When the suppliers are located far from the customer there is an increase in lead times and usually a lower resilience. However, more important than the distance to the supplier is the reliability of the deliveries from the supplier (Kritchanchai, Hoer, and Engelseth 2018). If unreliable supply chains, hospitals could risk stuck outs, which would significantly risk patients' lives. Therefore, a supplier with the knowledge and capabilities to be flexible enough to respond to customer needs is essential. For the supplier to improve their service, they could benefit significantly from hospitals implementing information systems such as ERP systems and E-procurement platforms. However, according to Kritchanchai et al. (2018) many hospitals don't have this infrastructure and thereby limiting the integration and collaboration with the hospitals. To assess the operational

performance of both hospitals and their suppliers, Kritchanchai et al. (2018) suggest that hospitals implement key performance indicators (KPI) to improve their services towards their internal customers and how their suppliers perform their deliveries to them. Suppose these KPIs are to be implemented successfully, it can increase efficiency by highlighting problems and pointing management in the direction needed to serve their hospital wards best and improve their patient-centeredness. Patients may be regarded as hospital supply chain end customers; therefore, their satisfaction is key to the continuation of operations. Still, hospitals supply chain show a lack of a patient-centric approach in the literature. Sometimes healthcare logistics are made more challenging by the government demanding providers to act both like suppliers downstream and as medical manufacturers with upper reaches, which is the case in Taiwan (Chen, Hsu, and Lee 2019). This article is based on pharmaceutical producers, not hospitals. Nevertheless, pharmacy is one of the most customer-centric sectors within the healthcare industry. Usually, there are multiple pharmacies to choose between, and they need to satisfy their customers in other ways than hospitals. Therefore, this approach is exciting because of how the market responds to different pharmacy strategies. Taiwan has a universal healthcare insurance policy headed by the Health Insurance Bureau. Insurance-based healthcare is advantageous because the costs of the systems are more visible than in universal public-driven healthcare, such as in Norway. In Taiwan they have, for instance, implemented a per-case payment scheme to try to control expenses, which also includes logistics costs. Taiwanese hospitals had to explore other business models, they found other methods to increase their profitability and improve their logistical performance. However, in the pharmaceutical industry, the distribution market was closed because either the pharmaceutical producer owned logistics or had close ties to a distributor, which led to poor logistical performance industry wide (Chen, Hsu, and Lee 2019). The pharmaceutical industry found out they could drastically improve customers' satisfaction by finding the best possible suppliers of logistical services in order to serve their customers in the best way possible. The customer demands superior logistical performance over the industry's protective needs (Chen, Hsu, and Lee 2019). Improving logistical performance was a crucial element in achieving higher customer satisfaction. Healthcare logistics, no matter if they supply public hospitals, private hospitals, municipal health care services, social care or pharmacies, has to set the customer in focus to properly function. This brings us to what logistics can provide for healthcare. Which growth potential can hospitals obtain through better logistics or healthcare supply chain.

## 2.5 Healthcare supply chain management

According to an article from 2011 (Wieser 2011), hospitals lack the informational systems to change from healthcare logistics to supply chain management. One of the deficiencies this leads to is the need for an overview of stocks and correctly forecast quantities consumed. Hospitals should implement RFID technology to address this problem (Wieser 2011). In 2011, this technology was rapidly spreading throughout industries and service industries. Applying RFID technology to the patient flow would drastically improve productivity because nurses and doctors could only scan the patient's RFID and then receive all the medical history of a given patient, and thereby ease processes by making them digital (Wieser 2011). This technology could also involve medical equipment used in treating this patient to produce a good forecast of what staff members could need during their care. Furthermore, hospitals should also use one system, like ERP systems for private industries (Wieser 2011). The main benefits of having one system with many modules or well-integrated multiple systems are that staff only need to add information once. The adding information decreases the value added to negative because of the waste of time in doing so. In a Swiss canton, an integrated information system was successfully implemented. This implementation leads to less ergonomic stress, better cooperation between staff, and significantly improved operations in medical prescriptions and operating theatres. The implementation of information platforms makes hospitals more efficient (Wieser 2011).

The digitalization of the hospital industry can increase efficiency to improve healthcare supply chains (Beaulieu and Bentahar 2021). In the previous paragraph, Weiser (2011) stated that the hospital sector is behind other industries technology-wise, something (Beaulieu and Bentahar 2021) agreed on ten years later. Hospitals are 20 years behind other industries, such as food and retail. Because healthcare supply chain lag behind in technological implementations, it makes the healthcare supply chain among the most expensive supply chains. Therefore, making the supply chains more efficient is more complicated due to a lack of personnel, leading to a single-tracked, cost-oriented focus, ironically making it more expensive to run. Digitalization initiatives in hospitals remain focused on implementing classic technologies, such as ERP and EDI systems. However, this tends to be quite challenging to implement successfully due to a lack of collaboration with internal and external partners Beaulieu et al. (2021). Hospitals need initiatives to

make them more resilient when it comes to stock outs, one tool to tackle this is lean. Lean is because hospitals must develop demand predictors to implement more proactive inventory management, not only restocking what is needed. Lean would make the hospitals more dynamic. Another technology to make hospitals more dynamic is implementation of AGV'S, which greatly impacts their flow of materials and waste. The technology under investment is only one among multiple problems facing healthcare supply chains.

Therefore, the next initiative is to: implement logistical automation to ease the flow within the hospital. On the other hand, this would mean a more dynamic approach to the supply of materials, which can only be implemented if the supplier is adapted to the evolution of care activities, which is a must to increase overall efficiency. If the different actors in the healthcare supply chain are better integrated, that will increase resilience in the supply chain, which is what the content of the following paragraph is.

Hospitals need a synchronized supply chain to deal with the supply chain disruptions.

However, this requires good cooperation between the entities in the supply chain.

Organizations need knowledge sharing and shared value to implement resilience properly and succeeded in doing it. Resilience is more important in healthcare supply chains than resilience is for other industries because of the potential consequences for patients and patient safety (Mandal 2017).

## **2.6 Risk and resilience in healthcare supply chains.**

Risk is an essential aspect, especially for the healthcare supply chain. All supply chains experienced presented challenges leading during the COVID-19 pandemic. In developed countries, healthcare benefits from their high level of digitalization, which leads to increased transparency, so management has better access to data to base their decisions (Choi 2021). The better access to data also made the supply chains generally more resilient towards risks. The following paragraph is about how hospitals dealt with the supply chain disruptions of Covid-19.

Hospitals and their supply chain treat patients, which is their end-user; therefore, they do not have the luxury of other supply chains to use the time to ramp up their production (Scala and Lindsay 2021). Some supply chain managers even chartered their planes to pick up PPE (Personal protective equipment) to ensure their partners had protective gear available. Supply chain resilience is different for middle-income and high-income

economies. The high-income economies have higher degrees of emergency procurement plans than middle and lower-income economies. High-income economies can afford expensive digitalization efforts to ease the impact of supply chain disruptions on their operations (Scala and Lindsay 2021). During the pandemic, the flow of materials was hindered due to export bans enacted by some governments, making the supply of materials even harder. When these countries were taken out of the equation, there was a severe fear among professionals that other actors had started profiting from the market and even committing fraud (Scala 2021)—culminating in a highly competitive market and dramatic price increases. Some material prices increased multiple times, as facemasks increased from 9 pence to 90 pence for the same material (Scala and Lindsay 2021). Facemasks were a particular case since the shortage extended to some of the raw materials used in the production of facemasks. Therefore, procurement had to resort to substitute products. Unprecedented demand led hospitals to change from their annual update of forecasts to daily for sort materials, even though the infection rate varied greatly and posed a severe problem to the teams. These teams tried their best, but predicting a pandemic is incredibly hard. No one was prepared for it. Hospitals in the UK lacked the human resources and logistics capacities to deal with pandemics (Scala and Lindsay 2021).

The first thing the NSS (purchasing for Scottish hospitals) was to conduct a vulnerability analysis to assess their supplier base, especially since they passed their dependency on production in China and other Far-eastern countries (Scala and Lindsay 2021). They assessed how the supplier could provide them with the materials needed. The analysis showed that due to commercial pressure, their supplier was lean organizations operating with bulk purchases. This means that their supplier nearly did not have the materials needed and, due to the usually long lead times, would need to wait weeks before restocks accrued.

The NSS of Scotland did not only make a vulnerability analysis but also implemented new (to the organizations) technologies to improve cooperation among Scottish hospitals and external partners. These new technologies help continuity, unprecedented demand while maintaining business continuity, and NSS successfully expanded their customer base to include social services. In Scotland, these social services are provided by private actors. NSS grew in this period from operating one warehouse to operating seven warehouses. For this to work, the staff of NSS worked hard and adapted to new challenges with new solutions. NSS adopted Microsoft Teams practically overnight to facilitate communication.

One of the success factors was the adoption of a new strategy. NSS implemented "buy" and "make" strategies. The "Buy" piece of the strategy was based on building up buffer stocks, which required purchasing outside the organization. The "make" strategy involved cooperation between NSS, the Scottish government and private partners to establish the production of needed materials in Scotland (Scala and Lindsay 2021).

There is not only through adoption and quick and decisive decisions from management which mitigates risk and makes the whole supply chain more resilient. Another way is through Lean implementation in streamlining operations (Alemsan and Tortorella 2022). For the hospital supply chain to increase its resilience, it is essential for them not to use all of its capacity during normal operations and therefore be able to use this access capacity in times of need. However, this principle goes against the Lean philosophy. On the other hand, Lean and resilience can go hand in hand. This is possible to obtain, according to a study from the automotive industry. Alemsan (2022) conducted an empirical study in Brazil to verify if this is the case for healthcare supply chains, not just the automotive industry, where resilience mediates the relation between lean principles and operational performance (Alemsan and Tortorella 2022).

An organization that implements Lean is more vulnerable to supply chain disruptions than others because Lean aims to minimize waste throughout the process (Alemsan and Tortorella 2022). This extra capacity could be useful during disruptions. Therefore, Lean organization needs some resilience measures to face this decreased vulnerability. The access capacity, which by Lean is identified as waste, could instead be relocated. However, Lean is beneficial for reducing process waste, making the process more smooth and more resilient during disruptions (Alemsan and Tortorella 2022). If a process is intricate and takes extended lead times, the process could hinder responses to disruptions by simply being too complicated. Implementation of Lean strengthens operational performance also, not just removing process waste. The third and last positive element of implementing Lean that this article will touch upon is the reduced cost of operations by streamlining them to make them safer and cheaper to operate. Lastly, Lean and resilience can be implemented independently because they strengthen the other philosophy and make the organization more resilient when supply chain disruptions hit. However, Alemsan and Tortorella (2022) study's findings might not apply in other settings or countries.

## **2.7 Enhancing resilience in healthcare supply chains**

Modern supply chains are based around production in developing countries, while the consumers are in developed countries leading to supply chains to be exposed over large geographical areas, making it harder to withstand disruptions. Disruptions are unforeseen sudden changes in the supply of material. Organizations need to handle disruptions through being resilient, meaning they can restore the pre-disruptions level of supply to their customers as quickly and efficiently as possible (Ivanov 2022b).

In recent years the most disruptive event is the Covid-19 pandemic which put healthcare supply chains under pressure. This supply chain experienced unprecedented demand for materials, which they were unable to meet due to lack of coordination and preparedness. In Italy there are three different levels of public procurement agencies making coordination of response hard. Regions such as Veneto and Tuscany shifted to a more regional coordination of procurement of the different medical supplies needed. Veneto and Tuscany had more success than other regions which didn't coordinate in this way. These regions managed to procure necessary medical equipment quickly by establishing networks of local suppliers. However, there is a lack of strategic focus in Italian public procurement which contributes to harder time sourcing materials. If the public procurement agencies would make a list of qualified suppliers and their performance in advance this would drastically increase the preparedness and enhance the resilience of public procurement (Vecchi, Cusumano, and Boyer 2020). When we talk about enhancing the performance of public procurement it is instrumental to enhance the performance through performance management. Measuring the performance can be done in several different ways. Different measures measure different aspects, and they need to be connected to make sense. If an organization uses KPI they also need procedures to measure the performance of public procurement. Public procurement should not only be measured on the price and efficiency to other areas such as quality of purchases, job execution, innovation and sustainability in order to truly improve their purchases to enhance the benefit of the people. Therefore, there is a need to find new and better ways to measure the efficiency of public procurement, to truly take on their responsibility (Patrucco, Luzzini, and Ronchi 2016).

Healthcare supply chains, and in this regard especially hospitals, are facing multiple risks in their supply chains. There are multiple ways in which hospitals can improve their supply chain resilience. Among other factors the five most important factors to increase hospitals resilience are Industry 4.0, multiple sourcing, risk awareness, agility and geographic



diversification (Rehman and Ali 2022). Industry 4.0 is a framework which connects networks of machines into a common system by utilizing real-time data sharing. In other sectors real-time data sharing has decreased the effects disruptions have on other sectors' supply chains. Healthcare supply chains could also greatly benefit from this information sharing technology, because the earlier the hospitals receive information about possible disruptions the higher is the probability of resolving the problem by transferring volumes to other suppliers. The resilience strategy of using multiple suppliers for one product is called multiple sourcing (Rehman and Ali 2022). Multiple sourcing could help hospitals by adding flexibility to their supply chains, the probability of multiple suppliers experiencing the same disruptions simultaneously is lower than one supplier. Multiple sourcing could also add bargaining power to the hospitals. Hospitals then have to use more resources on monitoring their supply chain in order to pick up shifts in the supply towards certain suppliers (Rehman and Ali 2022). Another important factor for hospitals is the need to improve their capabilities when it comes to risk awareness. In this regard hospitals need to improve their ability to identify, predict and locate risks in a timely fashion (Rehman and Ali 2022). However, this requires a hierarchically organized supply chain team. Industry 4.0, multiple sourcing and risk awareness are only some of the strategies which hospitals could use to increase their supply chain agility so they could react faster to disruptions. If they don't react in a timely manner, they could risk patients' death, due to lack of equipment.

## **2.8 Why the cost-focused provision of logistical services?**

There are multiple reasons why hospitals in different countries have yet to utilize new technology to enhance efficiency and thereby make their services better. In some ways, such as resilience, lean and digitalization, healthcare supply chains are behind other industries, such as automotive or retail, because they have other agendas. Healthcare has to serve both political and public interests, which can lead to cost minimization. In 1998 hospitals were reluctant to implement strategies that the other industry had successfully implemented (Jarrett 1998). This information is valid because the cost is still one of the essential elements for hospital management. The research at that time also focused on cutting costs because they researched how to improve contracts, business process design, and establishing the right relationship with suppliers. One of the reasons for the single-

tracked focus on cutting costs is that hospitals can reduce the cost of their care mainly by two methods. One is cutting the quantities of services, and the other is cutting the price of their services or both (Jarrett 1998). Cutting the quantity of services would lead to decreased healthcare service production for the public, while cutting the service costs makes it possible to maintain the quantity of the services. A given service in healthcare has mainly three costs: labor, materials and utilities. The most expensive cost is the labor cost. This cost enables production of healthcare services since politicians and the public demand adequately educated staff. The cost is materials used during the service, and the third is utilities such as electricity and water. The main cost which can be cut is the cost of materials; therefore, hospitals have a single-tracked cost of materials focus (Jarrett 1998). A possible solution is to open the healthcare market up to competition and let the market supply its best materials in order for the hospitals to provide their best services. Then a Just-in-time system could be implemented, drastically reducing the amount of capital tied up in warehouses (Jarrett 1998). Suppose the public and politicians change their perceptions of the services, away from the cost focus and towards a more quality-oriented view. With a quality-oriented approach, healthcare supply chains can find human and monetary capital to invest in the digitalization of their outdated systems. This, together with a more resilient supply chain, would significantly improve the service.

### **3 Case description**

This case is about hospital supply chain in Norway. To properly understand the case there is a need to describe how the hospitals in Norway are organized. Norwegian hospitals are organized different than their Scandinavian counterparts, creating both opportunities and disadvantages. Norwegian hospitals are organized in health enterprises which again is organized into regional health enterprises (Lægreid, Opedal, and Stigen 2003). Every regional health enterprise is owned by the Ministry of health and care services, see figure 4 below. The regional health enterprises collectively own a number of support activities such

as procurement and pharmacies.

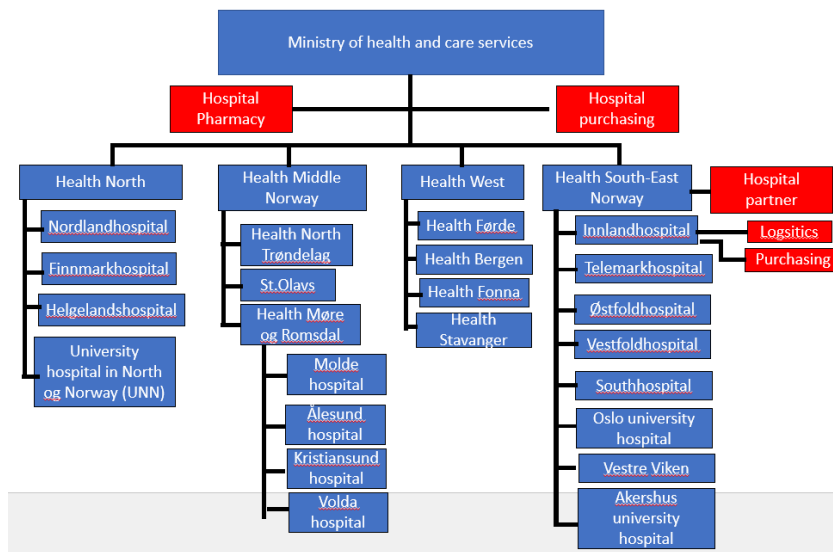


Figure 4: Organization of Norwegian health care

This case is based on a health enterprise, like the Innlandet hospital. There they have a local purchasing department and a local logistics department. Interview subjects in this case are employees in one such department. A good example to understand the structure is through Innlandet Hospital. The interview subjects in this case do not work at Innlandet hospitals, this hospital is just used as example. Innlandet hospital has five hospitals spread throughout the county of Innlandet in Norway. Each hospital has its own logistics department. Innlandet hospitals has only one purchasing department located in Lillehammer. Innlandet hospital uses the logistics partner Hospital partner (Sykehuspartner), which also delivers IT and HR services to all the other health enterprises in the regional health enterprise of Health Southeast Norway. Hospital partner (Sykehuspartner) has one logistics center located centrally outside of Oslo. This center is franchised out to a Swedish wholesaler called OneMed, according to one of my interview subjects. The other hospitals regions (Middle Norway and West) are currently working to establish a similar logistics center. These logistics centers aim to utilize many of the same purchasing agreements as the logistics center in Health Southeast Norway.

Hospital procurement handles multiple purchasing agreements. To this case, Hospital procurement utilizes no more than two award criteria when purchasing agreements are awarded. These award criteria are price and quality. Other award criteria which the private sector uses, like environmental award criteria and resilience are non-existent (Hospital Procurement 2022c; Hospital Procurement 2022b; Hospital procurement 2022a; Gærnæ

2022). Another important point is that the Hospital procurement also award the entire volume to only one supplier. Due to this purchasing agreement being national because they are negotiated by Hospital procurement, which is an organization under the ministry of health and care services and can help all the different regional health enterprises and health enterprises with their purchasing agreements. One clear advantage of having a national purchasing agency is that they can negotiate on behalf of the entire country and therefore achieve significant economies of scale. These purchasing agreements are then between Hospital procurement and the supplier, but the user are the health enterprises, and the delivery point are the regionally owned supply centers. These supply centers receive orders from different wards in the hospital, this order and the subsequent restocking of materials are handled by the local logistics department. However, there are two different purchasing organization, one is organized on a national level and is called Hospital procurement in this thesis and the other is local organized on the level of each health enterprise, meaning they each have their own local purchasing department. This unit is called the local purchasing department. Local purchasing department which handles orders with low monetary value, and potentially low demand. Typically, the cost of maintenance is handled by the local purchasing department where they often contract local contractors for the maintenance. The supply of drugs and medicine are done by Hospital pharmacies and negotiated by Hospital purchasing. Since this category is handled by its own agency, they do not enter the regional supply centers and therefore for the most part left out of this master thesis. This sole supplier then receives the bid and then supplies the material to the regional supply center, which is owned by the regional health enterprise. Then employees at the regional supply center pick the order and supply it to the logistics department at each hospital, where each ward has their own logistics employee. This employee is technically not employed by each hospital, but by the logistics department serving all hospitals. One example of this is the hospitals in the North of Trøndelag. Where each hospital is divided between the surgical ward and the medical ward (HNT 2023). The clinic for internal service is their own department in red square which continues down through the arrow down to clinic overview. Further in this thesis departments means the different clinics, units and wards of the hospitals. However, if any of the support departments are mentioned, their area of expertise is mentioned first, as is the logistics department.

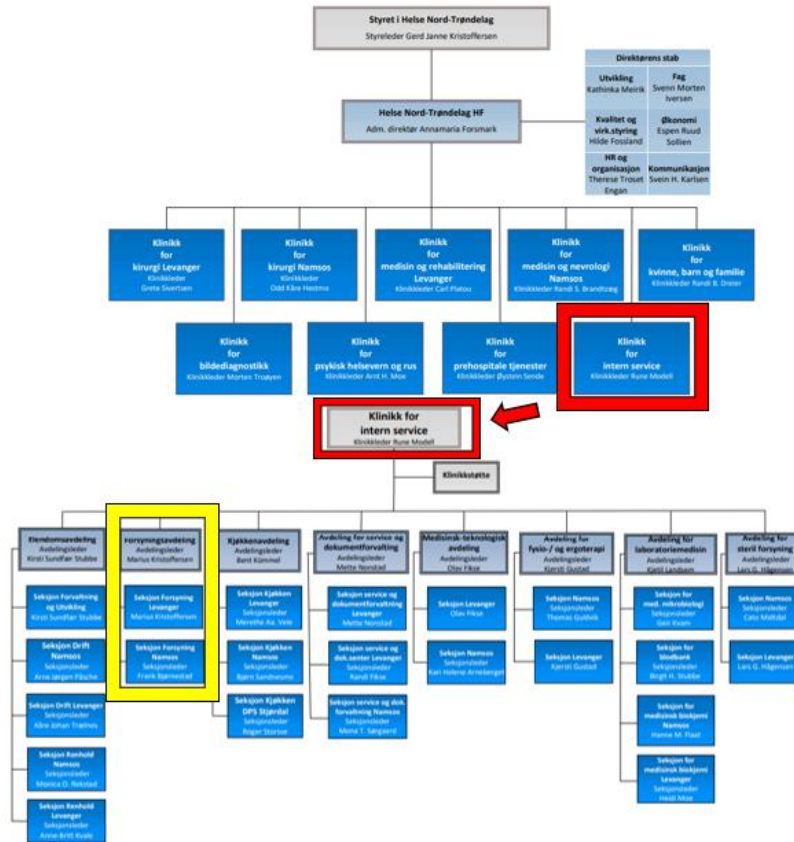


Figure 5: The organizational structure of a health enterprise

The logistics department is in yellow and operates at every single of HNT`s locations. Organizing logistics as a part of a clinic, like it would be a ward, makes it easier for the organizations to communicate with other departments and wards, than if it would be a part of the hospital's director's own staff. Making it easier for leaders to communicate with the logistics department if they have a need for material which they currently don't have available. Organizing the purchasing department at this level also eases communication between departments. By organizing the logistics department and giving them the responsibility of ordering and stocking each department or wards warehouses, the clinical staff (such as nurses) get more time to tend to their patients (Oslo Universitetsykehus 2022a). Therefore, this organization of logistical tasks makes it easier for nurses and doctors to do stuff they are trained to do, tend to patients. The organizations also decrease the number of backorders, since the warehouse of each ward or department is properly managed. Before this organization of the logistical tasks, medical staff had to do this work and then it was hard to find the material, find time to properly manage the warehouse and

newly arrived materials are restocked. This is also how it is organized in the organization which this case builds on.

Norway has a centralized organization of the hospitals. The Ministry of Health and Care is responsible for the operation of hospitals, as in Scotland. Since hospitals are organized differently in other countries, the transferability of knowledge from this case study might not be possible to apply to other healthcare organizations. Norway has a centralized organization of the hospitals.

### **3.1 Participants in my study**

To understand this case, the researcher conducted interviews with six different employees in one Norwegian health enterprise. These were leaders and employees with different backgrounds. These responders are grouped into three samples based upon which department within the organization they belong to. The first sample is based on the logistics employees where both the “chief of logistics” participated and three employees from one of the hospitals. The second is the medical ward unit where one nurse in charge of the medicine supply participated. The third sample is nurses from an intensive care unit.

## **4 Data and Methods**

This case-study is a qualitative study placed in the interpretive constructivist paradigm. In this worldview knowledge and meaning are seen as something constructed by the participants in the interaction with the world and the researcher (Cresswell and Poth 2018).

### **4.1 Methods**

Case study is characterized by a bounded system with well-defined borders. A qualitative single case study is a well-suited method for this thesis (Tjora 2021). This case is about a Norwegian regional healthcare organization which provides me with a well-defined border. A qualitative approach was appropriate, because there was little knowledge of the use of AURA-framework in the hospital supply chain contexts. Therefore, quantitative methods

were not suited for this study (Creswell and Poth 2018). The methods for data collection were interviews with key personnel from hospital settings. The results from a case study are not necessarily transferable to other contexts.

## **4.2 Data collection**

This master thesis is based on the data collection of interviewing different persons with knowledge within the field. The interviews were conducted as individual personal interviews, and one focus group interview. The interviews were conducted on two occasions as individual interview and audio taped using a Dictaphone, and in two instance as a Microsoft teams meeting which was recorded using teams' functions for recording meetings. The focus group interview was conducted with three participants and audiotaped using a Dictaphone. The reason for doing a focus group interview was because several participants wanted to participate when one of the individual interviews was to begin. The participants also expressed that they wanted to participate together, and since this seemed like a valuable opportunity to collect several perspectives at once, and not risk losing this opportunity. Therefore, I used focus group interview. Due to the constructivist belief about knowledge this setting provided rich descriptions as the participants discussed the questions with each other in the setting.

The structure of the interview used is semi-structured interviews, even though it can be argued some of the questions are structured, this is because some questions are verification questions used to verify existing knowledge.

## **4.3 Sampling**

The sampling was discussed with my supervisor and defined as logistics personnel and nurses in two different ward units. One special unit, intensive care unit (ICU) and one general medical care unit, also called medical ward.

The recruitment process was executed by emailing potential participants. Quickly the first interview was arranged. After conducting the first interview, former participants recruited the next participants. This strategy is called snowball-sampling (Creswell and Poth 2018, 159). Snowball sampling strategy identifies cases of interest from people, who know people, who know people. These people know who might have valuable insights into the

case. Other participants volunteered, for instance the leader, while I was asking permission to recruit among his employees.

#### 4.4 Analysis methods

The analysis method was chosen in order to analyze data to answer the research question. The research questions were formulated to create an explanation of how resilience is described in this particular case. A suitable approach to analyze the material to investigate and answer the research question, was found to be SDI (Stepwise deductive inductive method) by Aksel Tjora (2021).

The SDI method is described by Aksel Tjora in his book “Qualitative research methods in practice” (2021). This method is depicted on the right side. It is based on both a deductive method and an inductive method to ensure the quality of the data. The first step is to generate data through the empirical work, which is the data collected in the interviews.

Then these are processed or transcribed as in this study. Each interview was written into a spreadsheet. The transcribed data are then coded into codes, meaning the data is elevated to a higher state where the essence of the data is summarized in short sentences. The codes were then added to the spreadsheet. If the need arises these codes could be deducted back to transcribed data. These sentences are then grouped together in a code group, which is what the code has in common. If the researcher discovered something wrong, he/she could deduct the

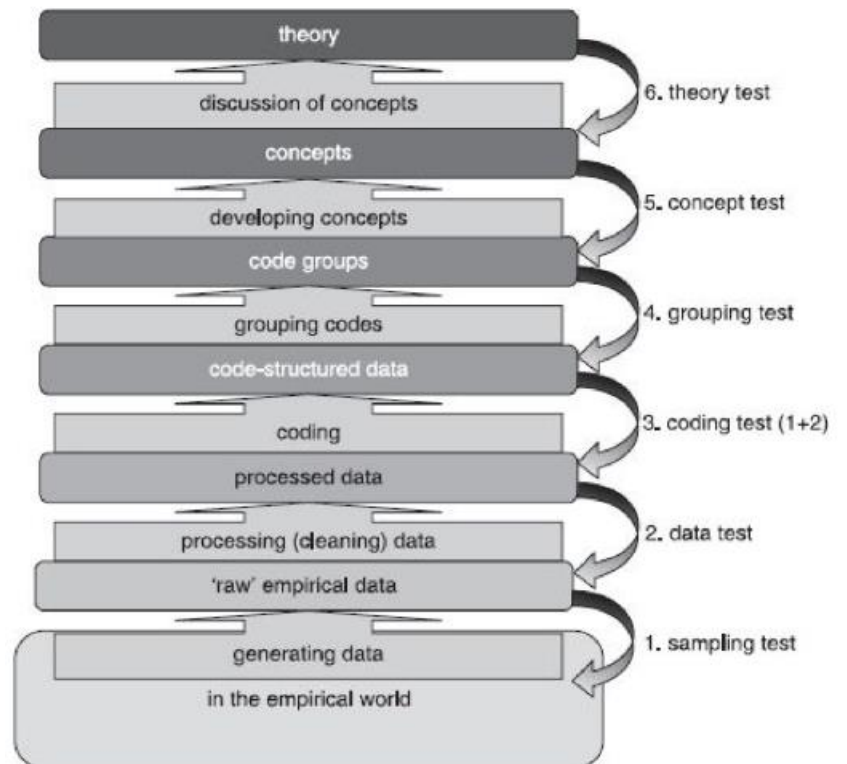


Figure 6: SDI by Tjora (2021)



data back to codes. These code groups make the fundamentals for how the concepts are developed. The concepts are developed thoughts originating from the empirical data collected during the interviews. The concepts are then analyzed with the help of the existing theory to try to either verify existing theory, improve, or discard the theories. This is done in the analysis and discussion. Each of the steps described could be deductively reversed back to the previous step, making the method easy for other scientists to redo later.

#### **4.5 Research ethics**

The project was approved by NSD (Norwegian board for scientific data) before the recruitment process began, the report can be found as attachment 1 in the appendix. The interview was transcribed immediately after the interview was conducted and therefore no personal data was stored. Immediately upon finishing transcribing each interview, the recording was deleted. When each participant gave their consent to participate, they were also informed at the beginning of each interview that their contributions were possible to withdraw as long as their contribution were possible to identify in the material.

#### **4.6 Data**

The data in this study are the transcripts from the interviews that were conducted using a semi structured interview guide (attachment 2, 3 and 4). The data shown in this part is the transcribed interviews. These data are organized into one excel book and each selection has its own page in the excel book. The first selection to be presented is the logistics personnel. These data have origin from both the operational level (through interviews with personnel in the department) and strategic through the interview of the leader of logistics in the organization. Minor changes to the interview guide were made in between. The interview guides are placed as attachments in appendix two for the interview guide to the logistics personnel.

The first selection of interview was based upon a 22-question long interview guide adapted in regards of this research being the researcher's first scientific work. This selection interview guide can be found in attachment two. Therefore, although this being a semi-structured interview where the person interviewed is to describe, some questions are there

to contribute with a background while others are quite to the point, almost as if it were a structured interview.

The second selection, which were interviewed, was a nurse at a medical ward. This nurse received fewer questions than the logistics selection. The questions are found in attachment four. She was recruited by logistics staff pointing towards her. This interview was the shortest of all interviews, even though the questions were semi structured too. Medical wards have their warehouses managed by professionalized logistics personnel (Oslo Universitetsykehus 2022b).

The third selection was a nurse from the Intensive care unit. The questions are similar to the second selection and can be found in attachment three. This department runs their own warehouse and therefore they have other descriptions and therefore some other questions. These interviews were then coded. Similar codes were grouped together to create code groups which could be observed in figure seven. These code groups are the basis for the analysis in the next chapter.

Code groups							
Plan assets		Source assets	Make assets		Deliver assets		Furthermore
A resilient plan needs to openly communicated and supported	Plans made for departments tends to be self-centerd from the procurement view	Tranforming warehouse structure doesnt always improve resilience	A self-serving focus in health enterprise and their procuremnet agncies, create limitation to resilience	Professio nalized roles to acheive common goals	Disruptions has never harmed patients	The implications of the new warehouse structure	What is resilience

Figure 7: The codegroups

In figure 7, the code groups are organized into the different assets in the AURA-framework. These code groups are further developed into concepts. The concepts can be observed in figure 8 below. The concepts form the basis for the discussion in the article, where selected code groups are added. Between the code groups and the concepts there are some synthesized citations from the interview to highlight important citations within that code group. There are arrows pointing from the code groups and towards the concepts they create. Since the article is based on a much short analysis and this analysis needs to be sufficient on its own, the concept in the article is slightly different than what the concept in the essay is. Therefore, there concept for the essay is “Professionalized roles to improve

efficiency” and the article has “How plans become better”, because the essay provides enough data to support this statement, while the article has less data available and therefore its need its concepts. However, in the discussion in the article, professionalized roles are an integral part of this chapter. These concepts are also based upon the analysis in the article and therefore a little bit different code. These concepts are what are then used to create both the managerial implications and the suggests in the conclusions.

Codegroups	Synthesized citations	Concept
A resilient plan needs to openly communicated and supported	"I don't know about any plans"	
Plans made for departments tends to be self-centered from the procurement view	"My department didn't receive any help in creating our resilience plan"	Professionalized roles improve efficiency
Transforming warehouse structure doesn't always improve resilience	"The warehouses are very efficient with the new structure, nurses always has medical consumables available"	
A self-serving focus in health enterprise and their procurement agencies, create limitation to resilience	"Hospital procurement don't include other award criteria than price and quality, which disrupts our resilience"	Efficiency warehouse structure provides more time to care for patients
Professionalized roles to achieve common goals	"The logistics personnel are real professionals"	
Disruptions has never harmed patients	"We have never had any problems due to lack of equipment"	Improving purchasing agreements
The implications of the new warehouse structure	"We need a local security stock"	
What is resilience	"Resilience is so much more"	

Figure 8: Code groups, with citations to create concepts

## 5 Analysis

The investigation of how consumer-practice influence hospital resilience resulted in eight concepts related to the AURA framework by D. Ivanov.

## **5.1 A resilient plan needs to be openly communicated and supported.**

The first asset to be analyzed is the plan assets. The first code group is that the plans are unadaptable and unknown. One of my responders said that she “I didn’t know about any plans”. This could be due to her position as nurse at a medical ward, and normally most of the employees in an organization don’t know about plans for resilience. The employees at the logistics department described how the medical ward is managed by their department. Further, the nurse from the Intensive Care Unit (ICU) described how they manage their warehouse themselves. She said, “We don’t have a plan, but a structure”. When a product is not delivered according to the order, the ICU department has to contact the purchasing department to get the contact details for the supplier and then contact them to get them to find a substitute. However, the ICU has quite a few machines that other wards or units don’t have and therefore they cannot not find other materials within the hospital and making it harder for purchasing to find substitution products. Other departments with the same activities, such as the two medical wards can borrow materials from each other. The logistics personnel at the hospital described how they usually contacted the local purchasing department to find a suitable product to substitute products needed at the wards they operate when orders are not delivered on time.

The leader for the logistics department also confirmed that the department which operates the warehouse of a given unit or ward has to either contact the supplier to find the product or substitute for the product. The logistics manager also pointed out, when Hospital procurement makes a purchasing agreement, they don’t make resilience as part of these plans/agreements, making the health enterprises quite unadaptable. Therefore health enterprises and their hospitals might struggle making resilience plans. Combining single focused purchasing agreements with the regional supply center who handle the deliveries for the units and wards within the hospital regions makes the regional supply center a very large entity.

To sum up this paragraph there are plans and structures in place, depending on which unit is being analyzed. The findings also indicate that consumers who don’t have anything to do with handling orders don’t know about the plan due to this task not being part of their work description to know. However, their plans are quite unadaptable in the way that resilience is not a part of the purchasing agreements with suppliers, and these suppliers deliver the

volume of the regional supply center. According to one of the interview subjects, one of these region health enterprises and their regional supply center stands for fifty percent of total volume bought by Norwegian hospitals. This means that this regional health enterprise's volume is quite hard for other suppliers to fill in the case of disruption.

An interesting finding is the nurses and the leaders' descriptions of the most strategic products. The nurses especially had diverging descriptions and meanings about the most strategic product in their unit and ward. One of the nurses' first response was prefilled syringes of salt water, the other nurse also touched upon this very product category. However, the second nurse quickly found another product which is more important for her unit because the syringes are quite easy to substitute with other syringes. The first nurse described how not having the prefilled syringes involves that every task involving this product category takes some longer time, and prefilled syringes is used a lot in medical wards and thereby they might need to call in extra personnel to help because tasks now require longer time than anticipated.

The ICU nurse, however, described the pads for the heart starter and tubes for the machines at the ICU as strategically important for her department. However, these tubes are not substitutable, because different manufactures produce these tubes of different diameters and thereby, they are not substitutable. If they are to change the supplier of the tubes, they need a nozzle to make the tubes fit. This further leads to the need to change procedures too, according to the ICU nurse. This makes the operation of substituting this product much more complicated than filling syringes with saltwater.

The logistics personnel said that for the most part the whole hospital has the same strategic materials for them to keep operations running. Special departments such as ICU and Surgery have their own assortments. Therefore, they have other products which are strategic for them. Consequently, the most ideal plan would be to have one for the general ward and one for each specialty department.

Plans are imperative to have a to deal with disruptions. This knows both the Hospital procurement and every health enterprise. Therefore, they have plans and procedures in place to deal with disruptions. However, as described in the case description the hospitals are organized under the ministry of health and care, which all together makes quite large structures. While the award criteria of procurement agreements heavily rely on economics, and not taking into account other criteria, they are vulnerable to disruptions as described by

the nurses in the medical ward and the ICU. A plan needs to be openly communicated and supported by all consumers in the supply chain to be resilient. This way adjustments to the real-world practice can be communicated. This makes the hospitals suffer from upon disruptions. This way adjustments to the real-world practice can be communicated back to the central procurement to enhance the hospital supply chain resilience.

## **5.2 Plans made for departments tends to be self-centered from the procurement view.**

The second and last finding and concept related to the plan area in the AURA-framework finds procurement plans for the different departments in the hospitals, are suboptimal due to self-centered focus on the economics of procurement (Ivanov 2022a).

The logistics manager described how plans for sourcing of the high monetary value and a high percentage of all the transactions are handled by Hospital Procurement, more or less everything from the regional supply center and selected other categories. Somewhere above 70% of medical consumables are bought through Hospital procurement`s purchase agreements. Technical equipment and medicines are also handled by the local hospital purchasing department.

However, as mentioned in the case description, Hospital procurement is a larger organization owned by the hospital`s regions. Large organizations are generally harder to change than smaller and younger organizations. The influence of organization size clearly comes into play by the descriptions of the logistics manager. He had contacted Hospital procurement together with other managers to make them include more resilience efforts into their purchasing agreement, without any luck. He said, “Hospital procurement will not include resilience within the next 40 years” said the logistics manager.

To describe both the health enterprises, regional health enterprises and Hospital procurement based on the interview subject`s opinion is obstinate, which means stubbornly refusing to change one`s opinion or action, despite attempts to make them change.

However, the logistics manager also reported that recently Hospital procurement has added environmental award criteria to their purchasing award criteria. After the pandemic Hospital procurement and local purchasing departments will have to implement more resilience into their purchasing agreement. It is only then, when those who make the

purchasing agreements and implement resilience into their purchasing agreements, that the plan asset and the following sourcing of products becomes resilient.

### **5.3 Transforming warehouse structure doesn't always improve resilience**

The case of this study has recently transformed the warehouse structure, by implementing regional supply centers sending the ordered materials directly to the wards or units and not through the central warehouse. The logistics manager described this transformation as a success as they saved a lot of resources and storage space. The released storage space (previously the central warehouse) can now be used for treating patients.

However, the medical consumables used are then stored at each clinic, unit and ward instead. One of the logistics personnel who is responsible for some of the wards in their hospital, described how many departments complained that they don't really have space for the increased need in storage space. Described one of the logistics employees.

Another logistics employee pointed to the transport that increased from twice a week to daily. Before the implementation of direct shipments to the departments (clinics, units and wards) the local hospital received supplies from the regional supply center twice a week, as of now they receive them every day.

Besides, in the transition to this direct shipment strategy, the departments received little guidance. One of the responders, the ICU nurse, said "During the pandemic, when our department was full. We suddenly had to totally change the layout of our warehouse, alone. No one helped us". Therefore, the change to direct deliveries, instead of going through the central warehouse in the hospital, the transformation of storage wasn't the most optimal for the department according to this nurse. In summary it may seem as though the implementation mainly focused on what the logistics managers recommended, not directly what the departments needed. Logistics might have thwarted the department's needs in the transformation.

"Normally the health enterprise uses 4500 facemasks, but during the pandemic they used 450.000 facemasks" said the logistics manager.

Without the support of the regional supply center and Hospital procurement this explosive change in the demand wouldn't been met. This demand was possible to cover due to cover this demand. On the other hand, the time needed for medical consumables now is way

more time consuming to get to their consumer. The central warehouse had around four hours to deliver, while the regional supply center has a day. If any materials are needed faster, they can order an express delivery, but this is also more expensive. Commented the logistics personnel.

One of the nurses described how they never unanticipated needed products urgently. But in an event of urgency and the item is not in their own storage, but in the regional supply center, they make an order, and the product is delivered the next day. This does not make it harder for her department to treat this given patient without this product for 24- hours.

However, when they order such products, they usually receive too large shipments so the unused items in the package of products then expire before the next patient with the need for this product in their treatment arrives. Therefore, she said she wished they had a system for when a department has something in storage which another department might need.

Normally, and for most of their patients the nurses manage to treat them without implications. The ICU nurse pointed out they wanted more support in the process of which products are important for them and then fielding these products in sufficient numbers.

Overall, the transformation of the supply chain in this case was successful, but from the two nurses' perspectives there are improvements to make. This will be analyzed further down.

While the transforming of the warehouse had some hiccups, the system after transformation is more efficient with the current warehouse structure. This structure has led to a professionalization of the role of managing each unit and wards warehouse. Many departments have the opportunity to transfer the task of managing their warehouse to professional logistics personnel. This transfer involves that care personnel have more time to care for their patients.

“We can assume that the hospitals own central warehouse played a key role in that system, while the employees now operate the departments own warehouses and thereby freeing up time from medical personnel, for them to care to patients instead do warehouse managing” said the logistics manger. The logistics personnel commented “The system is way more efficient now, and the loss of inventory is lower than before”

Professionalizing the operation of managing each department also meant more centralized control which means more control throughout the health enterprise. However, decisions made centrally might not suit each department’s needs. As illustrated with the quote below, specialist departments were dissatisfied with the level of resilience in the new structure.



After pressure from the nurses and doctors a local security stock of strategically important medical consumables was established.

“In the beginning of the transformation to the new system, we didn’t have any security stock” said the ICU nurse. The complaints led to products being planned and sourced according to the degree of importance of security stock in each department, in order to treat their type of patient. The implementation of the new structure made the health enterprises more efficient. However, their resilience decreased because the new structure didn’t have local security stocks. The professionalization of the logistics role led to more efficiently managed hospital warehouses of the health enterprises departments. Furthermore, it improved their ability to source huge quantities of needed PPE during the pandemic.

#### **5.4 A self-serving focus in Health enterprises and their procurement agencies, create limitation to resilience.**

Norwegian Hospital procurement agency rely on the award criteria of price and quality, as earlier mentioned. Within certain product categories, hospitals are grouped together on a national scale, and without multiple sourcing, that means that Hospital procurement sometimes accidentally creates monopolies or nearly monopolies. One of the interview subjects brought up clothes washing up as an example. According to the interview subject, the hospital’s supplier Norteksil was able to establish national coverage of cleaning health personnel uniforms, thanks to the deal with Hospital procurement. The agreement with Hospital procurement represents a stable income which in turn has made the basis for the expansion. In Norway today, there are no other laundry service with this heavy established network nationwide. According to another interview subject, Nortekstil also make suboptimal decision when it comes to the allocation of which hospital are getting their clothes washed where.

“This is because without the hospital, this laundry service would be close to closing, due to small numbers of other customers.” Said the logistics manager.

As Nortekstil now has national coverage, consequently they have the capability to make agreements with hotels chains to wash their laundry in addition to hospitals.

In microeconomics, one monopolist can charge more money than competition would allow. According to the logistics manager, in Hospital procurement there are many different suppliers of different products, but not from the same products. Medical

consumables also suffer from this. He further described one example with peripheral vein cannula, or PVC, which were supplied from Baxter and their factory in Serbia. Baxter had the agreement to supply to the South-East regional health enterprise and Codan had for the three other health enterprises in Norway. Thereby these two suppliers shared the Norwegian PVC market equally between them. However, Baxter had a disruption at their Serbian factory and therefore were unable to deliver the required amount. Hospital procurement then contacted Codan to hear if they could fill the missing amount, but they weren't capable of double their production amount overnight.

The findings state that these practices influence resilience in a negative way. If the resilience assets were deployed, they would first of all have multiple suppliers for each regional health enterprise. In addition, a system for security stock, and have alternative suppliers to source missing products and amount from. Luckily Baxter was able to solve the disruption on their end quite effectively on this occasion.

If a more decentralized supply network, dual sourcing, and robust and supported plans for recommended actions when disruptions occur, hospital supply chain resilience related to the make asset probably could be improved/strengthened.

## **5.5 Professionalized roles to achieve common goals.**

In hospitals there are multiple different professional specialists working. The health care medical specialist's main task is treating and providing care for their patients. Therefore, it seems smart to professionalize the logistics personnel too. Hospitals are not production companies. Hospitals employees are equipped to handle many different situations, usually simultaneously. Production companies usually specialize in producing few products, and so do their employees. Since logistics can take up a lot of time for medical personnel who already have a heavy workload, caring for the patients, the role of maintaining warehouses by the medical personnel may lead to improper management. "By employing professional logistics personnel, nurses' doctors and other care personnel have more time to their actual job. The warehouses are also better managed with professional employees" said the logistics manager.

Among the disadvantages of having a nurse running the warehouse is the waste of products. Therefore, it is beneficial for all departments, especially specialist units and wards for them to have their storage managed by professional logistics personnel. The

reduction in waste leads to less capital bounded up in stocks. This way the warehouse resilience could be more stable, and the time saved by medical staff to provide missing product. Employing logistics personnel to operate the warehouse and moving stock away from the central warehouse to the regional supply center, frees up space and time to care for patients. Logistics personnel are someone to stand on their (medical staff) demands when discussing products with the regional supply center.

According to the findings, the different ways the hospital personnel do their operations to ensure that their patients are treated for their illness, it seems as if none of the resilience assets from the AURA-framework fit seamlessly the operations of hospitals. The assets of plan and source and plan could be relevant to implement.

## **5.6 Disruptions has never harmed patients**

Lack of supplies has never affected the treatment of a patient, and the patient has received the right treatment because of always available materials, according to both the nurses.

However there have been instances, as mentioned earlier, where the tubes to the machines were missing and another time where they received the wrong tubes. The delivered tubes were not direct substitutes for the ones the ICU normally used. Having the wrong tubes supplied caused some delay in the treatment of patients, but never any serious complications due to disruptions or mistakes at the regional supply center.

The nurses described their practice when the nurses need materials which are not featured in their own warehouse. Then they can either order it and receive it the next day, or borrow it from another unit, clinic or ward who might have it in stock. The solution to this problem could be to have a central warehouse digital overview for all items at each hospitals department. In that way all nurses in the hospital can check what the other department has in stock. Putting less stress on what nurses need to remember could possibly enable better care for patients.

Decentralized storage improves the flow of products, for example moving slow-moving products further behind in the supply network. In addition, decentralized supply network for delivery in the AURA framework is recommended for slow-moving products. This could further save both capital and resources and could provide the hospitals with an overview of

products hospitals have and need in storage. Such an overview could be enabled through the use of ERP-system.

## **5.7 The implications of the new warehouse structure**

“The implementation of the new logistics is successful and leads to more time for care personnel to care for their patients” according to the logistics leader. Wards and other units, which have their warehouses operated by the logistics personnel, seem to have better experience with direct shipments from the regional supply center. Wards and units where nurses operate their warehouse themselves receive no guidance from the logistics department about how to deal with changes or disruptions in the flow.

Support of dedicated logistics personnel in the ward or unit could improve flow of products, and further strengthen collaboration with the regional supply center.

It could be argued, according to the logistics leader, that the implementations of the new warehouse structure are more successful for wards, than for specialist units. This could be explained by the fact that a medical ward uses less advanced equipment than an ICU.

Therefore, ICU have some difficulties to source and receive their products, according to the ICU nurse. The less advanced equipment of medical wards is easier to manage since there are many other units like them in the hospital. However, in each hospital there are only one or two ICU's.

Larger hospitals have less problems with the sourcing of products, as they have more supplies in their central warehouse. A wider variety of products make hospitals less vulnerable to disruptions, as their security stock is in closer proximity when disruptions happen. Furthermore at large hospitals, the units are consequently in need of a more locally secure source. On the other hand, smaller hospitals also need to make their supply chain operations resilient, even though they use less material.

## 5.8 What is resilience?

Now all the resilience assets are covered and analyzed. However, some of the interview subjects provided the researcher with some closing remarks. At the end of one of the interviews, one of the interview subjects asked, “What is resilience for hospitals?”. The interview subject by this question elaborated the differences of the meaning of resilience for hospitals compared by production companies or other companies.

“What is a strategic product for a hospital? I’ve never thought I had a serious problem sourcing toilet paper.” For hospitals there are multiple strategic articles. How do you really define what is strategically important for hospitals to have in stock. None of the classic approaches work, mostly since hospitals in developed countries such as Norway, hospitals don’t have any profit. They are a non-profit driven organization. Sure, the products come in huge quantities and are super important to a large number of activities, such as prefilled syringes with salt water. There are substitutes for prefilled syringes, as they have both salt water and syringes. The Kraljic matrix doesn’t provide much help either, as many of the items are required to treat specific illnesses and are less important in the treatment of other illnesses. Since there is such a large spectrum of illness and a large spectrum of treatments, it is hard to point out what are really the strategically important products to have in stock, and which is not strategically important. Drugs could also be analyzed in the same way, after quantities order and different treatment used, but what about the patients who needs the less important drugs? The focus for hospital efficiency and resilience must include the patient activities in the hospital and therefore the logistics and procurement should focus on patients and treatment, not what would make them the most money. The same interview subject said “The logistics department's most important task, to ensure continuous operations are garbage collection. Without waste collection the hospitals have to shut down mid-day.” Garbage collection is important as it ensures mobility of personnel and the continuing operation of the different departments. Without it, the hospitals would be an unhygienic place and consequently this could prompt new diseases. Resilience is not the same for hospitals and other health care providers as it is for, e.g. manufacturing companies, due to the nature of hospitals' operations.

## 6 Conclusion

This case study aims to investigate hospital supply chain resilience in one Norwegian regional hospital by the perspectives of nurses, logistics personnel and logistics leader using the AURA framework assets as a theoretical lens.

This investigation found that hospital supply chain resilience is influenced by consumer practice in various ways. The AURA-frameworks plan assets need to be openly communicated and supported. The plan needs to be embedded at all levels of the organizational levels and the operators of the warehouses. The plans need to be developed using interdisciplinary knowledge and they could be supported by other organizations, such as Hospital procurement. Resilience asset sourcing could be improved by at least dual sourcing their strategically important product. Furthermore, professionalizing warehouse management in all wards and units leads to more time for medical professionals to tend to their patients. However, the practice of single-sourcing products has led to the creation of monopolies and damaged competition nationwide. The findings related to the make assets imply that the hospitals generally are resilient, as disruptions have never hurt their patients. Avoiding that patients are hurt due to supply chain disruptions is possible because of a good collaboration between the different professions working together towards a common goal. Last but not least is the delivery assets where the new warehouse structure could imply problems for nurses providing care to their patients when they are close to running out of strategic medical consumables. Therefore, hospitals specialist department requires local security stocks.

Resilience needs to be implemented throughout the organization of Norwegian healthcare. Hospital procurement, regional health enterprises and their regional supply centers, health enterprise both through their hospitals and their local purchasing department needs to improve their resilience procedures. It is only through a coordinated common approach to resilience, like with the help of the AURA-framework that the hospitals and health enterprise truly becomes resilient. Resilient to withstand the next pandemic with less stress on suppliers, procurement, logistics employees and medical professionals.

## 7 Research summary

Hospital resilience can be analyzed using the AURA-framework, where the first asset needed is the planning. Plans for hospitals are not widely known in the organization, and one responder didn't even know any plan. However, departments who manage their warehouse themselves have developed their own plan, this plan could benefit from input from professional logistics personnel. Developing a uniform plan for hospital resilience is hard. A uniform plan needs to take into account all the different objectives of the different departments, and therefore resilience plans could be developed on a departmental basis.

However multiple resilience plans could make sourcing harder. Sourcing and management of warehouses for some departments is done by professional logistics personnel under the current system. However, sourcing would be easier if the hospital procurement implemented additional award criteria in their competition documents, for now they only have cost and quality. Single sourcing of products makes production of healthcare services harder. The production of healthcare services is made easier by professionalizing the roles and thereby reducing the amount of waste and losses in the warehouses and thereby reducing the operating costs. Professional logistics personnel managing a department's warehouse gives better control over the warehouses and provides medical professionals with more time to perform their patient-oriented tasks. Interestingly, according to my participants disruptions have never hurt patients. However, disruptions have maybe hurt patients, and responders didn't trust the researchers enough to say it. However, the unrepresented achievement of never harming patients was made possible due to a new warehouse structure, where the supply of department warehouses is managed centrally and thereby providing managers with better forecasting data which makes it easier to calculate economic of scale benefits. To end this paragraph, it could be beneficial to mention that resilience for hospitals is quite different than what it is for production companies.

## 8 Managerial implications

Hospital resilience has similarities with resilience of a production company. Production companies have more available knowledge and scientific studies centered on their resilience. So far, hospital resilience has less published knowledge around their resilience. However, if hospitals were operated as a production company their resilience would look quite different.

In the first round of assets, the companies need to develop plans for how their resilience would evolve during disruptions. In production companies not everyone knows about these plans for what happens in the case of disruptions, so does not some nurses. Nurses at other departments, however, had to develop their own resilience plans, which would be unthinkable in a production company. Therefore, hospitals should try to involve both staff and professional resilience planners in the planning for a resilient supply chain which can withstand regardless specific or more general disruptions. These departments tend to not take into account what that department actually needs. Some departments don't receive the support they need to either make room for new products or face their new responsibilities. These departments are more on their own when they are both making plans and storage of materials. The support activities such as Hospital procurement don't support health enterprise according to their needs when it comes to assessment of resilience. Hospitals need help to develop their plans for what they will do when disruptions happen. Production companies also source their products in a more resilient way than what hospitals do. This is because they recognize the role strategic products play in their production and therefore, they either collaborate closely with their supplier or at least dual source these products. In Norway, the procurement agency Hospital procurement doesn't use more than two award criteria, and this makes the organizational readiness for when disruptions happen quite low. However, the hospitals have implemented professionalizing of the roles which logistics plays on their organization and thereby making a foundation for future improvements of the healthcare supply chain resilience. Professional employees working together to create the best possible plans based upon interdisciplinary between the employees would significantly improve the resilience and make it easier to efficiently develop the organization's resilience. One department cannot do this on their own, production companies do not let their every department plan and source their resilience independently either.



However, according to the findings of this case-study, supply chain disruptions have never harmed patients, which points to the hospital resilience being adequately system.

Since health enterprises and their supply chain partners have such good resilience that supply chain disruptions never harmed a patient, this point towards a quite resilient system. However, in some instances the supply chain has created problems for the nurses in the ICU which could be adverted if the ICU and the regional supply center made a better way for them to communicate. Since an ICU has many different machines and tubes that they need in order to care for their patient, it should be a security stuck locally at each hospital to ensure that the tubes and nozzles fit to the machines.

Overall Norwegian health enterprises and their hospitals has a quite good resilience. This resilience is closely linked to the resilience of their regional supply center. Consequently, this makes each hospital and health enterprise not that resilient individually, but if they had their own disruptions plans for what they could do on top of what their supplier can do, this could strengthen their resilience. One such measure is to implement local security stock. This security stock could either be on a health enterprise level or at a hospital level. One suggestion could be to utilize the efficiency of the regional supply center in everyday operations and have a security stock at health enterprise level for strategically important products for departments such as medical wards. Departments such as ICU and surgery should have this security stock at a local hospital level due to different machines and acute need when the need first arises. Having a health enterprise level security stock would decrease the amount of capital tied up in department security stock, and simultaneously maintain the benefits of security stocks.

The importance of having well developed plans and implementing these in both the sourcing of products and production of service is important. Today the system is very efficient and based upon normal operating conditions, which makes unforeseen problems harder to meet. Today's system is lean with few resilience elements present making a potential response harder, as the quantities to supply becomes too large for the supplier to handle. In the present system Norwegian hospitals are trying to be resilient, but they still have a way to go in order to truly become resilient. Resilience also prepares health enterprises and their hospitals for the next pandemic.

## **9 Limitations of study**

This study is limited in the way of it being a case study from one specific Norwegian health enterprise, which health enterprise is unfortunately kept a secret due to the possibility of uncovering the informants to the study if the health enterprise were known. Even other Norwegian hospitals might not have the same circumstances as this health enterprise, due to different organization of the different departments within the hospitals. To sum up, this study's findings cannot be seen as transferable to any other hospital, as it requires specific context to be relevant for other researchers.

Another limitation of this study is its structure. This study is based upon a qualitative research method, meaning it is a picture of the current situation: If another researcher would interview the same interview subjects at a later point the opinions and data would have changed. If another researcher were to investigate the same topic, within the same organization it is advised to change the questions in the interview guide. Changing the questions could ease the process of analyzing the data and thereby produce another and probably more satisfactory result. This case study was conducted in the aftermath of the covid-19 pandemic which highlighted the weaknesses of healthcare supply chain structures and at a later point in time the interest for this field of study might decrease and therefore produce other results than the results of this investigation.

It also had to be said that the researcher didn't interview Hospital procurement, so they couldn't comment on what the interview subjects said. Therefore, the interview subjects subjectively answered are unanswered, by those who are framed.

## **10 Further research**

Healthcare supply chain is a rapidly emerging field of study and therefore further research into the topic of healthcare supply chain resilience is quite important to improve the sector. Further research could be done through involving more decision makers in the study. Another interesting way would be to obtain the ABC analysis of different health enterprises and compare them.

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# Article: A case study to investigate Norwegian hospital resilience using the AURA framework

## 1. Introduction

Norwegian hospital supply chain resilience was severely challenged during the Covid-19 pandemic. Norwegian hospitals lacked essential equipment, like personal protective equipment (PPE), to handle the anticipated large influx of patients. The resilience of the Norwegian hospital's supply chain is based on its capability to source necessary and strategic medical consumables. Resilience in Norwegian hospital supply chains is built through the cooperation between the organization's Hospital procurement (Sykehusinnkjøp), regional supply centers, the hospital logistics department and the clinical units and wards. There is a lack of published knowledge about Norwegian hospital resilience and the use of any framework to do this (Alemsan and Tortorella 2022). The Active Usage of Resilience Assets (AURA) framework is a newly developed resilience assessment framework that this case study aims to explore concerning the hospital supply chain.

Resilience in the healthcare supply chain is described in different ways. Generally, in the Western world, hospitals have many challenges (Ageron, Benzidia, and Bourlakis 2018; Wieser 2011). However, hospitals operating in different countries have different challenges. There have been comparative studies on resilience in different countries, where developed countries have better resilience than developing countries (Kritchanchai, Hoer, and Engelseth 2018). Productivity and customer satisfaction increased when the logistics management outsourced hospitals or pharmacies their logistics to a private provider (Chen, Hsu, and Lee 2019). On the more operational level, multiple studies are published on how lean can be implemented in hospitals to increase productivity (Alemsan and Tortorella 2022). Hospitals could benefit not only through the application of lean in their process but also through digitalized logistics processes, especially the patient's information (Beaulieu and Bentahar 2021). Digitalization could help hospitals in their effort to modernize their procedures. Hence, they are closer to the level of other enterprises in other sectors, especially the logistics and data need to be patient-centric (Roy, Prasanna Venkatesan, and

Goh 2021). This makes the hospitals more patient-centric, which digitalization could contribute to; digitalization could significantly improve the hospital's resilience and profitability (Rehman and Ali 2022). Another way to increase hospital resilience is by applying centralized purchasing groups, which would help generate new ideas and improve profitability and resilience (Patrucco, Luzzini, and Ronchi 2016). However, recently, the hospital systems in many countries were/ and are still under immense pressure to ensure the availability of critical strategic materials during a pandemic. In Scotland, they implemented a series of different local actions to battle the enormous strain pandemic put on their supply chain (Scala and Lindsay 2021). Hospitals in different countries acted differently on the shortage of the pandemic posts (Vecchi, Cusumano, and Boyer 2020). However, none of these studies has compared how different professionals in the hospital describe resilience. Most of these studies have either explored the different other challenges hospitals face in a global setting or the effect of an intervention or change. Other studies have reported on the new potential digitalization of their logistics process. Recently researchers have discovered how the supply chain of hospitals challenges their ability to provide adequate care for their patients (Beaulieu and Bentahar 2021). None of the studies the authors of this article found describes the perspectives of the personnel who provide care to patients perceive supply chain resilience. To limit this study, the supply centers, which other researchers have described are excluded.

There is a lack of published knowledge about Norwegian hospital resilience and the use of any framework to do this (Alemsan and Tortorella 2022). The Active Usage of Resilience Assets (AURA) (Ivanov 2022a) framework is a newly developed resilience assessment framework which this case study aims to explore in relation to hospital supply chain. Studies describing how supply chain resilience is described by personnel closest to where patientcare is produced, has not been found in literature searches during the work with this study

This case study aims to investigate hospital supply chain resilience in one Norwegian regional hospital by the perspectives of nurses, logistics personnel and logistics leader using the AURA framework assets as a theoretical lens.

**Research question:**

**How do leaders, logistics personnel and nurses describe hospital resilience?**

## 2. Literature review

Supply chain management rose as a scientific discipline through the latter half of the 20<sup>th</sup> century. One of the best-known ways to classify the different goods the purchasing organizations buy is the Kraljic Matrix (Kraljic 1983). The Kraljic matrix defines what articles are strategic, leverage, bottleneck and non-critical items. The strategic items are items the organization can only operate with; substitutes cannot easily be implemented. The relationship between the supplier of these items and the customer is usually very close since these items are essential to the buyer (Bynhildsvoll 2018). However, this classification needs to include more about how the organization as a whole can be resilient. Organizations need to support their resilience strategy through concepts, not just through classification of their inventory. Organizations need frameworks. The AURA framework is one such concept which means the organization must actively use their resilience assets (Ivanov 2022a). The AURA framework is shown in figure nine below.

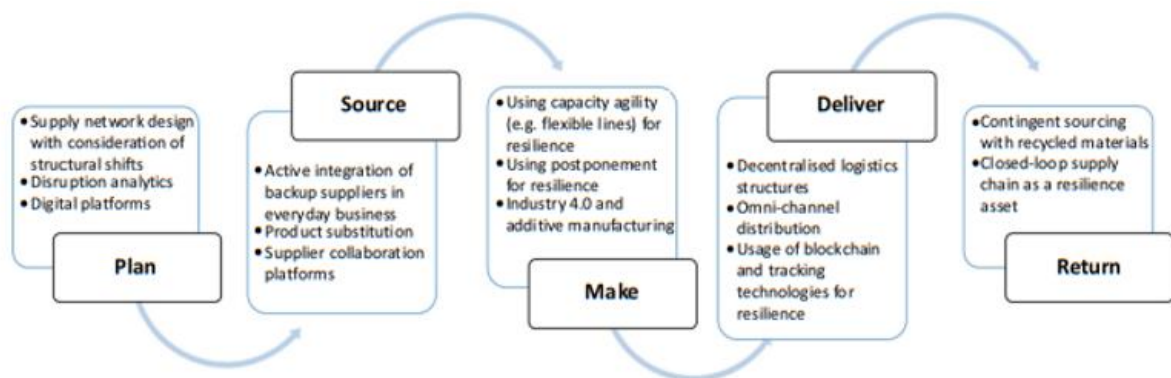


Figure 9 9: The AURA framework by D. Ivanov (2022)

The Aura framework consists of five assets. The first is the plan, where the organization prepares and plans for possible disruptions. The second asset is the source dimension, where the organization sources the products, they need to limit disruptions' effect on the organization through actively integrating backup suppliers in everyday business, which is also at least dual sourcing a product. Another essential element is to find products which can substitute products used today. The last element of the source assets is supplier collaboration, often done on digital platforms. The third asset is how the plan and source are implemented into the production. The make, dimension describes production techniques to make manufacturing companies more resilient through the postponement of production, capacity agility and industry 4.0 production strategies. The fourth dimension is the deliver dimension which is about how the products are delivered to the customer

through a decentralized distribution network and utilization of tracking technologies. The last dimension is the return dimension, where used products and manufacturing waste are turned back into materials used in production to make a short cycle and hence easier to manage (Ivanov 2022a). These five dimensions make production companies more resilient, but how can health care become resilient?

Healthcare as an industry is digitally underdeveloped compared to other industries. Generally, healthcare supply chain management is twenty years behind other industries, such as food and retail (Beaulieu and Bentahar 2021). Hospitals could increase their logistical performance by implementing centralized purchasing and procurement (Kritchanchai, Hoer, and Engelseth 2018). Outsourcing functions to the private sector and outsourcing logistics improves the system's overall performance and makes the patients more satisfied with the service (Chen, Hsu, and Lee 2019). Further, centralizing the hospital unit storage could give medical staff more time to tend to their patients, resulting in better treatment (Ageron, Benzidia, and Bourlakis 2018).

During the recent pandemic, hospitals faced unprecedented problems. The Scottish NHS and its logistics arm, NSS, needed to prepare for disruption on this scale. In Scotland, the costs associated with procuring medical equipment rise by ten times as much. The disruptions made it harder to source products from their global suppliers. The global suppliers also had a longer lead time involving multiple connections at ports/airports, which were also affected by the pandemic. A solution where to create multiple sourcing teams to find alternative ways to source the products needed. Another way was to establish local product suppliers, which could be a welcome extra income during the pandemic. The local suppliers help the country recover faster because local economies are strengthened. Local suppliers were also credited for establishing a "Made in Scotland" badge to raise awareness of local production during the pandemic (Scala and Lindsay 2021). Similar studies are not found from a Norwegian context.

### **3. Case description**

In Norway, the hospitals are owned by the government and not by the region as in other countries, such as Sweden. The Ministry of Health and care services are in charge of all four Norwegian regional health enterprise based upon existing geographical subdivisions of the country (Lægreid, Opedal, and Stigen 2003). The regional health enterprise consists



of three to seven health enterprises, like Oslo University Hospital (Roosa Tikkanen 2020). This health enterprise usually consists of two to four somatic hospitals and at least one psychiatric hospital. The regional health enterprises and health enterprises handle support services. The handling of support activities such as pharmaceuticals and central purchasing is done by specialist health enterprises and owned collectively by the four regional health enterprises. Three out of four regional health enterprises either operate or building a regional supply center for the hospitals in their region, which then sends requested consumables to each hospital. Logistics within the hospitals deal with deliveries and operate most of the hospital ward's warehouses. At the same time, the information is scanned and sent to the regional supply center, as observed in figure 10. The logistics department operates but receives the required amounts from the regional supply center.

## Flow of products within a hospital enterprise

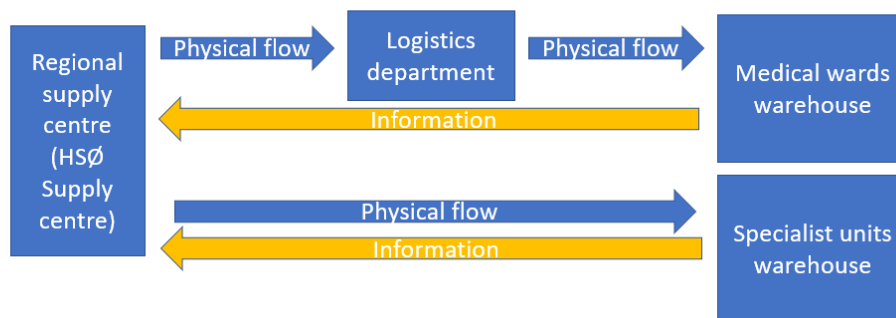


Figure 10: The flow in the hospitals

Due to this organization, Norwegian hospitals generally have high resilience. The national purchasing agency handles these agreements. This organization negotiates significant economies of scale and establishes Norwegian hospitals as enterprises with power over their supplier due to their share size. Each health enterprise has its own purchasing department handling purchasing agreements of lower value or hospital-specific purchases. The purchasing agreements place the fundament from which hospital suppliers can purchase their materials. This material is then supplied to a regional supply center and onwards to each hospital.

## **4. Methods and Data**

This study used a qualitative case study approach to describe how do leaders, logistics personnel and nurses describe hospital resilience in Norwegian hospitals.

The method is a semi-structured interview, and the analysis method was inspired by SDI methods or Step by Step deductive, inductive methods (Tjora 2021). The first step of this method is to read inductive interviews to create codes. The codes are the essence of what the interview subjects said. Similar codes are then formed into code groups. These code groups are then discussed to create concepts. The concepts are then, through applying existing theories to create new theories, hopefully answering the research question (Tjora 2021). This chapter describes the entire process, from recruitment to analyzing methods.

Afterwards, the interviews were conducted flexibly for each interview subject at the workplace or digitally. First, the researcher found two interview subjects, and these two found the rest of the subjects through snowball recruitment methods (Tjora 2021). Each interview subject was recruited based on their knowledge and opinion. This led to the prequalification of the interview subject, which worked remarkably well; however, other scientists could have done better trying to replicate or enhance this study due to the recruitment process.

### **4.1. Participants**

Originally the plan was to conduct 6 personal interviews with three groups from a hospital setting. The first step in the recruitment process was to grant permission from the hospital enterprise leadership, and one informant from the leader-group was recruited in this process. Then one local hospital logistics department was approached by email, and three informants were recruited. The researcher found two interview subjects and these two found the rest of the subject through the snowball recruitment strategy (Tjora 2021).

The aim was to recruit two nurses from two different wards. By using the snowball-method one nurse from an intensive care unit (ICU) and one from a medical ward were recruited.

## **4.2. Data collection methods**

The interview guides were based on semi-structured interview style due to the main aim of this study, to investigate the phenomenon, not validating existing knowledge (Tjora 2021).

In this study, 3 personal interviews and one focus group interview were conducted, in three samples. Within the sample of logisticians, the interviews were conducted as one group interview. The interviews with the leader and the nurses were conducted as individual interviews. This choice was based on a pragmatic framework and ontological belief, where reality is known by using tools of research that reflects what is practical and what works (Creswell and Poth 2018). Time was a straining factor in this face and led to the choice of different approaches to the interviews in order to not lose any participants.

The interviews were conducted using a flexible approach to the interview setting and by each interview subject's choice, either at the workplace or digital.

Each interview subject where recruited based on their knowledge and on the scope of the study. This led to a kind of prequalification of the interview subject, which worked remarkably well, however other researchers might face problems when they are trying to replicate or enhance this study due to the recruitment process.

## **4.3. Analyze method.**

The SDI method by Tjora (2021) is a method for analyzing qualitative data in an efficient and secure way.

The first step of this method is to read inductive interviews to create codes. The codes are the essence of what the interview subjects said. Similar codes are then formed into code groups. These code groups are then discussed to create concepts. The concepts are then, through the application of existing theory to create new theories which then hopefully answers the research question (Tjora 2021)

This method is based on grounded theory where the purpose of the study is to examine and discover a specific field, also called a case study. A case study has its weaknesses, like not necessarily being possible for other scientists to do the same study in other contexts. But the use of SDI-method in the analysis provides credibility and transparency to the process.

## 5. Results

Three overall concepts were generated, and these are presented as results in this chapter.

The three concepts are based on plan, source and deliver assets of the AURA-framework.

The concepts are:

- 1) A resilient plan needs to be openly communicated and supported,
- 2) Sourcing of products is difficult due to different focus, and
- 3) The hospitals have suboptimal purchasing agreements.

### **5.1. A resilient plan needs to be openly communicated and supported.**

This first concept is related to the plan area in the AURA framework. The hospital has a plan in case of supply chain disruptions. Generally, if it takes too long for the supplier to send them the product, someone must contact the purchasing department, either the local department or Hospital procurement. The analysis showed that the responsibility of contact purchasing depends on the clinic, unit or ward. For instance, the ICU nurse said,

"We must contact the purchasing department in question ourselves". Nurse from ICU dep.

This statement reflects the differences in the warehouse structure, this nurse's department differs from other departments with another warehouse structure. The medical ward nurse said the logistics department manages her warehouse. According to the logistics personnel, when clinics, units and wards have their warehouse operated by the logistics department, the logistics personnel are responsible for ordering the missing product. An openly communicated plan is only useful when it is known and communicated, but this nurse describes their practice as being outside the plan.

“Some departments within the hospital have the logistics department to operate the warehouse on behalf of the ward/department and therefore we handle missing products and potentially finding other products to substitute the given product. We receive help from local purchasing department to do this.” Said the logistics personnel.

When departments operate their warehouse themselves, then it is the ward personnel who has to contact purchasing. What purchasing department to contact depends on whose purchasing department is responsible for the purchasing agreement, local purchasing, or hospital procurement. However, the local logistics department contacts the local purchasing department to get them to source the missing product from an alternative supplier, while departments managing their warehouse themselves must source an alternative product themselves. This alternative supplier search then comes as an extra task for their employees during a probability hectic workday. Within each health enterprise they should establish comprehensive plans to deal with different supply center and use specialist in the field to make them. An openly communicated and supported plan is a essential.

## **5.2. Sourcing strategic products differs between the different actors in the chain**

The second finding is that the assessment of strategic products differs between different actors in the chain. The nurse at the medical ward said that it would be prefilled syringes with salt water for her department. This is a strategic article because they are used in large quantities daily, in many different treatments, and the substitution demands time-consuming alternative tasks. However, the nurse from the ICU touched upon this product too but quickly discarded it because they are easier to substitute for her department. The

ICU nurse discussed the strategic importance of tubes for their machines and pads for their defibrillator. These products are essential because they are hard or impossible to substitute and require different procedures and extra equipment, which must also be ordered.

“The pads for the defibrillator is hard to find because the ICU is the only department which uses pads based defibrillator, and it is rarely used,” according to the ICU nurse.

An ICU generally has patients who generally are more ill than a medical ward, and therefore, they use a machine to stabilize their patients, which wards do not use. These machines use tubes of given dimensions, and changing tubes means changing tube dimensions. Therefore, the nurses have to order nozzles to make the tubes fit the machines. The procedures, which are quite time-consuming to change, also have to be changed, and therefore, the share amount of time and resources involved for an ICU to change tubes is large. Therefore, these are strategic items for them, based on how hard it is to substitute them. To sum up, the focus group of logistics employees said that, for the most part, the strategic items are the same for all departments in the hospital.

“Generally, every department has the same strategic products, while some specialist units might have other strategic products which they need to prioritize” said the logistics employees at the local hospital.

Further, the manager reflected upon the term resilience for him in the role/function of a department leader in a hospital context. In his view, categorizing an item as strategically inventory/item is complicated. He exemplified this by concluding that garbage disposal is the most important task for his department. To sum up, it could be pretty hard to list what is a strategically essential product because different employees have different views of it based on their reality.

### **5.3. Delivery of products is based on suboptimal agreements.**

The third interesting point is that Hospital procurement seem to have suboptimal purchasing agreements.

“The purchasing agreements of Hospital procurement usually only use price and quality as award criteria. This leads to critical stages in resilience, needing to be included in agreements.” Said the logistics manager.

If the sourcing of products is as described in the AURA framework (Ivanov 2022a), the organization must be more resilient. Hospital procurement, by not incorporating and due to their practice, leads to only one supplier receiving all the volume in the purchasing agreement. Single sourcing is not resilient because if this sole supplier of products, then experiences a disruption, the entire supply of these materials is hit. The logistics manager mentioned that he had tried to get Hospital procurement to include at least a double source of their product, but they would not. Since Hospital procurement negotiates regionally and nationally, giving the entire volume to one supplier leads to a lack of competition.

In one instance, the supplier of peripheral vein cannula had a disruption at their Serbian factory. Since this was a regional agreement for Health South-East, which stands for fifty per cent of the demand nationally, the supplier to other regional health enterprises could only fulfil the demand if it was of lower volume. The most logical, then, is to multi-source and split the significant demand between different actors in the market. More actors in the market would also benefit the hospital and other buyers positively because today, markets are too tight.

“If a supplier loses the hospital demand, they will leave the country under the current system. This practice from Hospital procurement has helped with, on one occasion, developing a monopolist, which is bad for competition and illegal (Norwegian government 2022). Establishing a monopoly, in this case, within washing of clothes where one supplier Nortekstil where able to build up a nationwide coverage for washing clothes, which affects other nationwide companies too.” Said the logistics manager critically.

## **6. Discussion**

The three code groups are discussed in the context of knowledge about the case and the AURA resilience assessment framework to create concepts.

### **6.1. How plans could be done better**

A plan is only good if it is known. The plan is in case of lengthy supply chain disruptions, i.e., empty warehouses. When disruptions of product deliveries occurs, the department in charge of the warehouse contacts the purchasing department.. However, the support from purchasing varies greatly. If the logistics employees manage the warehouse, they will find substitutes with help from the local purchasing department. Departments that manage their warehouse themselves have to take on this task on their own, with little help from purchasing. This unfair distribution of support from the local purchasing department could be due to more frequent contact between the logistics and local purchasing department on the matter, and they have established common knowledge and understanding of how this process proceeds.

On the other hand, the specialist units could need help even more than the logistics department. Since the ICU has less contact with the local purchasing department, at least on the department level, than the logistics department, this cooperation isn't as mature yet. The units and wards with dedicated logistics personnel from the logistics department have their own specialist in the matter and professionalization of the role (Patrucco, Luzzini, and Ronchi 2016). While in the ICU, the staff has more time with each patient, even with substantial responsibilities, than the medical ward nurse.

During the interviews, one point came forward, why doesn't procurement engage more in finding substitutes? It is, after all, their purchasing agreements. Maybe it is outside of their jurisdiction, or they need to be more staffed. In the AURA framework (Ivanov 2022a), the procurement department is to work actively with resilience, while in hospitals, they seem to assess resilience to a lesser extent. Procurement specialists know the market way better than nurses; therefore, it is remarkable that procurement engages as little as they do. These procurement specialists (Mandal 2017) would also know of a product that could substitute and source a substitute for the missing product. Oversight and coordination are crucial elements in the healthcare supply chain, but they need to be there regarding resilience.



Departments have to find substitutes themselves, which take up their time unnecessarily. Hospital procurement needs to catch up, while the local purchasing department does help on a limited scale.

However, if the product supply difficulties continue, the product or the more likely product category is put under the supervision of a particular office in Oslo. This office then coordinates the volumes each hospital receives. Coordinating volume is called rationing and happens quite often. Over one hundred products can be set under rationing from time to time hospital wide. The rationing office then collects the demand from all the hospitals in the regional health enterprise and decides how much each hospital receives from this product—leading to a need for certain products and difficulties for employees to find an alternative. A solution to this problem would be to produce products within Norway to shorten communication and lead times. As they did in Scotland (Scala and Lindsay 2021), the region's health enterprises could achieve a higher degree of control of their supply chain. The second benefit is that they could cooperate to optimize the supply chain and product development to ensure a secure supply of this product on a national level. This would make the sourcing of these products more accessible. However, the broader organization has barriers to improving the purchasing agreements.

## **6.2. Sourcing could be done differently.**

Resilience is not only a problem regarding hospital procurement and the need for more engagement. The AURA framework (Ivanov 2022a) is based on manufacturing companies where they can change the production lines and clearly define what products are strategic for them. A hospital has many different wards, units, and clinics, each with its essential strategic products. Which makes sourcing all kinds of products harder because the number of strategic products needs to be more significant. The need for storage for all these products also leads to large security stocks. Resilience is, after all, how well the performance of an organization is in the case of disruption, and how well their recovery is. In a hospital, there are also patients, each with their own illness and treatment. One patient's illness and corresponding treatment could differ from a patient with the same illness. The hospitals' performance is measured in how well they manage to treat these patients for their illnesses, and therefore it is hard to find a strategic product because that

can change from patient to patient. A hospital cannot turn patients away because they cannot treat their illness. The hospital must treat them regardless. This highlights one of the significant difficulties in hospital resilience; the variety is too great. The variety is highlighted when asking the nurses and logistics department what an essential article for their department/hospital is. The ICU nurse mentioned that tubes for their machines and pads for their defibrillator are strategically vital to them, as also mentioned in the findings. The medical ward nurse said prefilled syringes with salt water. However, this article was not crucial to the ICU because they have substitutes or can fill the syringes themselves. However, filling syringes themselves would take a significant toll on the resources available at the ward because the nurses have more patients to tend to than ICU nurses. The logistics personnel said that the hospitals usually have the same strategic article. Strategic items could be a range of products that make care more efficient or products without substitutes. These products without substitutes have a security stock in the local warehouse because of the difficulties faced in using substitutes, as the findings from the interview with the ICU nurse show. The different view of what resilience is imminent. For the wards, it is a product which makes their work more efficient and gives them more time to care for their patient, and thereby becoming more patient-centric (Roy, Prasanna Venkatesan, and Goh 2021). For the ICU, it is a product in which they can only provide care to their patients with significant difficulties in ordering additional nozzles and changing procedures. However, the management has a different view; for them, it is what is hard to replace and how well they can manage without it. An email to the purchasing manager at the local purchasing department confirmed that her department only does a little in terms of resilience.

The logistics department has a range of different products in their product range, and this variety makes it hard to point out precisely what is essential. Like toilet paper, it is used in huge quantities, and the hospital cannot be without it. If they were to buy toilet paper for around eleven thousand people, they would empty an entire city's supply. The hospitals have faced problems in sourcing toilet paper, and in that regard, they faced problems finding alternative sources. Toilet paper is probably on a national or regional contract, making it even harder to source because the quantities demanded within a geographically limited area are too large for local suppliers to fulfil. One way to implement resilience in hospitals is based on a person's pyramid of needs from Maslow (Willy 2021) as long as the

patient has covered their essential functions such as breathing, eating and relieving themselves. The second tier could consist of products which make care safer, like prefilled syringes. Then it could be general equipment needed for their treatment, like tubes and PVC. These products are usually stored in large quantities; if they run empty, they could borrow from another department. Another way to implement hospital resilience could be to have one master plan for resilience and then one plan and one set of products for each department. Splitting the volume and variety could make it easier to source these products. Each department could be organized with the other departments at the other hospitals to make a focus group of employees together to find these products—the logistics employee, one nurse and one procurement specialist when needed. Then instead of needing nurses at each hospital, they could have one for four departments who voice the nurses' concerns if they need to do it through their department's dedicated logistics employee. Since all these departments, according to official strategy, will have their dedicated logistics employees sooner or later, they could work with the employees in the same position at other hospitals to create a resilience group. If one cannot source the product, the other hospitals cannot either. Sourcing would work best on a hospital organization level; it could be a too-large group on a regional health enterprise level. However, the regional supply center could use the resilience measures they have today. The hospital's resilience assets could then build on top of its resilience assets. Since the hospitals receive over seventy per cent of their transactions from the regional supply center, their resilience assets could make a fundament where they could be. Usually, disruptions have a negligible impact on the hospitals in the health enterprise because the regional supply center has a resilient system. However, there is still room for improvement.

### **6.3. Improving purchasing agreements**

The third and last aspect is resilience on the system level; hospital procurement needs to include resilience in their purchasing agreements, especially in award criteria. This was described by the logistics manager from the health enterprise, who has tried to get hospital procurement to include resilience. Therefore, Hospital procurement can be called obstinate because they are hesitate to change even though people are trying to advocate for change. The award criteria might be less critical, but only operating with two to three award criteria challenges resilience. The two award criteria are price and quality and sometimes

environment. So there needs to be more active use of resilience in the award criteria. The most important factor is that hospital procurement single sources everything (Ivanov 2022a). This delimits the resilience of Norwegian hospitals. The practice of single sourcing greatly challenges resilience since the volumes are so large that companies losing the tender would exit the market and consequently create monopolies.

Since the hospitals have single sourced their laundry service and gave Nortekstil national wide coverage, other companies also have to use Nortekstil. Especially, hotels have Nortekstil as their supplier, too, because Nortekstil were able to be nationwide thanks to the hospitals. Nortekstil could use access capacity or invest in new capacity to increase the size of the competition and conquer another business area with the stable and secure flow of capital from the hospitals.

Therefore, when disruptions happen, they need other suppliers to fill the gap in the country. During the pandemic, there was essential for Scotland (Scala and Lindsay 2021) to have local production of medical consumables. Hospital procurement also hurts other healthcare providers, such as the municipalities, because they have to use the same suppliers. Monopolies and duopolies are a form of market organization that hurts buyers and suppliers. The buyers have to pay more per unit due to lack of competition, and the suppliers have little incentive to innovate around the products and services they provide. Therefore, Norwegian hospitals will lack behind when it comes to resilience due to unwillingness and lack of incentive in the market. In one instance, Hospital procurement helped an organization become a nationwide monopolist, which hurt its market. However, at that scale, this market has relatively high entry barriers. Therefore, Hospital procurement should split up the volume to different suppliers to facilitate improvements in resilience, and maybe even one or two substitutes will enter the market.

## **6.4. Limitations**

In this article, information kept from being shared cannot be analyzed or discussed. This is a significant implication for this article as the interview subjects did not share some ground-breaking problems. Hospital Procurement should have been interviewed to answer for the claim in this article, unfortunately the author didn't have the opportunity to do so.

## **7. Conclusion**

Hospital resilience is a difficult topic, which demands a great deal of coordination and collaboration. It is key to collaborate both on the hospital, health enterprise and regional health enterprise level. All of these different functions need to listen to each other and collaborate better than what they do today. Nurses have different descriptions of resilience, depending on which department they belong to. ICU needs security stock of their strategic medical consumables. For a medical ward the system works efficiently to not require security stock. However, specialty units should have their own resilience plan. Leaders describe resilience as a quite wide term, because they meet the term in ways, they or other staff members never would imagine. For logistics employees it is their ability to supply the departments they operate the warehouse for.

Resilience in healthcare supply chain is after all only used to levitate the pressure from caring personnel, so they can spend more time with their patients. Logistics needs to ensure the supply of medical consumables so the health enterprise and its hospital can treat their patients.

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# Appendix

## 13 Application and evaluation to NSD, Attachment 1

09.05.2023, 14:36

Meldeskjema for behandling av personopplysninger



[Meldeskjema](#) / [Resilience assesment using AURA framework in hospital logistics](#) / Vurdering

### Vurdering av behandling av personopplysninger

**Referansenummer**  
235440

**Vurderingstype**  
Automatisk

**Dato**  
26.02.2023

**Prosjekttittel**

Resilience assesment using AURA framework in hospital logistics

**Behandlingsansvarlig institusjon**

Høgskolen i Molde – Vitenskapelig Høgskole i Logistikk / Avdeling for logistikk

**Prosjektansvarlig**

Birgithe Eckermann Sandbæk

**Student**

Øyvind Rinde Rusaanes

**Prosjektperiode**

13.02.2023 - 20.05.2023

**Kategorier personopplysninger**

Alminnelige

**Lovlig grunnlag**

Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet. Det lovlige grunnlaget gjelder til 20.05.2023.

[Meldeskjema](#)

**Grunnlag for automatisk vurdering**

Meldeskjemaet har fått en automatisk vurdering. Det vil si at vurderingen er foretatt maskinelt, basert på informasjonen som er fylt inn i meldeskjemaet. Kun behandling av personopplysninger med lav personvernulempe og risiko får automatisk vurdering. Sentrale kriterier er:

- De registrerte er over 15 år
- Behandlingen omfatter ikke særlige kategorier personopplysninger;
  - Rasemessig eller etnisk opprinnelse
  - Politisk, religiøs eller filosofisk overbevisning
  - Fagforeningsmedlemskap
  - Genetiske data
  - Biometriske data for å entydig identifisere et individ
  - Helseopplysninger
  - Seksuelle forhold eller seksuell orientering
- Behandlingen omfatter ikke opplysninger om straffedommer og lovovertrедelser
- Personopplysningene skal ikke behandles utenfor EU/EØS-området, og ingen som befinner seg utenfor EU/EØS skal ha tilgang til personopplysningene
- De registrerte mottar informasjon på forhånd om behandlingen av personopplysningene.

**Informasjon til de registrerte (utvalgene) om behandlingen må inneholde**

- Den behandlingsansvarliges identitet og kontaktopplysninger
- Kontaktopplysninger til personvernombudet (hvis relevant)
- Formålet med behandlingen av personopplysningene
- Det vitenskapelige formålet (formålet med studien)
- Det lovlige grunnlaget for behandlingen av personopplysningene
- Hvilke personopplysninger som vil bli behandlet, og hvordan de samles inn, eller hvor de hentes fra
- Hvem som vil få tilgang til personopplysningene (kategorier mottakere)
- Hvor lenge personopplysningene vil bli behandlet

<https://meldeskjema.sikt.no/E3de7850-40bd-4c50-92bd-bb66c04e051c1/vurdering>

1/2

09.05.2023, 14:36

Meldeskjema for behandling av personopplysninger

- Retten til å trekke samtykket tilbake og øvrige rettigheter

Vi anbefaler å bruke vår [mal til informasjonsskriv](#).

**Informasjonssikkerhet**

Du må behandle personopplysningene i tråd med retningslinjene for informasjonssikkerhet og lagringsguider ved behandlingsansvarlig institusjon. Institusjonen er ansvarlig for at vilkårene for personvernforordningen artikkel 5.1. d) riktighet, 5.1. f) integritet og konfidensialitet, og 32 sikkerhet er oppfylt.



## **14 Interview guide for logistics staff, attachment 2**

### **Summary of study**

The COVID-19 pandemic has led to one of the major supply difficulties of our time. This pandemic affected everyone. Organizations around the world implemented plans to become more resilient, to reduce the impact the pandemic had on their organization. This has led to interest in looking at how hospitals are adapting. In particular, whether the systems are resilient enough when there is a sudden interruption in supply and how this affects the operation of the service internally. This master thesis aims to map and describe the resilience of one health enterprise.

This work is a master thesis in logistics at Molde University College.

### **Interview**

- 1: How long have you worked in the department?
- 2: Have you worked in the field for a long time?

### **Plan level**

- 1) Does your hospital have a plan to deal with a situation where you cannot get an item into stock?
- 2) Can you use internal resources to source this article outside the existing supplier? Has this happened? Involve the purchasing department?
- 3) Do you have alternative suppliers if you have backorders, if yes: When are these used, if no, which consequences appears

### **Source assets**

- 4) Are there variations in the time it takes to get goods into stock?
- 5) How often are there backorders (approximately once a week, several times a week?)
- 6) If there is a backorder, what do you do?
- 7) Do you have one or more suppliers who provide most of the goods?
- 8) Do you and your supplier use a common ERP system?
- 9) Do different suppliers supply the same article? Do you have multiple suppliers for the same article?

### **Making/production of health services**

- 10) Can you describe if you know of alternative ways to get articles? E.g. from other hospitals within your HF? Other ways? Deliveries from other hospitals?

11) Do you have articles inside that are not in daily/regular use? Articles that are used e.g. 1 in half a year

### **Delivery/storage structure**

12) Has the hospital reorganized/changed its warehouse structure in the last 10 years? 13) When was this reorganization introduced?

14) What did the reorganization consist of?

15) Do you think the resilience of hospitals has changed after the reorganization?

16) Does the hospital use one centralized distribution system (Ex, from one supply center)?

17) Does each hospital have its own security stocks or are security stocks also centralized?

18) Do you use multiple distribution channels?

19) Do you use tracking technology?

20) Could it be applied to specific product groups?

### **End question**

What can the logistics department improve?

## **15 Interview guide for Intensive care unit nurses, attachment 3**

### **Summary of study**

The COVID-19 pandemic has led to one of the major supply difficulties of our time. This pandemic affected everyone. Organizations around the world implemented plans to become more resilient, to reduce the impact the pandemic had on their organization. This has led to interest in looking at how hospitals are adapting. In particular, whether the systems are resilient enough when there is a sudden interruption in supply and how this affects the operation of the service internally. This master thesis aims to map and describe the resilience of one health enterprise.

This work is a master thesis in logistics at Molde University College.

### **Introduction**

What are you most satisfied with when it comes to the storage structure at the hospital?

### **Plan level**

1) Does your department have plans for what to do if you don't have an item in stock?

2) What would you say are the department's most important goods?

**Source assets**

3) What do you do if you run out of these items? Have you ever run out of essential items?

4) Do you need goods that are not in the range?

5) What do you do with the treatment of patients if goods are needed that have not been delivered as ordered?

**Make/production of health services**

6) When an article has not been delivered as ordered, has it affected the treatment of a patient?

7) Have you had to postpone an operation on a patient because you did not have the item in stock? Postpone, cancel or transfer a patient to another hospital?

**Delivery/storage structure**

8) In your opinion, could the hospital change its resilience with a local safety stock?

9) How often are goods ordered?

10) Where do you order from? Central warehouse? Supply centre? External supplier?

11) Do you have a person responsible for the warehouse?

12) Has the consequence of lack of equipment for patient care changed compared to the previous structure?

**End questions:**

What do you think could be better when it comes to the warehouse structure?

## **16 Interview guide for medical ward nurses, attachment 4**

### **Summary of study**

The COVID-19 pandemic has led to one of the major supply difficulties of our time. This pandemic affected everyone. Organizations around the world implemented plans to become more resilient, to reduce the impact the pandemic had on their organization. This has led to interest in looking at how hospitals are adapting. In particular, whether the systems are resilient enough when there is a sudden interruption in supply and how this affects the operation of the service internally. This master thesis aims to map and describe the resilience of one health enterprise.

This work is a master thesis in logistics at Molde University College.

### **Introduction**

What are you most satisfied with when it comes to the storage structure at the hospital?

### **Plan level**

- 1) Does your department have plans for what to do if you do not have a medical consumable in stock?
- 2) What would you say are the department's most important goods?

### **Source assets**

- 3) What do you do if you run out of these items? Have you ever run out of essential goods?
- 4) Do you need goods that are not in the range?
- 5) What do you do about the treatment of patients who need goods that have not been delivered as ordered?
- 6) Do you need goods that are not in the range?

### **Make/production of health services**

- 7) When medical consumables have not been delivered as ordered, has the treatment of a patient been affected?
- 8) Have you had to postpone a patient's treatment because you did not have the item in stock?
- 9) How has it been handled? Borrowed from another department?

### **Delivery/storage structure**

- 10) Where do you order from? Central warehouse? Supply centre?
- 11) In your opinion, could the hospital change its resilience with a local security team?
- 12) Do you have a person responsible for warehouse one?
- 13) How often are goods ordered?

### **Ending question**

What do you think could be better when it comes to the warehouse structure?