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Understanding Healthcare Process:

The case of Pneumonia care at Skaraborg Hospital Group

Master's thesis in Quality and Operations Management

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SUMMARY

Pneumonia is one of the most common infections in today's society as well as the fourth largest cause of death worldwide. At Skaraborg Hospital Group (SHG) it has been noted that the pneumonia patient group is a complex one where patients characteristics vary, and a large part of patients have complex care needs. For the creation of a future pneumonia care process at SHG, it is therefore of interest to get an overview and understand the current pneumonia care.

The aim of this thesis is to explore and understand the care process for pneumonia patients at SHG with an additional focus on patients with complex care needs. The work has an iterative approach involving hypothesizing using quantitative data retrieved from SHG, as well as qualitative data collected using interviews with care personnel from SHG. Statistical analysis and process mining have been a part in analyzing the quantitative data. Improvement areas and recommendations have been based on literature on performance measures within healthcare as well as literature on areas of interest found from empirical data.

From the empirical findings and analysis five areas of improvement have been identified which would benefit the quality of care for pneumonia patients as well as care practice at SHG. These recommendations are presented in the order of execution. i) Reorganize the hospital to conform to a more value network-based logic, connecting wards with one another and improving communication. ii) Standardize the manner of information transfer in terms of creating a uniform way to write medical records and transfer notes. iii) Integrate and connect support functions i.e., physiotherapy, more strongly to the pneumonia care process. iv) Introduce a guideline in pneumonia care, which would consist of a clinical pathway and work towards a more value chain-based way of working. v) Measure the process, which includes collecting data on the pneumonia care process and use it to continuously keep track and improve it. The results provide a basis for future improvement work and process development for the pneumonia care process at SHG.

Keywords: healthcare, care process, pneumonia, complex care needs, process mining.

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1
Introduction

Today, society faces considerable changes in terms of population growth and longer life expectancies (Statistiska Centralbyrån [SCB], 2020). The implications of these changes and the challenges they impose on the healthcare system have frequently been discussed in literature (Stiernstedt et al. 2016; Hwang and Christensen, 2008; Kelly et al., 2019). Today, care needs are more varied than ever, ranging from simple needs to patients suffering from chronic diseases or multiple diseases, with very complex care needs (Lifvergren et al. 2012). All these needs call for different types of process logics (treatments and care plans), to be handled in an efficient way, where coordination between different actors is essential (Stiernstedt et al. 2016; Hwang and Christensen, 2008; Kelly et al., 2019).

Despite the shifting needs in care, healthcare in Sweden is currently focusing on care within silos, resulting in a fragmented care system (Stiernstedt et al. 2016). According to Stiernstedt et al. (2016), our current system is good at delivering individual efforts with high quality, but when it comes to information exchange, coordination, and continuity around the individual patient there are major shortcomings. One of the most critical groups when it comes to these aspects are patients with complex care needs, that are receiving treatment at multiple places within the healthcare system (Kelly et al., 2019). In Sweden, today around 80-85% of healthcare resources are spent on chronically ill patients, where around 50% of the resources are dedicated to patients with complex care needs (Stiernstedt et al., 2016), which possibly could be attributed to this inefficient way of organizing healthcare.

Skaraborg Hospital Group (SHG) is located in the Västra Götaland region and consists of four hospitals located in Skövde, Lidköping, Falköping and Mariestad. SHG has identified that patients diagnosed with pneumonia are highly represented amongst patients with complex care needs. They define complex care needs as having at least three different diagnoses. As noted in the quantitative data, the pneumonia patients are treated at several different wards located around the hospital and usually have contact with more than one ward during a care episode, indicating a fragmented group often transitioned between different parts of the hospital. According to Coleman (2003) patients are particularly vulnerable to experience poor quality of care when transitioned back and forth between different units at the hospital. Problems that arise due to the fragmented care system can, for example, be a lack of coordination between wards and healthcare personnel, insufficient continuity of care, inadequate preparations, gaps in the service, lack of collaboration and so on (Naylor et al., 2017; Coleman, 2003).

There are therefore possibilities for identifying areas of improvement in the care for pneumonia patients with complex care needs. This thesis could be used as a basis for why there is a need to develop and establish a standard care plan for the pneumonia diagnosis at SHG, as well as locate factors that may improve the care practice and patient outcomes.

1.1 Introduction to case organization

The healthcare in Sweden is arranged in linear processes which is structured around the functions of the hospital (Stiernstedt, 2016). On the other hand, the patient journey through the healthcare system is

more often than not non-linear (Stiernstedt, 2016). This is especially the case for the studied pneumonia patient group, where the combination of multiple diagnoses that can be completely unrelated to one another causes patient to be moved between different functions to receive the needed care. The care is arranged with the functions being responsible for their own resources and goal fulfillment (Stiernstedt, 2016). This linear approach makes for difficulties in establishing a horizontal care processes for the patient (Stiernstedt, 2016).

SHG is a process-oriented hospital with established processes for specific diagnoses (S. Lifvergren, personal communication, April 20, 2021). As mentioned, the hospital consists of four different hospitals, and although they all are part of SHG their organizational structure differs. In this thesis, interviews and quantitative data are focused on the hospitals in Skövde and Lidköping. In Skövde, the organizational structure is based around specialized wards such as cardiology, nephrology, pulmonary, infection, and so on (S. Lifvergren & R. Javid Gholam, personal communication, 31 March, 2021). In addition to those there are two emergency care wards that are either specialized in medicine (MAVA, Medicinsk akutvårdsavdelning) or surgery (KAVA, Kirurgisk akutvårdsavdelning). At the emergency care wards acutely ill patients are admitted and treated until they are stabilized. After this they are either discharged or moved to another ward, see Figure 1. Due to the higher capacity and specialization in Skövde in cases where illnesses are very serious or severe, patients can tend to be moved from other hospitals in SHG to Skövde. Since pneumonia is a diagnosis that is not assigned to a specific specialized ward, patients tend to be treated at varying wards in the hospital, there among MAVA. Subsequently, this leads to the pneumonia patients to be moved between wards during their care episode (Lifvergren & Javid Gholam, personal communication, 31 March, 2021).

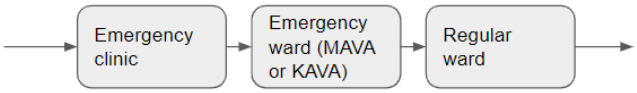

Figure 1 Common care path in Skövde

In Lidköping the organizational structure revolves around the surgery ward and the medicine wards. Although these are somewhat specialized around cardiology, stroke and hematology etc., they are also general in nature and treat patients that have symptoms that are more generic. In contrast to Skövde, where a patient often either goes through MAVA or KAVA before being admitted to a regular ward, a patient in Lidköping is directly admitted to one of the medicine wards alternatively the surgery ward after the emergency clinic, see Figure 2.

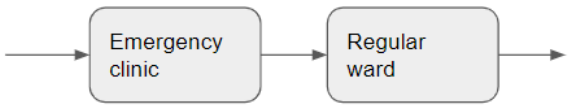

Figure 2 Common care path in Lidköping

1.2 Background of the patient group

During 2018-2019 there were a total of 2338 patients that had been diagnosed with pneumonia at SHG. Out of these patients, 533 were considered as patients with complex care needs, showing that about ~23% of the pneumonia patients are considered as having complex needs. Looking at the whole hospital for the same years, there were about 33000 unique patients, with ~3300 (or 10%) being classified as having complex needs (R. Javid Gholam, personal communication March 23, 2021). This shows an overrepresentation of patients with complex care needs amongst pneumonia patients.

The average age of the pneumonia patient group is ~71,1 years with a median age of 76 years, and looking at the patients with complex care needs the average age is ~74.7 years with a median age of 77 years. The distribution of sexes is fairly similar between both the group as a whole and for the patients with complex care needs, however there is a somewhat higher share of males than females (~55% M and ~45% F for the group as a whole, and 57% M and 43% F for patients with complex needs).

During 2018-2019 these patients amounted to 6479 care episodes. Out of these episodes 1783 were unplanned readmissions, giving a readmission rate of ~27.5%. Looking at the patients with complex care needs, these patients had 2981 care episodes out of which 1160 were unplanned readmissions, giving a readmission rate of ~38.9%. This is considerably higher than the hospital average, where the readmission rate is about 15% (R. Javid Gholam, personal communication, March 3, 2021).

Out of the 2338 pneumonia patients 361 died while at the hospital, giving the mortality rate of ~15.4%. Looking at the patients with complex care needs the mortality rate was instead ~19.6%, with 104 of the 533 patients having passed away. These numbers signify that there could be a need to improve the care process for these patients, hopefully, reducing the cost and resources needed as well as make advancements in the quality of care.

1.3 Aim

The aim of this thesis is to explore and understand the care process for pneumonia patients at SHG, with an additional focus on patients with complex care needs. Additionally, the thesis will visualize the care flow for these patients utilizing process mining. This will result in a report illustrating the current care process and areas of improvement in the process, as well as give recommendations on what to focus on when forming a future care process for pneumonia.

1.4 Research questions

In order to achieve the aim, the following research questions will be looked into. These questions are formed on the basis that answering them will lead the authors to find areas of improvement in the pneumonia care process.

Before it is possible to analyze the care process and come with suggestions, one must first understand what the current process looks like. Therefore, the first research question is the following:

- **RQ1: What does the pneumonia care process currently look like at SHG?**

As noted in Section 1.1 and 1.2, pneumonia care seems to be dependable on multiple variables. The second research question therefore strives to reveal what these variables are and what aspects in terms of quality of care and performance measures they affect:

- **RQ2: What variables in the pneumonia care process influence the quality of care and performance measures?**

Furthermore, there is a need to locate where in the care process improvements are needed and what could be altered to reap the benefits of these improvements. Based on this the final research question is:

- **RQ3: What are the areas of improvement in the care process?**

1.5 Delimitations

This thesis work will address the care process at SHG focusing on the pneumonia diagnosis. Furthermore, the work has involved process mining on a high abstraction level, only looking into the different ward patients are located at as well as the moves between them. More value could be gained through looking into the actual activities of the treatments i.e., if a person is sent for x-ray, blood tests etc. However, this information cannot be accessed for improvement work without specific consent, and even then, the allowed use is restricted. The thesis is therefore concerned with organizational aspects and how these affect the care process, and will not look into the actual care activities performed during the patient stay.

1.6 Societal and economical aspects

At large healthcare exists to improve quality of life for a nation's citizens. This thesis strives to be useful for an upcoming pneumonia care process at SHG, that is hoped to improve the care at the hospital as well as patient outcomes. In that sense, this thesis is beneficial on a societal level, where an improved care system would benefit the population. In turn, improving the pneumonia care process is anticipated to lead to reduced care days for the patients. An in-care stay at the hospital requires a significant amount of resources, which amounts to greater levels each day that passes that the patient is admitted. Through, improving the process and hopefully reducing the LOS, monetary and human resources could be saved, making it available for other pressing matters in society. This is beneficial since healthcare in Sweden is funded through taxpayer money, that could then be spent on other vital societal functions.

1.7 Disposition of thesis

The following section describes the disposition of this thesis. Chapter 1 (*Introduction*) introduces the readers to the research topics as well as the research questions. It then follows with a *literature review* (Chapter 2), presenting the literature background that the thesis is built upon. Chapter 3 (*Methods*) then describes the research design, how this study is conducted and methods used. The chapter also describes the ethical aspects and the main quality criteria concerning the thesis. *Empirical Findings* (Chapter 4) are then presented based on qualitative and quantitative data, which have been divided into relevant areas. Chapter 5 consists of the discussion of the empirical findings in relation to the literature. Furthermore, the improvement areas and recommendations are presented and elaborated on. Lastly, the *conclusion* (Chapter 6) presents the answers to research questions and opportunities for future research.

2
Literature Review

2.1 Processes and value creation

A process is, in its most basic sense, the sequence that transforms inputs (resources) into outputs (products or services) (Holweg et al., 2018). A process has the purpose of creating a specific desired outcome. In other words, to optimize a process one needs to determine how to organize your resources in the best way to create the desired output in terms of services or products (Slack & Lewis, 2017). The basic idea is that the process should be value adding for the company, refining the inputs to satisfy the customers, while not wasting unnecessary resources. It is important to recognize that processes do not exist in a void. As Holweg et al. (2018) describes it, processes are always influenced by the national, industry, and intra-firm setting that they are embedded within. There can be differences in such things as working hours, breaktimes, company culture, and similar things that affect the possibility to change the process, and acts as restrictors for the management system (Holweg et al., 2018).

According to Stabell & Fjeldstad (1998) firms differ greatly in the sense of how they create value through their processes. They propose three different logics for value creation that firms generally are configured after: *Chains*, *Shops*, and *Networks*. Businesses that are built around chains focus on the process of transforming inputs into outputs itself, with sequential activities, with the organization's capabilities in its process rather than in its resources (Stabell & Fjeldstad, 1998; Hwang & Christensen, 2008). Shops are on the other hand more focused on dealing with unstructured problems, delivering value primarily through its humanitarian resources and expertise (Stabell & Fjeldstad, 1998; Hwang & Christensen, 2008). Lastly, networks are built around facilitating a flexible interaction among people, places, and things, and creating value by ensuring the effective operation of the network and parallel activities (Stabell & Fjeldstad, 1998; Hwang & Christensen, 2008; Fjeldstad et al., 2020).

An important part of processes is to control and measure their impact (Holweg et al., 2018). Without any measurements on performance of the process it is difficult to say anything about the value of the process. Holweg et al. (2018) states that a common mistake is to omit the “baseline” measurement in process improvements. Unless you have any measurements on the operational performance of the organization before implementing a certain process, you cannot say if the process brought any improvements. Therefore, it is important to both collect data and measure the operational performance before implementing a process and during the time it is running, to be able to analyze any potential improvements.

2.1.1 Processes and value creation in healthcare

There are several processes at a hospital, such as the physical flow of patients, as well as decision and information flows. The input of the process can be seen as when the patient is admitted to the hospital, the output when the patient leaves the hospital, and the activities in between as the transformation.

Historically, healthcare has largely been organized after the shop value logic, where the care has mostly relied on the intuition of highly skilled professionals (Hwang & Christensen, 2008), this is still the

predominant way for value creation in healthcare today (Fjeldstad et al., 2020). It centers around highly customized responses to individual problems, based on the patient-professional relationship. However, there is a tradeoff associated with this logic, mainly between the breath of diagnosis that can be managed, and the depth of expertise that can be provided (Fjeldstad et al., 2020).

There have been several initiatives to incorporate the value chain logic into healthcare (Hwang & Christensen, 2008; Fjeldstad et al., 2020). This includes repeatable and standardized treatment processes, such as Clinical pathways (CPW). A CPW is a set of standardized treatment recommendations that aims to create an optimal care process for a certain condition or patient group (Lawal et al., 2016; Kuntz, 2019). They are a means to standardize the care process, and thus shifting the focus from the organization's humanitarian resources, to the process. However, it can be difficult to maintain the needed level of differentiation with the value chain logic, as a highly standardized chain is less able to address a diversity of needs (Fjeldstad et al., 2020). This logic can be highly effective when dealing with predictable treatments, but the challenge is that only a fraction of the healthcare fits into this. When dealing with more complex medical problems it might be hard to apply standard treatments, and attempts to "install" this logic widely in the healthcare system has been frustrating (Fjeldstad et al., 2020).

Value networks in healthcare have generally been an underdeveloped area (Hwang & Christensen, 2008). However, the healthcare system is configured in a way that would largely be suited for a value network as it consists of many different actors with varying interests and purposes (Myllärniemi & Helander, 2012). The main attributes of a value network are to ensure the connectivity among the actors. A network approach to healthcare would make it possible to aggregate knowledge and information and apply it to the point of care. In this way it would facilitate the integration of value shops and value chains dispersed over the current system, into a larger and more flexible system of treatment procedures (Myllärniemi & Helander, 2012; Fjeldstad et al., 2020).

2.2 Process mining overview

Given the growing digitalization of businesses today, an abundance of events is recorded in different systems such as various enterprise systems, case handling systems, PDM systems, hospital information systems, etc. (van der Aalst, 2010). All these events can be utilized to understand business processes and get an understanding of what is actually happening. Traditionally, the approach when conducting business process design has been to perform a detailed mapping over the business, using multiple resources to try to conclude what the most recognized process model would look like (Garcia et al., 2019). The idea of process mining is instead to use the already existing data to extract the relevant information needed to construct a meaningful process model (van der Aalst, 2010; Rojas et al., 2016; Garcia et al., 2019).

Processes in healthcare are characterized by their high degree of complexity, flexibility, variability, and multidisciplinary nature (Martin et al., 2020; dos Santos Garcia et al., 2019; Rojas et al., 2016). To gain a deep understanding and process overview in organizations with such processes can be difficult as well as cost and time consuming (Martin et al.,2020). Martin et al. (2020) therefore proposes process mining to simplify process understanding, as well as minimize the mentioned negatives.

Process mining combines process analysis techniques and data mining, making it possible to derive statistics and descriptive process models (Partington et al., 2015). Rebuge & Ferreira (2012) proposes

a way of working that focuses on process mining activities. The steps involved are event log preparation, log inspection, analysis of control flow, analysis of performance, organizational analysis, and lastly results transfer. However, there are several ways to conduct a process mining study which is adapted to the purpose and goal of the work.

The most common way of using process mining in healthcare is for case studies (Martin et al., 2020). The method is commonly used in exploratory work, investigating behavioral patterns, process improvements and patient outcomes (Litchfield et al., 2018). The use of it in healthcare has increased significantly during the last decade (Gurgen Erdogan & Tarhan, 2018; Litchfield, 2018). Gynecological oncology, dental, urology and stroke-care are only a few of the areas in which process mining has been employed in healthcare (Agostinelli et al., 2020).

Concerning using process mining in relation to pneumonia, Arias et al. (2020) has looked at mapping the patient journey for patients diagnosed with pneumonia. Their work analyzes the medical procedures and the type of activity that is performed during treatment. Furthermore, their work involves looking at the LOS and its relation to the care pathway of the patient, the gender and age of the patient (Arias et al., 2020). According to their study older patients have more touchpoints in their pathways, meaning that they go through more medical activities such as laboratory exams and x-rays (Arias et al., 2020).

Jacob & Ramani (2012) writes that data mining has been used to detect patients admitted in the hospital with pneumonia. Graumans (2021) has studied the care model pathways for patients diagnosed with either viral, bacterial or fungal pneumonia that are cared in the intensive care unit (ICU). They noted that the three types of pneumonia had similar pathways in general, although there were some unique procedures that differentiated fungal pneumonia to the other kinds (Graumans, 2021). Lastly, Khajehali & Alizadeh (2017) has used process mining as a case study in a hospital in Iran, where they looked at identifying key factors that affect the LOS for pneumonia patients.

Process mining makes use of *event logs* to understand what a process looks like de facto (Martin et al., 2020). An event log is a set of traces, where all events in a process or case are presented (Arias et al. 2020; Rojas et al., 2016). Event logs showcases what activity was performed, when and by whom they were performed (Agostinelli et al., 2020; Martin et al., 2020). Information that is included in event logs is oftentimes: case Id, time stamp, activity type, transaction type and resource (Martin et al., 2020). However, creating the event log is not an easy task and it can be time consuming. One of the biggest challenges lies in finding and extracting the relevant data, as well as determining how to scope it (van der Aalst, 2011).

2.2.1 Goals of process mining

Literature divides process mining activities in three different types: process discovery, conformance checking and enhancement (Martin et al., 2020, Mans et al., 2008). Process discovery is a prerequisite for further analysis that is done during conformance checking and enhancement, it is therefore the basis for process mining (Gurgen Erdogan & Tarhan, 2018). Process discovery implies using event logs to create process models (Martin et al., 2020). Without prior information of the process (Gurgen Erdogan & Tarhan, 2018), process discovery is done to visualize and compile information (Martin et al., 2020), and in this way make it possible to observe the order of activities (Martin et al., 2020) and gain further information about the process, its organizational context, and properties of the execution (Mans et al., 2008).

Conformance checking is used for comparing if the process model reflects reality (dos Santos Garcia et al., 2019; Mans et al., 2008), as well as validating if an existing process model emulates the event log of the same process. In this way researchers are able to verify the quality of the model (Martin et al., 2020; Rojas et al., 2016). Enhancement involves working with the event data to improve the process (Gurgen Erdogan & Tarhan, 2018; Martin et al., 2020). Utilizing a pre-existing process model and enriching it with additional data allowing for further perspective and identification of improvements in the process (Mans et al., 2008; van der Aalst, 2010). Since this thesis mainly is concerned with the process discovery perspective given that no process model already exists, these types will not be elaborated on further.

2.2.2 Three perspectives on process mining

In process mining there are three different perspectives (Agostinelli et al., 2020; van der Aalst, 2010): *control flow*, *organizational* and *performance* perspective. In their literature review about process mining in healthcare, Rojas et al. (2016) mention control flow as the primary perspective within healthcare. The Control flow perspective focuses on the order of activities (Rebuge & Ferreira, 2012; van der Aalst, 2010), and intends to investigate the process behavior and execution order (Rebuge & Ferreira, 2012). The aim is to find all possible paths in the process, oftentimes resulting in a visualization of the process (Agostinelli et al., 2020; van der Aalst, 2010).

The organizational perspective aims to investigate dependencies between resources in the log (van der Aalst, 2010). One aspect is identifying who did what, and how the different resources are related to one another (Agostinelli et al., 2020; Caron et al., 2014; Rebuge & Ferreira, 2012; van der Aalst, 2010). This perspective is the least favored of the three perspectives (Rojas et al., 2016). The organizational perspective allows for investigating the organizational structure inherent to the process, as well as individual relations in the organization, where one way of doing this is to explore the relations through creating social networks (Agostinelli et al., 2020). This is done to find which actors, departments, systems and roles are involved in particular systems and their relations (Agostinelli et al., 2020). Through social networks one can identify patterns of interaction and role importance in processes (dos Santos Garcia et al., 2019). Lastly, the performance perspective aims to locate bottlenecks and performance indicators in the process (Agostinelli et al., 2020; Rebuge & Ferreira, 2012). This perspective was also found to not be as common in work (Rojas et al, 2016).

2.2.3 Spaghetti and lasagna processes

Process mining can be used to investigate both structured and unstructured processes, each which leads to different prospects available for investigation (van der Aalst, 2011). Structured processes are often called *lasagna processes* referring to the order in which activities are repeated and the input and output are clearly defined. On the other hand, unstructured processes are oftentimes referred to as *spaghetti processes*, referring to the poorly defined conditions of the activities (van der Aalst, 2011). Moreover, the activities in spaghetti processes are characterized by being intuitive, experience driven and going by rules of thumb. Litchfield et al. (2018) mention that due to the complex nature of healthcare processes, where different patients have different needs and therefore take different paths through the care system, process mining in healthcare tends to end up with spaghetti models.

Processes where more than 80 percent of the events happen as planned can be categorized as lasagna processes (van der Aalst, 2011). Through these structured processes one is able to predict future flows, detect bottlenecks and deviations, as well as ideas for redesigns. In contrast, spaghetti processes are

unstructured and can therefore be difficult to use as operational support since they have too much variability. Spaghetti processes are more challenging to analyze than lasagna processes, however they are more interesting to analyze due to their greater improvement potential compared to lasagna processes (van der Aalst, 2011).

An approach to making spaghetti processes more useful and easier to analyze is to make them more lasagna like (van der Aalst, 2011). One of the means in doing so is through clustering, which imply breaking down the logs and data into smaller sub-groups that have similar properties (Mans et al., 2008). Essentially, clustering is used as a step to enable analysis of spaghetti models, this can be done with clustering traces, activities, or sequences (Gurgen Erdogan & Tarhan, 2018).

2.3 The healthcare context

The following chapter presents the studied diagnosis and the different aspects in healthcare that will be considered in this thesis.

2.3.1 Pneumonia

Pneumonia is a pulmonary disease that involves inflammation in one or both lungs (National Health Service [NHS], 2019). Most commonly pneumonia is caused by bacteria, but it can also be caused by a virus (NHS, 2019). All humans can develop pneumonia, however children, elderly and people with additional health conditions or a weakened immune system are more susceptible to getting it (NHS, 2019).

2.3.2 Performance measures in healthcare

There are several performance measures that are relevant to consider in the healthcare context (Socialstyrelsen, 2009). In this thesis three main measures will be considered: readmissions, length of stay (LOS), and mortality. In this section these different measures will be described, why they are important to consider, and aspects to consider in relation to pneumonia patients.

Readmissions

According to Barrett et al. (2012) "*hospital readmissions are defined as multiple inpatient stays within a specified time period by the same patient."* (s.1). The most common time frame used in the definitions is 30 days, although this can vary depending on the setting (Barrett et al., 2012). This is however the time frame used by SHG (R. Javid Gholam, personal communication, February 17, 2021). Further, it is also important to differentiate between planned and unplanned readmissions, since it is the unplanned readmissions that contribute to unexpected costs, use of resources and so on. Therefore, it is the unplanned readmissions that will be the focus in this thesis.

According to the American insurance system Medicare, reducing the number of readmissions is key to increase quality of care and lower the associated costs (Barrett et al., 2012). Due to the high costs and associated risks with readmissions, this is often used as an indicator for describing and following up on the quality of healthcare (Socialstyrelsen, 2014; Leppin et al., 2014).

When considering patients diagnosed with pneumonia several studies have concluded that readmissions to the hospital following an episode with pneumonia is a relatively frequent event (De Alba & Amin,

2014). According to studies in the USA, readmissions are estimated to occur in about 17-25% of the cases where patients are hospitalized with pneumonia (De Alba & Amin, 2014; Weinreich et al., 2016). However, De Alba & Amin (2014) points out that a significant portion of the pneumonia readmissions may be unavoidable. They point out that multiple factors are connected to the readmission of pneumonia patients, such as age, sex, education and certain comorbidities, but most of them are not modifiable or susceptible to intervention. Although many of the readmissions are unavoidable, De Alba & Amin (2014) also emphasize that reducing readmission rates is feasible. The most important factors to target are for instance fragmentation of healthcare and variation in practice style, transitional care, care coordination, and post discharge care.

Concerning fragmentation of healthcare and variation of practice, there have been several US studies that show that regional variation of care may influence the readmission rate of pneumonia patients (Epstein et al., 2011). Readmission rates vary greatly between geographic locations in the US (Lindenauer, 2010), indicating the feasibility to lower readmission rates through things such as practice style or quality of care.

De Alba & Amin (2014) also points out that previous studies have shown that pneumonia readmissions often not are due to strictly pneumonia related causes, but because of other unstable comorbidities. They argue that because of this, interventions aimed at improving all cause readmission rates also should be effective for these patients. For instance, interventions aimed at care transitions, discharge plans and post discharge care has proved to successfully reduce readmission rates (Jack et al., 2009; Hansen et al., 2013; Marks et al., 2013).

Length of stay

Length of stay (LOS) is an important measure that indicates the efficiency of the hospital management, and it can be interesting to predict both for economical as well as organizational reasons (Khajehali & Alizadeh, 2017; Baek et al., 2018). A decreased LOS could result in for example an improvement of the quality of care, more efficient use of resources and bed management, and a lower risk of medication side effects etc. (Khajehali & Alizadeh, 2017; Baek et al., 2018).

When considering the LOS for pneumonia patients there seem to be a considerable variability between hospitals (Menendez et al., 2003). According to Laing et al. (2004), previous studies have shown that patient characteristics such as age and comorbidity only account for a small amount of the observed variation. Moreover, the LOS of pneumonia patients has been shown to depend on the initial severeness of the illness, but only to a limited extent (Menendez et al., 2003; Garau et al., 2008; Laing et al., 2004). Laing et al. (2004) states that it mainly is the variations in clinician behavior and system structure, rather than the patient factors that contribute to a prolonged LOS.

As pointed out by Laing et al. (2004), there is variations in clinical practices, differences in hospital characteristics, and organizational differences affecting the LOS for pneumonia patients. According to Menendez et al. (2003), this indicates the need for objective criteria in the care of pneumonia, so that the differences in the clinical management of the condition is reduced. Previous studies suggest that incorporating a clinical pathway for pneumonia patients can significantly reduce the LOS, without affecting readmission rates or mortality (Nicasio et al., 2010; Meehan et al., 2001; Benenson et al., 1999; Hauck et al., 2004). A clinical pathway is a structured care plan with three main characteristics: it is used to translate guidelines into local structures; it details the steps of the care treatment in a plan, protocol or similar; and it aims to standardize the treatment of a specific clinical problem or condition

in a specific population (Rotter et al., 2019). The role of clinical pathways for pneumonia patients will be further elaborated on below (see Section 2.3.4).

Studies have also shown that the fragmentation of care significantly increases the LOS (Epstein et al., 2010). If a patient is subjected to multiple physicians or care personnel during their hospital stay (Epstein et al., 2010), or if the patient is moved between wards (Escobar et al., 2011), there seem to be an increase in the LOS. Further, mobilization and physiotherapy seem to have a significant role in reducing LOS for pneumonia patients (Larsen et al., 2019; Melgaard et al., 2018; Rice et al., 2020). The role of transitional care (see Section 2.3.3) and physiotherapy (see Section 2.3.5) will be further elaborated on below.

Mortality

Worldwide, pneumonia together with lower respiratory tract infection (LRTI) is the fourth leading cause of death (Marshall et al., 2018). In elderly patients it is one of the leading causes of death from infection (Chebib et al., 2019). Although the mortality rate is different in countries in Europe, the median mortality for the studied countries was 19,8 per hundred thousand males, and 6,9 per hundred thousand females for the observed years (Marshall et al., 2018). Furthermore, a trend that was noted is that in general males have a higher mortality rate than females. When looking at elderly pneumonia patients the mortality rate for hospitalized patients ranges between 5-15%, and in ICU-patients this is between 30-50% (Chebib et al., 2019). In addition, the chance of death is increased after a pneumonia-episode, possibly partly due to an increase in cardiovascular events (Chebib et al., 2019).

For patients with aspiration pneumonia, a predictive factor for 3-month mortality is losing muscle mass (Chebib et al., 2019). In elderly pneumonia patients, physiotherapy has shown to be a way for these patients to maintain muscle mass, illustrating that physiotherapy could be a means of reducing mortality in elderly pneumonia patients (Chebib et al., 2019). Another aspect that can result in a decrease of mortality rate in pneumonia is to implement guidelines regarding treatment and care, as seen in an article by Dean et al. (2001) which is elaborated on in Section 2.3.4.

2.3.3 Transitional care

Transitional care is defined by Coleman (2003) as "*a set of actions designed to ensure the coordination and continuity of health care as patients transfer between different locations or different levels of care within the same location."* (p.549). Patients with complex care needs often require treatment across different healthcare settings and are moved between wards depending on their current status. According to Coleman et al. (2006) there are numerous studies that indicate that such transitions cause serious deficiencies in the quality of care. Poorly executed care transitions can have many implications, but ultimately, they can lead to a greater use of hospital resources (Coleman, 2003). Several articles also point out that unplanned readmissions often are linked to problems in care transitions (Coleman, 2003; Hume et al., 2012; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018)

When considering what an effective care transition constitutes, well-functioning communication seems to be central (Coleman, 2003; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018). For example, there needs to be communication between the sending and receiving clinicians regarding things like a common care plan, the care the patient has already received, the goals and preferences of the patient, a list of problems, baseline physical and cognitive functional status, medications, and allergies that are up to date, and so on. Further, there also needs to be a well-functioning communication

between the patient and the care providers regarding for example what to expect at the next site of care, as well as what type of warning signs or symptoms to monitor extra carefully.

Wilson & Birch (2018) describes three main themes that are important to consider when dealing with care transitions: communication complexities, care planning and coordination gaps, and health system reform needs. Communication complexities include for example the lack of common communication standards, missing information, lack of information sharing, and hesitations in what information that can be shared with whom (Wilson & Birch, 2018). Further, communication also seems to be down prioritized due to workload issues and lack of resources. This is also backed up by Fuji et al. (2013) who describes that healthcare personnel often neglect proper documentation due to high workloads. When considering care planning and coordination gaps Wilson & Birch points out that moves are poorly coordinated. Coleman (2003) also mentions that there often is a lack of coordination between caregivers, often attributed to a lack of ongoing communication.

Wilson & Birch (2018) has revealed the general need for a reformation of the healthcare system. For example, transitions are often done due to lack of beds at the appropriate location, and there is a lack of an integrated care system. With healthcare being organized within silos it results in highly specialized services delivered at separate places. Patients with multiple needs will thus have to move between the different settings in order to receive the right care. Coleman (2003) also discusses the issue of healthcare being organized as silos where the care teams operate "*... without knowledge of the problems addressed, services provided, medications prescribed, or preferences expressed in the previous setting".* (p.550)

2.3.4 Clinical pathways

According to Rotter et al. (2019) clinical pathways (CPW) is a tool that is used to guide care practice. This involves translating recommendations, in this case clinical guidelines, into processes based on the specific context that are then used in practice. The creation of CPWs can be broken down into converting the guidelines into steps in the process such as type of care or treatments, ensuring that evidence-based healthcare practices are incorporated in healthcare. In turn, care practice for a specific clinical diagnosis can then be standardized for specific populations (Rotter et al., 2019). When studying the general use of CPWs when compared to regular care, it was noted that CPWs result in a reduced LOS for patients as well as reduced hospital costs (Rotter et al., 2019).

When looking at CPWs and pneumonia specifically, it has been shown that CPWs contributes to a reduced risk of prolonged LOS (Hauck et al., 2004). Furthermore, their study showed that patients where CPWs were implemented showed lower odds for mortality in hospital, where rapid administration of antibiotics was an important factor and the patients with CPWs in places, were more likely to have been administered antibiotics rapidly (Hauck et al., 2004). The reduction of time for antibiotic administration is further strengthened by Benenson et al., (1999).

For patients with ventilator-associated pneumonia, Nicasio et al. (2010) showed further benefits of CPWs, where the patients with a CPW in place experienced shorter treatment duration, LOS and lower hospital costs. In this case the CPW involved a guideline for drug administration, covering antibiotic selection and dosage (Nicasio et al., 2010). The effects of this sort of guideline were also studied by Dean et al., (2001), but in the case of community-acquired pneumonia, the results showed that the implementation resulted in a reduction in 30-day mortality in elderly patients.

Meehan et al. (2001) analyzed aspects of pneumonia care with the intention of implementing a state-wide pneumonia pathway in Connecticut. Their study, measuring the care performance of the following practices when a pneumonia patient arrives at the hospital: antibiotics administration within 8 hours, blood culture collection and oxygenation evaluation within 24 hours, and if blood culture collection has been done before antibiotic administration (Meehan et al., 2001). These actions were assessed in relation to the outcomes such as, LOS, 30-day readmission rate and 30-day mortality rates. Although the actions were believed to be effective, the individual effects of them were not determined. The overall project was deemed beneficial, where one of the strengths of the venture was the multifaceted intervention in the care from several organizations, in turn resulting in alignment of expertise and resources Meehan et al. (2001).

Lastly, as Rotter et al. (2019) conclude, an established CPW is associated with improved patient outcomes and patient safety. Although the development and implementation of CPWs might be resource demanding, there are benefits in patient outcomes as well as organizational benefits such as reduced costs (Rotter et al., 2019). Engagement from the care practitioners that are involved in the care process is needed for incorporating CPWs in the care organization. Rotter et al. (2019) mention that a top-down approach will have little to no impact on the care. Instead, the process should involve so-called "local champions" that can help in identifying barriers, gaps in care practice, engage in educational sessions and be involved in the CPW's design and implementation. Furthermore, involving patients is a critical part to establishing valuable CPWs (Rotter et al., 2019).

2.3.5 Role of mobilization and physiotherapy

Larsen et al. (2019) approaches the topic of the importance of early mobilization in pneumonia care. They write that a 20-minute change from horizontal to a vertical position within the first 24 hours of hospital care which was followed by a progression of mobilization, can lead to benefits for the quality of pneumonia care. The practice was shown to result in a reduced LOS for patients, on the other hand the practice showed no impact on the risk of mortality or readmissions (Larsen et al., 2019). This result was strengthened by Melgaard et al. (2018) which through the same practice, concluded that early mobilization contributes to a reduced LOS. Furthermore, Khanna & Almulla (2012) claim that physiotherapy and occupational therapy early in the care episodes reduces the LOS for patients with community-acquired pneumonia (CAP).

Rice et al. (2020) has studied the impact of early mobilization in terms of walking for the recovery of CAP through monitoring step-counts. It was revealed that patients with a higher step-count had a reduced LOS at the hospital (Rice et al., 2020). One can argue that this emphasizes the importance of mobilization in the care and is a further reason for involving physiotherapy in the care of pneumonia patients. To add to the benefit of mobilization for patients with CAP, an experimental study comparing the benefits of respiratory physiotherapy and a rehabilitation program involving physical exercise was performed by Jose & Dal Corso (2016). The study showed that compared to the patients that receive respiratory physiotherapy, the patients that underwent the exercise-based program had greater benefits in quality of life, functional capacity, muscle function and dyspnea, contrarily it showed no difference between the groups regarding LOS (Jose & Dal Corso, 2016). This exercise-based rehabilitation program involved warm-up, walking for 15 minutes and peripheral muscle strengthening exercises (Jose & Dal Corso, 2016).

Physiotherapy can also be a means of preventing pneumonia as shown by Chebib et al. (2019), where elderly patients in the hospital that received mobilization physiotherapy were less likely to get hospital

acquired pneumonia and reduced the LOS. Additionally, Chebib et al. (2019), mention the effect of respiratory physiotherapy as a means of preventing pneumonia in elderly patients. Where they state that breathing exercises such as deep breathing and coordinated breathing reduces the risks of pulmonary complications and LOS in patients that have had major abdominal surgery. The use of physiotherapy is further affirmed through the study by Momosaki et al. (2015) which shows that early physiotherapy reduced the 30-day in-hospital mortality for elderly patients with aspiration pneumonia. By early physiotherapy meaning the patient receiving physiotherapy within three days of admission and partaking in physiotherapy for seven days at least, where the exercises involved mobilization and strengthening exercises (Momosaki et al., 2015)

2.3.6 Summary of key findings

Factor	Data availability at SHG	Affecting	Supported by
Mobilization of pneumonia patients	Data is documented in the patient's medical records, but it is not gathered or compiled further.	LOS	Larsen et al., 2019; Melgaard et al., 2018; Khanna & Almulla, 2012; Rice et al., 2020; Chebib et al., 2019
		Prevention of pneumonia	Chebib et al., 2019
		Mortality	Momosaki et al., 2015
Clinical pathway (guideline)	SHG has no incorporated clinical pathway for pneumonia patients.	LOS	Rotter et al., 2019; Hauck et al., 2004; Nicasio et al., 2010; Meehan et al., 2001
		Hospital costs	Rotter et al., 2019; Nicasio et al., 2010
		Mortality	Hauck et al., 2004; Dean et al., 2001; Meehan et al., 2001
		Readmission	Meehan et al., 2001
		Time for antibiotic administration	Hauck et al., 2004; Benenson et al., 1999
		Improved Patient safety	Rotter et al., 2019
Inadequate transitional care	Data is available of how the patients are moved around the hospital, between which wards and so on.	Quality of care	Coleman et al., 2006
		Use of resources	Coleman, 2003
		Readmission rate	Coleman, 2003; Hume et al., 2012; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018; De Alba & Amin, 2014; Jack et al., 2009; Hansen et al., 2013; Marks et al., 2013
		LOS	Epstein et al., 2010; Escobar et al., 2011
Organizational structure	It is logged where patients are treated at, hospital and ward. Unknown if this is used.	LOS	Laing et al., 2004; Menendez et al., 2003; Epstein et al., 2010
		Rate of care transitions	Wilson & Birch, 2018
		Readmission rate	De Alba & Amin, 2014
Differences in care practice	This is gathered by SHG, but not used for pneumonia care.	Readmission rate	De Alba & Amin, 2014; Lindenauer, 2010; Epstein et al., 2011
		LOS	Laing et al. 2004; Menendez et al. (2003)

3
Methods

This chapter describes the methods used in this thesis as well as analyzes the quality criteria and ethical aspects in the work.

3.1 Research design

This thesis is centered around understanding and finding areas of improvement in the pneumonia care process with an additional focus on patients with complex care needs. This is a topic that has not been explored by SHG previously, and the organization does not have a cohesive understanding of the patient group and what the care process associated with them looks like. To research this topic, this thesis will have an exploratory outlook. According to Saunders et al (2006), an exploratory study aims to "*seek new insights into phenomena, to ask questions, and to assess the phenomena in a new light.*" (p.592).

To understand the care process of a patient group one can investigate the patients' journey through the hospital. By separating the management of a specific patient into a series of events, or touchpoints, you can visualize this journey and gain an understanding of the patients' experience and what the care process looks like (Trebble et al., 2010). The thesis therefore focused on understanding the patients' journey through the hospital care in order to find improvement areas.

The thesis utilized an abductive approach, which aims to find reasoning of an empirical observation using established theory in literature, which can be done simultaneously (van Hoek et al.,2005).
This approach involved iteratively hypothesizing using the method grounded theory (Bryman & Bell, 2011). Hypothesis were made continuously through observed variables found from literature as well as interviews with care personnel. The authors then attempted to explain if these statements were valid based on quantitative data from SHGs data systems, observations from qualitative data and literature on the topics. The output of this thesis was to locate important areas in the pneumonia care process to consider and what areas of improvement there is.

3.2 Literature review

An initial literature review was done where topics concerning healthcare and process mining were explored to get a basic understanding of the field of study. Subsequently, once the work approach for the thesis had been determined, a structured literature review on the topic of process mining in healthcare was performed using the *web of science,* this was conducted from February 8 to 17, 2021. The initial screening was done using the search word *"process mining" healthcare,* this resulted in identifying papers regarding process mining in healthcare. After excluding proceedings papers the second screening resulted in 73 papers. The third screening was done through the authors' judgment of relevance through reading the articles' abstract, as well as through established exclusion criteria which included: journal impact factor above 1, articles concerning privacy or ethics, research regarding process mining in emergency rooms. Following the third screening snowballing was done, meaning that the references in the found articles were looked over to identify further useful resources (Wohlin, 2014). Furthermore, the authors were recommended to investigate Wil van der Aalst, Eric Rojas and Ronny

Mans, among others, which are renowned authors in the process mining in healthcare field. After this a further screening was done using solely the author's judgements, this resulted in 16 articles. Figure 3 showcases an overview of the process.

When looking for articles relating to process mining and pneumonia, it was noted there have been few articles published in the topic. During this search web of science and google scholar was used and ""process mining" & "pneumonia"" was used as search phrases. In the web of science, the search resulted in 29 articles, where after the assessments of the authors, one article was found to be on topic for this thesis. Searches in google scholar resulted in 146 papers, and again with the author's judgement a further three articles were found useful. This part of the literature review was performed April 6th, 2021.

Further, a literature review regarding the healthcare context has been made using the author's judgement. During this search web of science and google scholar where used, using search words such as "pneumonia", "LOS", "transfers", "clinical pathways", "mortality rate", "transitional care", "readmission", "mobilization", and "physiotherapy", in different combinations. This search was done between the 23rd of February and the 7th of April.

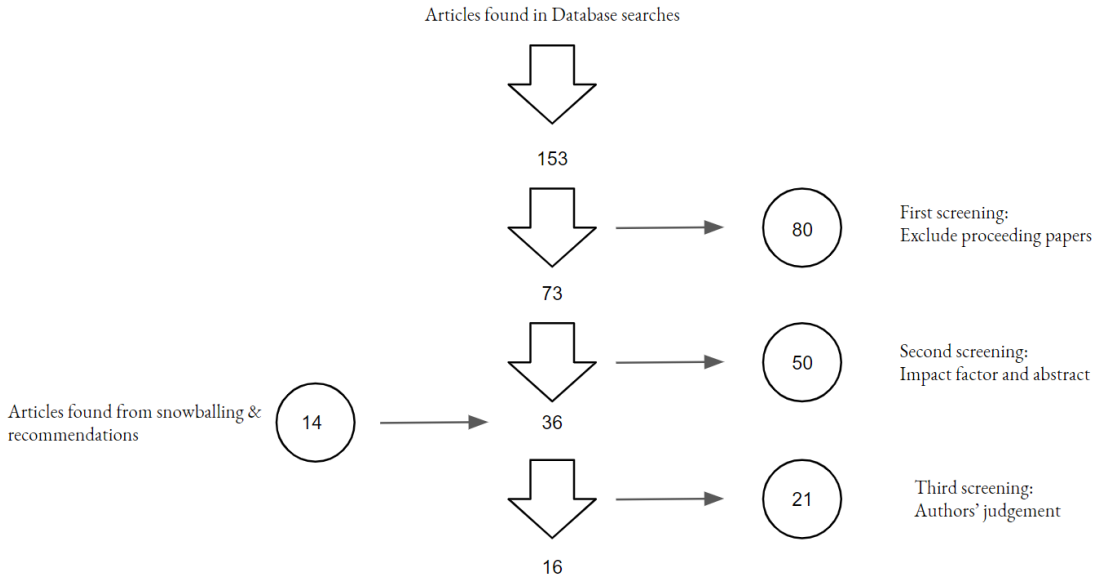

Figure 3 Literature review process

3.3 Qualitative methods

Qualitative methods in this thesis work included semi structured interviews, intended to expand the knowledge, and understanding of the pneumonia care process, as well as to use as a basis for hypothesizing questions needed to be answered through process mining. Hypothesizing was done iteratively throughout the data collection where the continuous addition of data formed the hypothesis in stages, which has the qualitative work based on the method grounded theory. Grounded theory involves iterative work in which theory is derived from empirical data which is methodically collected and analyzed. The method maintains a close bond between theory and empirical data where coding is used to break down data into components, allowing for constant comparison as a means of conceptualizing concepts and theory (Bryman & Bell, 2011).

3.3.1 Data collection

The qualitative data was gathered through semi structured interviews, which allows for expanding on mentioned topics that can be of interest (Bryman & Bell, 2011). The purpose of the interviews was to gain understanding of the current pneumonia care at SHG, moreover it was also used as means of identifying improvement areas and difficulties in the process. In total 24 interviews were performed with care personnel at SHG. The interviewees were selected using stratified convenience sampling. Stratified sampling has been chosen since the hospital structure allows for dividing the organization into units, in this case selecting interviewees from wards (Bryman & Bell, 2011) Furthermore, the sampling has also involved selecting what roles that one would like to interview, these included physicians and nurses, as well as staff from support functions. Specific wards have been chosen based on them being critical areas of the care process or in wards that experience many pneumonia patients, as seen in the quantitative data. The sampling was also deemed to be a convenience sampling since interviewees at the specific wards were chosen based on those being available and willing to participate (Bryman & Bell, 2011). See Table 1, for description on the role and working ward of the interviewees.

The choice of which wards to interview care personnel from was based on the data provided by SHG, showcasing that the following wards should be included in order to meet the pareto principle: Medical emergency ward (MAVA), Pulmonary ward, infection ward, medicine ward, surgery ward, surgery emergency ward (KAVA), medicine ward, nephrology ward, cardiology ward. The goal was to interview a medicine doctor, and a nurse from each ward which was at large achieved at every ward. Furthermore, the importance of support functions in the care was revealed, therefore the interviews included an interview with the unit manager for welfare officers and dieticians, the unit manager for physiotherapy and a physiotherapist. In addition, a physician from Södra Älvsborgs hospital (SÄS), was interviewed since it was revealed that they have a pneumonia care process currently in use, and it was of interest to see what aspects they are considering in their work.

A total of 24 interviews were held with various care staff from SHG. At this point a theoretical saturation had been reached (Bryman & Bell, 2011), meaning no new or relevant data seemed to emerge, which is a common approach in grounded theory. The interviews were held in Swedish and were performed online or via telephone, this due to the authors being in Gothenburg, whilst the interviewees were based in Skövde or Lidköping. A further reason for this was the covid-19 pandemic. Both authors were present during the interviews, where one author did the interviewing and the other took notes. The interviews were based on a prepared interview guide, see appendix A, where there was room for further questions about topics that were brought up. All interviews were recorded for the sake of analysis. The average length of the interview was approximately 23 minutes, where the shortest was around 11 minutes and the longest 44 minutes.

Table 1 List of interviewees

Interview id	Role	Ward	City	Date of interview
1	Support Function A	Physiotherapy	Skövde	March 1, 2021
2	Physician A	Infection ward	Skövde	March 5, 2021
3	Support function B	Welfare officers and dietitians	Skövde	March 9, 2021
4	Nurse A	Medicine emergency	Skövde	March 11, 2021

		care ward (MAVA)		
5	Physician B	Infection ward	Skövde	March 11, 2021
6	Nurse B	Medicine emergency care ward (MAVA)	Skövde	March 16, 2021
7	Physician C	Infection ward	Skövde	March 17, 2021
8	Support function C	Physiotherapy	Skövde	March 18, 2021
9	Nurse C	Surgical emergency ward (KAVA)	Skövde	March 22, 2021
10	Nurse D	Medicine ward	Lidköping	March 22, 2021
11	Nurse E	Nephrology ward,	Skövde	March 23, 2021
12	Nurse F	Medicine ward	Lidköping	March 23, 2021
13	Nurse G	infection ward	Skövde	March 24, 2021
14	Physician D	Medicine ward	Lidköping	March 25, 2021
15	Physician E	Medicine emergency care ward (MAVA)	Skövde	March 25, 2021
16	Physician F	Medicine ward	Lidköping	March 29, 2021
17	Nurse H	Medicine ward	Lidköping	March 29. 2021
18	Nurse I	Surgery ward	Lidköping	March 30, 2021
19	Nurse J	Cardiology ward	Skövde	March 31, 2021
20	Physician G	Medicine ward	Lidköping	April 6, 2021
21	Physician H	Cardiology ward	Skövde	April 14, 2021
22	Physician I	Surgery ward	Lidköping	April 14, 2021
23	Nurse K	Pulmonary ward	Skövde	April 15 2021
23	Nurse L	Pulmonary ward	Skövde	April 15 2021
24	Physician J	Infection ward	SÄS	April 15 2021

3.3.2 Data analysis

The data collected empirically through interviews was analyzed through examining the interview notes and recordings. Since the interviews were held in Swedish, for the purpose of this written thesis they were translated into English. This was done with great care and attention for the translations to contain the same meaning as in Swedish, if there were any points that were uncertain google translate was used to translate the sentence to English and back to Swedish to ensure a translation that conveys the sentence's meaning.

To analyze the gathered data, open coding was used (Bryman & Bell, 2011), which yields concepts that later are grouped and turned into categories. Coding is a fundamental aspect to grounded theory in combination with constant comparison (Bryman & Bell, 2011) which has enabled for continuous analysis in the work. Interview notes and opinions were made into bullet points and categorized in a compiled excel-file containing key points from all interviews. The statements from the interviews were then grouped into similar topics which allowed for identifying common denominators. The analysis revealed concepts, categories and properties that functioned as a basis for hypotheses regarding key issues as well as improvement areas in the pneumonia care process. These could then iteratively be evaluated through the quantitative data. The grounded theory method gave the authors a holistic image of the topic from all the interviewees' point of view.

3.3.3 Trustworthiness

To ensure credibility in the work triangulation has been used throughout. Triangulation is utilizing multiple sources of data, methods, and theoretical perspectives (Bryman & Bell, 2011). In this thesis triangulation has been done through interviewing care personnel from all over SHG and cross-checking the data with other participants, also literature has been a source of additional data, as well as using quantitative data as a means of comparing information. As mentioned above the work has included great care in transcribing interviews so as not to interpret the answers or them losing their original meaning. This level of care was then taken in the analysis of the data, where the authors worked together to reflect the statements made in the interviews through constant comparison.

In particular, authenticity has been an aspect that has characterized the work. Bryman & Bell (2011) describe that authenticity involves working to reflect different standpoints in the context and fairly representing them, helping participants understand their environment and other's perspective and work to engage care personnel to improve the current work practice. These are aspects that the authors have worked to achieve.

3.4 Quantitative methods

The quantitative methods of this thesis include process mining with data provided from SHG. This involved using the analysis and visualization software Disco, as well as the statistical analysis tool JMP. Process mining allows for visualizing the flows of patients, the common paths and allows for comparing different aspects of the process.

3.4.1 Data collection

The data used for process mining was retrieved from SHGs database Cognos and arranged in excel files. The data logs include information such as:

- Person-id
- Episode-id
- Gender
- Age
- Diagnoses
- Which ward the patient was treated in
- Where the patient is before and after the hospital stay
- If the patient is considered as having complex care needs
- Time of admission and discharge

The data log includes all the patients that have been diagnosed with pneumonia between the years 2018-2019. Furthermore, the raw data had been pre-processed by a data analyst (R. Javid Gholam) at SHG to only include the relevant patient group as well as to omit the social security number to protect the patients' privacy. See Figure 4 over the initial stages of data collection and pre-processing.

3.4.2 Data processing

The data analysis phase was based on the premise of answering the intended research questions. The method had the goal of process discovery, which implies visualizing the process in order to analyze it and understand in what sequence activities occur (Martin et al., 2020). The process discovery was done with the intention of understanding and locating important factors of the three process mining perspectives. This involved studying the data from the perspectives of control flow, organizational and performance (van der Aalst, 2010). In a similar manner to that of Rebuge & Ferreira (2012) process mining work has been undertaken, see Figure 4. The initial raw data was pre-processed and sorted in preparation for generating event logs. This included sorting the data based on the case-ids and the time of events. To get a better understanding of the patient group, the initial data was explored to answer questions such as: how long care time does the patient group have? What is the rate of readmissions? Where in the hospital are the patients located?

Log preparation then followed with identifying what areas of the process was possible to look at through the data. When creating the logs, it was decided to only include the care episodes where the patient had been treated with pneumonia as one of the diagnoses. This decision was made since the thesis is concerned with the process for pneumonia care, and it therefore was deemed irrelevant to look at care episodes where no pneumonia has been involved. The work then proceeded with locating the information that was relevant to include in the event logs. The following information was determined to be included in the event logs: the case ID, the activity, the start time of the event, the end time of the event, which ward the patient is treated at, which city the patient is treated in, the age of the patient, the gender of the patient, and lastly whether the patient has complex care needs or not. This was followed by processing the data so that the information would be interpretable by the process mining software, this included rearranging the data according to the event log format and transforming it to a CSV file. For an example of what the finalized event log looks like and what it contained, see Section 4.1.

Once event logs were prepared these were used for process mining utilizing the Disco-software. The program displays fuzzy models generated from the event log, which then can be used to understand the process, find causes and correlation as well as bottlenecks (Fluxicon, 2021). This resulted in several visual maps that visualize the flow of patients in the pneumonia care process, making it possible to analyze how the patients are moved throughout the hospital, where they are located and so on.

Furthermore, the software program JMP was used as an additional tool in the process mining process. JMP is a statistical software that makes it possible to visualize your data and perform a number of different statistical analyses (JMP, 2021). In order to make the statistical analysis in JMP the event log was summarized in a case log. Table 2 is an extract from the case log to show what was included and how it was summarized. The case log made it possible to efficiently analyze the data statistically in an interpretable way. Aspects such as distribution of age amongst the patient group as well as the location and duration of stays was visualized and evaluated using JMP.

Table 2 Extract from case log

Case ID	Age	Gender	Complex	Length of stay	Move between ward	Move between hospital	Readmitted	Normal discharge	Deceased	Hospital
1	19	M	0	26,14019	1	1	0	1	0	4
3	19	M	0	1,867972	0	0	0	1	0	2
4	18	K	0	0,366583	0	0	0	1	0	1

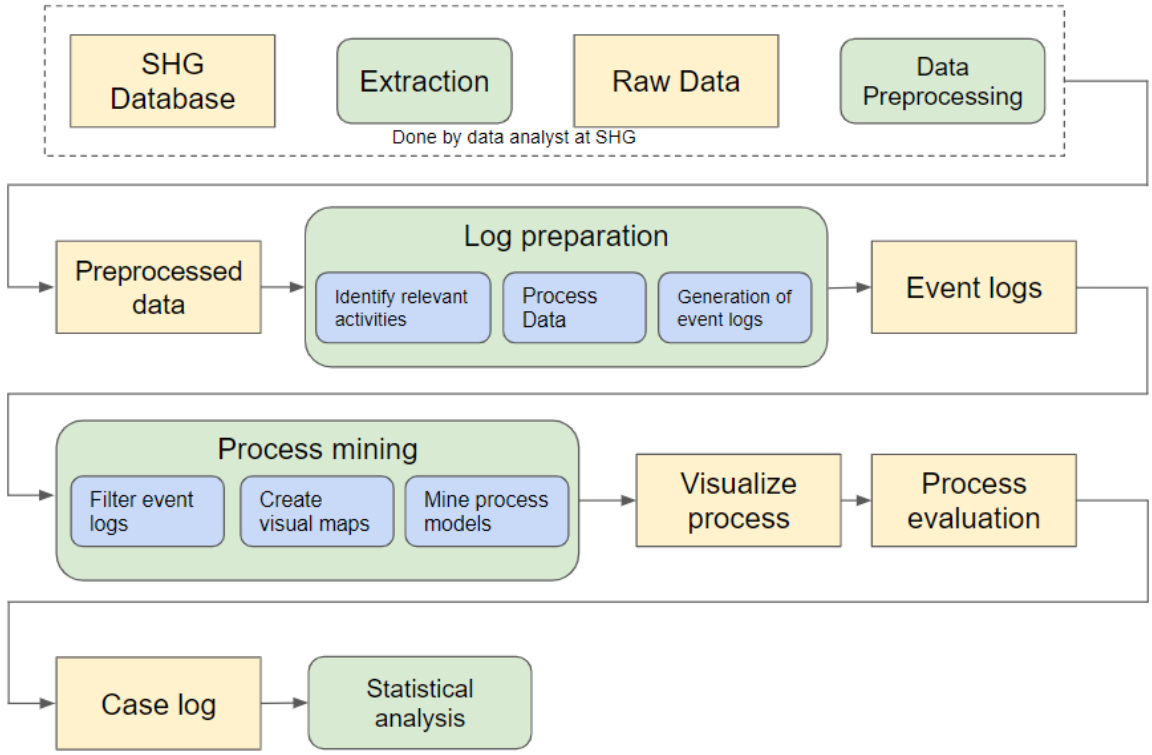

Figure 4 Visualization of the process mining process

3.4.3 Data analysis

The quantitative data was used for understanding and visualizing several different aspects of the pneumonia care process. For example, the flow of the patients throughout the hospital were visualized, highlighting aspects such as what wards they have been treated at, how often they are moved, the length of the care episodes, how often they end up being readmitted, and if they pass away during their stay. Further, the data were clustered in different ways such as in terms of complex or non-complex patients, which hospital they were treated at, and cases with or without care transitions, to see if there were any differences or similarities between different parts of the patient group as well as organizational differences that contribute to variation in care outcomes (Mans et al., 2008).

3.4.4 Validity & reliability

According to Bryman and Bell (2011), an important criterion for quantitative research is validity. It is concerned with the integrity of the conclusions that comes out of the research (Bryman & Bell, 2011). The data that has been received from SHG is assumed to have high validity and reflecting reality in the care. All measurements that are used in the study have been chosen based on literature and earlier studies, ensuring the measurement validity of the study. To ensure that the thesis work allows for investigating causal relationships between factors in the care process of pneumonia patients, internal validity checks have been included in the work. As mentioned by Bryman and Bell (2011) internal validity concerns checking whether one variable has a causal relationship with another one. Through validating the findings with literature on the topic, it could be argued that the internal validity has increased.

The degree of external validity of the results of this thesis is believed to be rather low. Due to the topic at hand being rather specific, dealing with a certain patient group with specific characteristics the results found in this study could most likely not be translated for other fields of healthcare. On the other hand, it is believed that the method used in this thesis is an aspect that can be applicable for further fields of study in healthcare. An aspect that has been emphasized by Mans et al. (2015) which states that healthcare is in need of investigating ways of becoming more efficient, reducing cost and evaluating the organization. This is something that could be done with the access to the vast amount of data that is currently being collected in healthcare systems (Mans et al., 2015).

Reliability is a concept that entails ensuring that the results found in the work is consistent and would be found again if the work were repeated (Bryman & Bell, 2011). Reliability checks in the process mining have been done through initiating it using a small sample of patients (1-5 patients) to ascertain that the generated process map from the process mining will reflect the actual events and show the true paths in the patient journey. Similarly, numbers retrieved from JMP have been compared with those found in Disco, in this sense working to ensure that the results reflect the data and if the analysis were performed again the results would not change.

3.5 Ethics

Bryman and Bell (2011) mention four principles that should be taken into consideration regarding ethicality. These principles address harm to participants, informed consent, privacy, and deception (Bryman & Bell, 2011). In the quantitative activities of this thesis the principles of not inflicting harm to participants as well as protecting their privacy are the relevant ones. Therefore, all data received from SHG had the social security number removed to protect the patients' privacy. Furthermore, the process mining has been performed in a way that does not allow for persons outside of the process to gain access to any patient's data, to protect them from harm. The work is performed and presented in a way that does not allow for individuals to be looked at in the system, avoiding any risk of identification that could harm or infringe on the privacy of the individual.

In the qualitative part of the thesis work further principles are considered. As mentioned above, data has been anonymized and protected to not affect privacy or cause harm to interview participants (Bryman & Bell, 2011). Informed consent has been ensured through notifying interviewees that the interviews are voluntary, and all answers has been anonymized. The persons interviewed were also informed of the purpose of the interview, what the material will be used for, and their right to end the interview at their own will if wished.

4
Empirical Findings

The following chapter presents the findings that have been discovered through process mining, statistical analysis, and interviews with care personnel at SHG. The findings and the creation of the hypothesis is work that has gone hand in hand in an iterative process, where discovered findings from interviews have led to further investigations in the quantitative data.

Qualitative information has been gathered through interviews, more information on this can be seen in Section 3.3.1. Quantitative data has been retrieved from SHGs data system. This chapter looks specifically at the care episodes where the patient has been treated with pneumonia as one of the diagnoses. In the data there were 2338 unique patients that have been treated with a pneumonia diagnosis sometime during 2018-2019 out of these were 533 patients with complex care needs. Out of the 6479 care episodes that these patients had, 2682 were related to pneumonia in some way. For the quantitative analysis, each care episode will be considered as a case - in other words, the same patient could have multiple cases. Of the 2682 care episodes, 769 were related to patients with complex care needs, while 1913 were related to non-complex patients.

4.1 Flow of patients

The quantitative data was processed by using the process mining software Disco, as well as the statistical analysis software JMP. As mentioned above only the care episodes where the patient at least once has been diagnosed with pneumonia will be considered. To understand and visualize the care process, event logs containing the following information were created: Case ID, activity, start time, end time, ward, city, age, gender, and if the patient has complex care needs or not. Table 3 shows an extract of the event log.

Table 3 Extraction from event log

Case ID	Activity	Start time	End Time	Ward	City	Age	Sex	Complex or not
1	Emergency Care	2019-05-19 11:08	2019-05-19 11:09	Emergency clinic	Lidköping	19	M	0
1	Admission	2019-05-19 11:11	2019-05-28 14:53	Medicin-avdelning 6	Lidköping	19	M	0
1	Move hospital	2019-05-28 14:54	2019-05-31 14:46	Infektion-avdelning 22	Skövde	19	M	0
1	Move ward	2019-05-31 14:47	2019-06-14 14:32	Neuro-avdelning	Skövde	19	M	0
1	Discharged	2019-06-14 14:33	2019-06-14 14:34	Neuro-avdelning	Skövde	19	M	0
3	Emergency Care	2019-12-28 17:56	2019-12-28 17:57	Emergency clinic	Lidköping	19	M	0

3	Admission	2019-12-28 17:59	2019-12-30 14:46	Medicin-avdelning 6	Lidköping	19	M	0
3	Discharged	2019-12-30 14:47	2019-12-30 14:48	Medicin-avdelning 6	Lidköping	19	M	0
6	Emergency Care	2019-07-22 05:57	2019-07-22 05:58	Emergency clinic	Lidköping	18	F	0
6	Admission	2019-07-22 06:00	2019-07-26 14:00	Medicin-avdelning 4	Lidköping	18	F	0
6	Furlough	2019-07-26 14:01	2019-07-28 04:59	Furlough	Lidköping	18	F	0
6	Back from furlough	2019-07-28 05:01	2019-08-01 12:00	Medicin-avdelning 4	Lidköping	18	F	0
6	Discharged	2019-08-01 12:01	2019-08-01 12:02	Medicin-avdelning 4	Lidköping	18	F	0
516	Admission	2018-12-03 14:36	2018-12-13 15:11	Hjärt-avdelning 32	Skövde	89	F	0
516	Move ward	2018-12-13 15:12	2018-12-19 14:48	Lungmedicin-avdelning	Skövde	89	F	0
516	Readmission	2018-12-19 14:49	2018-12-19 14:50	Lungmedicin-avdelning	Skövde	89	F	0
214	Emergency Care	2019-02-03 12:01	2019-02-03 12:02	Emergency clinic	Falköping	98	F	0
214	Admission	2019-02-03 12:04	2019-02-21 13:12	Ortopedi-avdelning Falköping	Falköping	98	F	0
214	Deceased	2019-02-21 13:13	2019-02-21 13:14	Ortopedi-avdelning Falköping	Falköping	98	F	0

4.1.1 Understanding the maps

To understand the visual maps created in Disco, this section describes how they are read. Eight different activities can be read from the raw data. They can be viewed as three parts of the process, either as entry points, actions during the stay, or exit points.

There are two entry points to the process. Either the patient comes to the hospital via the emergency clinic and then gets admitted, or the patient gets admitted right away to a specific ward. Therefore, the following two activities have been defined:

- *Emergency care*, when a patient acutely comes to the emergency care clinic.
- *Admission*, when the patient gets admitted as an inpatient at a ward.

During the stay the patient may be moved between different wards. There is also a possibility that the patient goes on a planned leave from hospital during the stay. To illustrate where the patient is located

during the stay, and show how the patient is moved around the hospital the following activities were defined:

- *Move between ward*, when the patient gets moved between two wards at the same hospital.
- *Move between hospital*, when the patient gets moved between two different hospitals at SHG.
- *Furlough*, when the patient goes on a planned leave from the hospital.
- *Back from furlough*, when the patient gets back to the hospital from furlough.

At the end of the hospital stay the patient is either discharged or passes away during the stay. However, there is a possibility that the patient is readmitted within 30 days from the discharge. Although if the readmission is unplanned or planned is something that is not revealed in the data. However, considering that a significant amount of the pneumonia patients are admitted through the emergency clinic, it can be assumed that generally the readmissions are unplanned. To differentiate between if a patient either has passed away, been readmitted after the stay, or the stay results in a normal discharge, the following activities were defined.

- *Readmission*, if the patient is readmitted to the hospital within 30 days from leaving the hospital.
- *Discharged*, when the patient gets discharged from the hospital and sent home but is not readmitted within 30 days.
- *Deceased*, when the patient has passed away during the hospital.

Below is an image showcasing an example with 5 patients that follows different paths through the hospital, to illustrate how to read the map generated from Disco (see Figure 5). Here one can see that four of the cases have gone through emergency care before being admitted. During the stay, two of the patients were moved between wards, and one of them was also moved between hospitals. One patient has been on a furlough during the care episode. From the exit points one can see that one patient was readmitted, three were discharged, and one passed away.

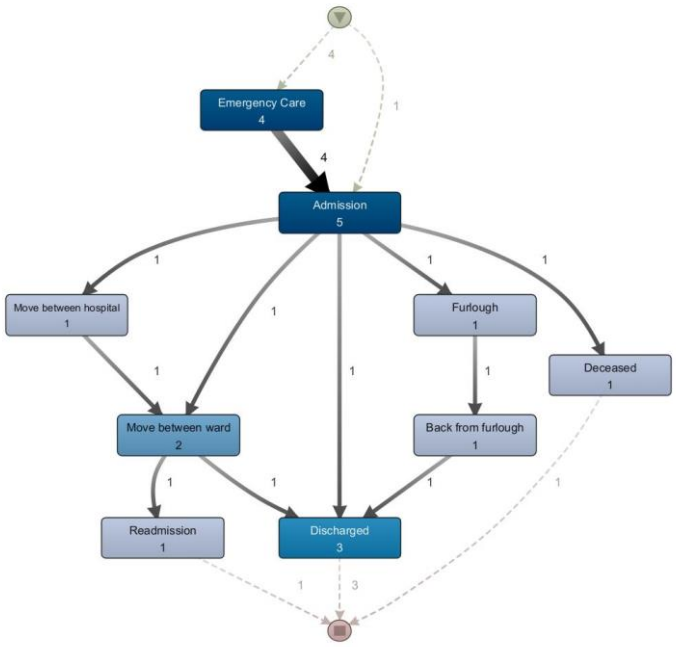

Figure 5 Example of 5 patients

Through interviews it has been revealed that the optimal way through the hospital is to come to the hospital, be admitted to a ward, be discharged, and be done with the treatment. The optimal traces would thus be either *Emergency care → Admission → Discharged*, or *Admission → Discharged*. Move, readmission and deceased are undesired events.

4.2 The Patient group

To understand the care process, it is important to firstly understand the characteristics of the patient group. When attempting to identify what characterizes the pneumonia patient group it was mentioned that *"Oftentimes they are old and have multiple diagnoses, and they often have underlying illnesses. This can lead to longer care episodes." (Nurse F).* This is something that was a common theme when interviewees described the characteristics of the patient group. Additionally, since *"They are a patient group that do not have a specialty care area. They are cared for all over the hospital." (Nurse F).*

When looking at the quantitative data this is evident. The patients have an average age of 71,1 years and have been treated at approximately 40 different wards throughout the hospital. Figure 6 shows the age distribution in the patient group, and Figure 7 shows all the wards that sometime have been involved in the care process.

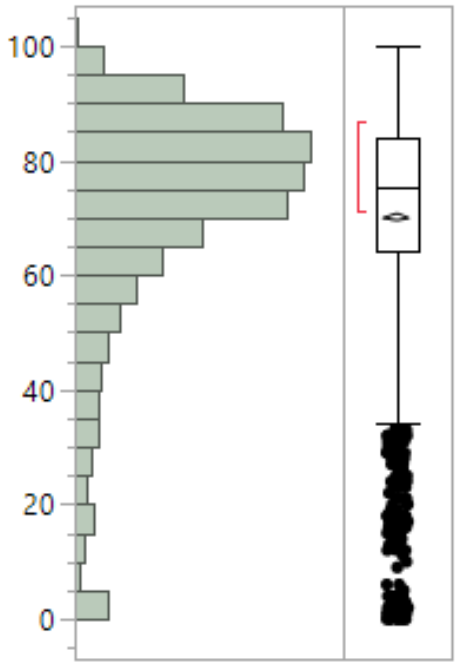

Figure 6 Histogram over the age distribution

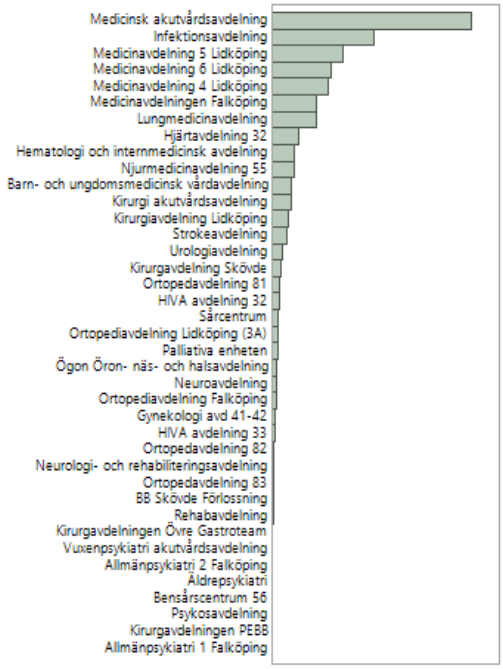

Figure 7 Histogram over all wards involved in the pneumonia care.

As noted in the interviews, older patients are generally more difficult to treat than younger patients. "*Pneumonia patients are often old and fragile, which can make the care more complicated. It is not uncommon that they have other underlying diagnoses as well that further complicates the sickness." (Nurse C)*. It was also expressed that, "*Older patients with multiple diagnoses are always harder to treat*" *(Physician E)*. In the quantitative data one can note that there is a significant relationship between an older patient and both a longer LOS and a higher mortality rate, as can be seen in Table 4. However, when looking at readmissions the relationship with age is inconclusive. Worth noting is that the R-square is very low for this model, indicating that age only accounts for a small portion of the variation.

Table 4 Impact of age on LOS, readmission rate, and mortality

	Y=LOS R-sq=0,0185			**Y=Readmission rate** R-sq=0,00005			**Y=Mortality rate** R-sq=0,0240		
Term	*Estimate*	*Std Error*	*P-value*	*Estimate*	*Std Error*	*P-value*	*Estimate*	*Std Error*	*P-value*
Intercept	3,5508	0,5017	<0,0001	0,1945	0,0280	<0,0001	-0,0714	0,0194	0,0002
Age	0,0483	0,0068	<0,0001	-0,0001	0,0004	0,7227	0,0021	0,0003	<0,0001
N	2682								

4.2.1 Complex care needs

In the interviews it was mentioned that the care process is somewhat dependent on if the patient has complex care needs or not. When other diagnoses are added to the pneumonia diagnosis, meaning that the patients have complex care needs, it adds complexity in the pneumonia care. There is additional care that needs to be taken for these patients, and with the added complications of several diagnoses there is an even greater need for individualized care.

> *"It is always more difficult to treat patients with several diagnoses. If you have several conditions, it gets more difficult to understand the overall picture. It gets harder to diagnose, to know if the symptoms are new or if the condition has worsened. These patients have less margins and certain treatments might not be suitable." (Physician C).*

Although most interviewees mentions that complex care needs and a pneumonia diagnosis adds complexity, some mentioned that the pneumonia care does not differ much from regular pneumonia care. *"Perhaps the physiotherapists are called in earlier, they are in a much greater need for help in breathing than what a younger patient is. Otherwise, it is much the same, but the care time can be longer because they don't have the same capacity any longer." (Physician F).* In general, it was mentioned that when assessing pneumonia patients with complex care needs one needs to consider what other diagnosis and medicines the patient is taking, in relation to the treatment as a whole.

It was mentioned that *"...these patients are often affected by pneumonia because of different conditions affecting their respiratory system. It is a very difficult patient group, and they can be placed almost anywhere due to their many conditions." (Nurse G)*, by this meaning that complex care needs might make it difficult to determine what ward to place the patient, and which diagnosis should be prioritized in the care. Given that complex care needs add complexity according to care personnel, this aspect will be further evaluated through quantitative data.

Comparison between complex and non-complex patients

The average age of the patients with complex care needs is 74,7 years, while for the non-complex patients the average age is 69,6 years, as can be seen in Table 5. The standard deviation of the age amongst the complex patients is lower than that of the non-complex patients. This indicates that the

complex patients in general are both older and has a lower variation in age than the non-complex patients.

When comparing complex and non-complex patients' paths quantitatively, there are several aspects in the care as well as care performance that can be considered. Figure 8 shows the flow when looking at the whole group of pneumonia patients, consisting of 2682 cases. One can note that most patients (~87,3%) come in through the emergency care clinic before being admitted to the hospital. In 23,8% of the cases the patient was moved between wards, and in 9,1% of the cases the patient was moved between hospitals. 18,5% of the cases ended up in a readmission, and in 8,1% of the cases the patient passed away. The mean case duration, i.e., the LOS is 7 days. The most common sequence is *Emergency care → Admission → Discharged* with 44,07% of the total cases. Also, 7,49% of the cases follow the sequence *Admission → Discharged.* Thus 51.56% of the cases follow an "optimal" path.

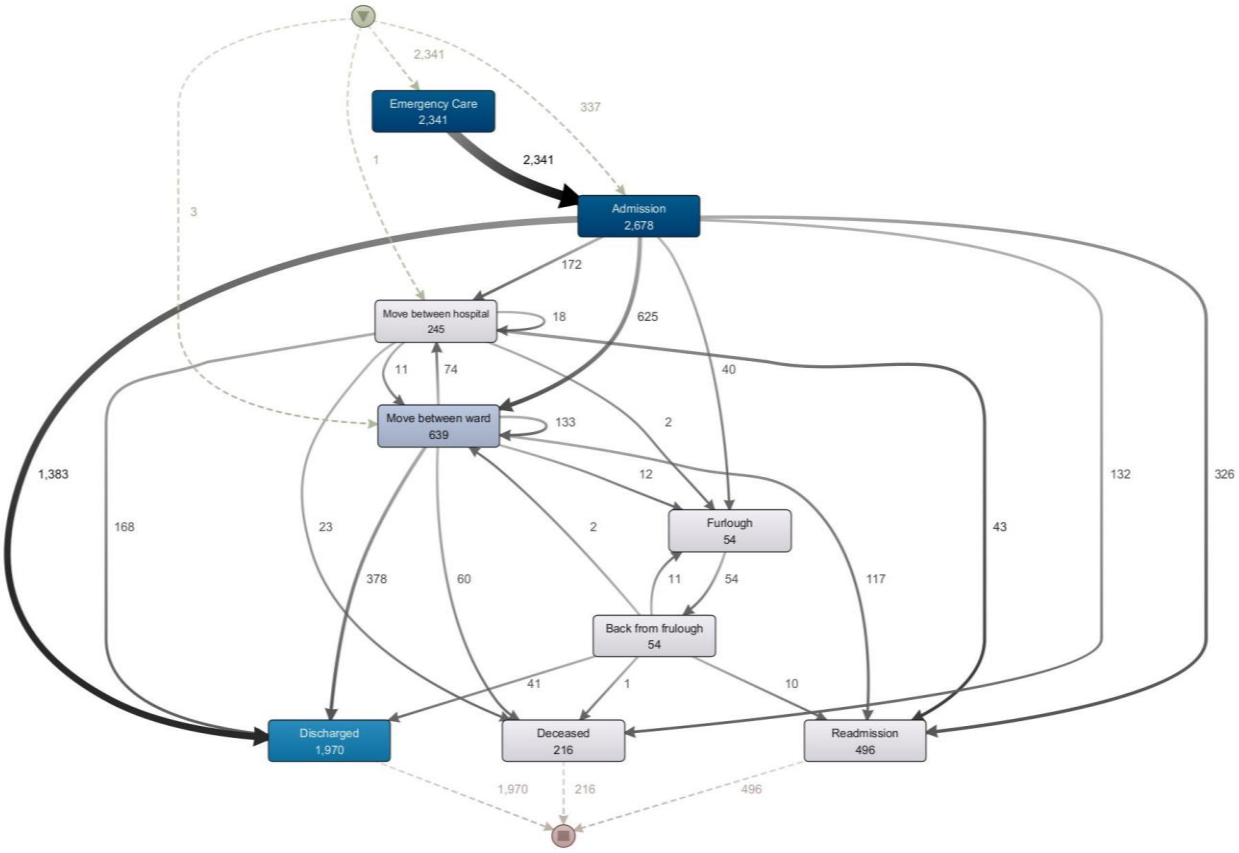

Figure 8 The flow of the whole patient group

From the findings it could be discerned that there is a relationship between the complexity of the flow and whether the patient has complex care needs. As can be seen in Table 5, significantly more of the non-complex patients follow the optimal path in comparison with the complex patients. Below two images of the flow comparing the complex (Figure 9) and non-complex (Figure 10) patients is shown.

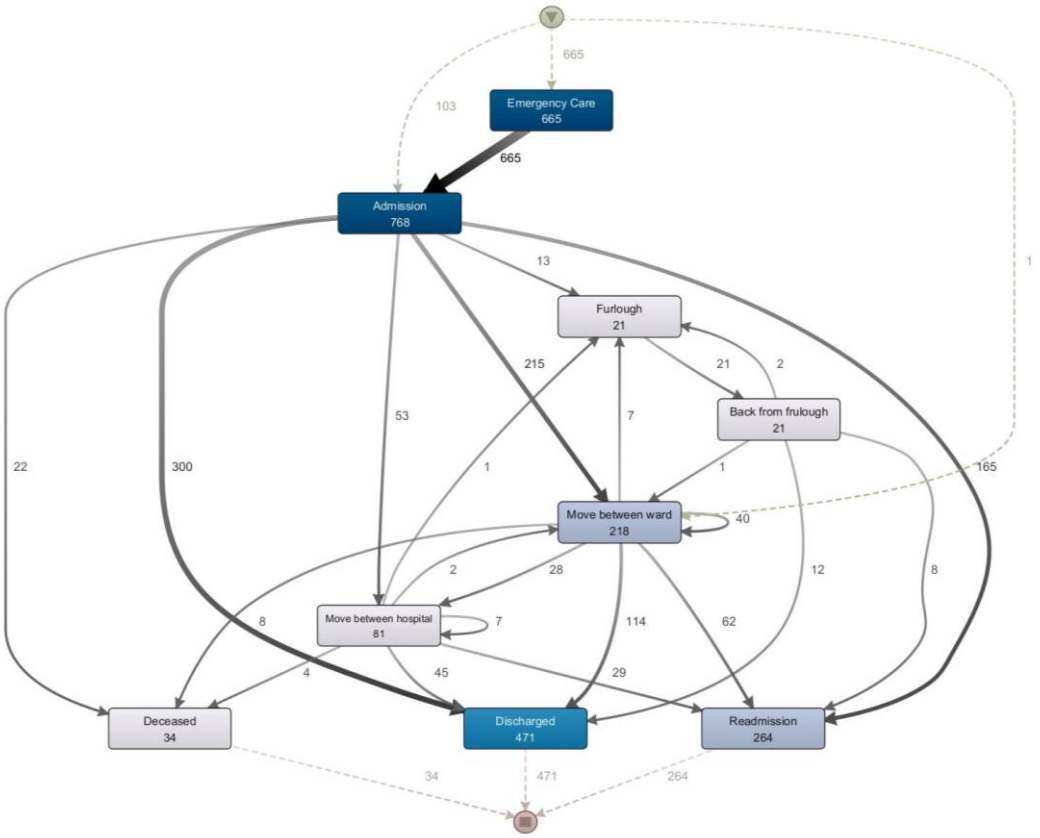

Figure 9 The flow of complex patients

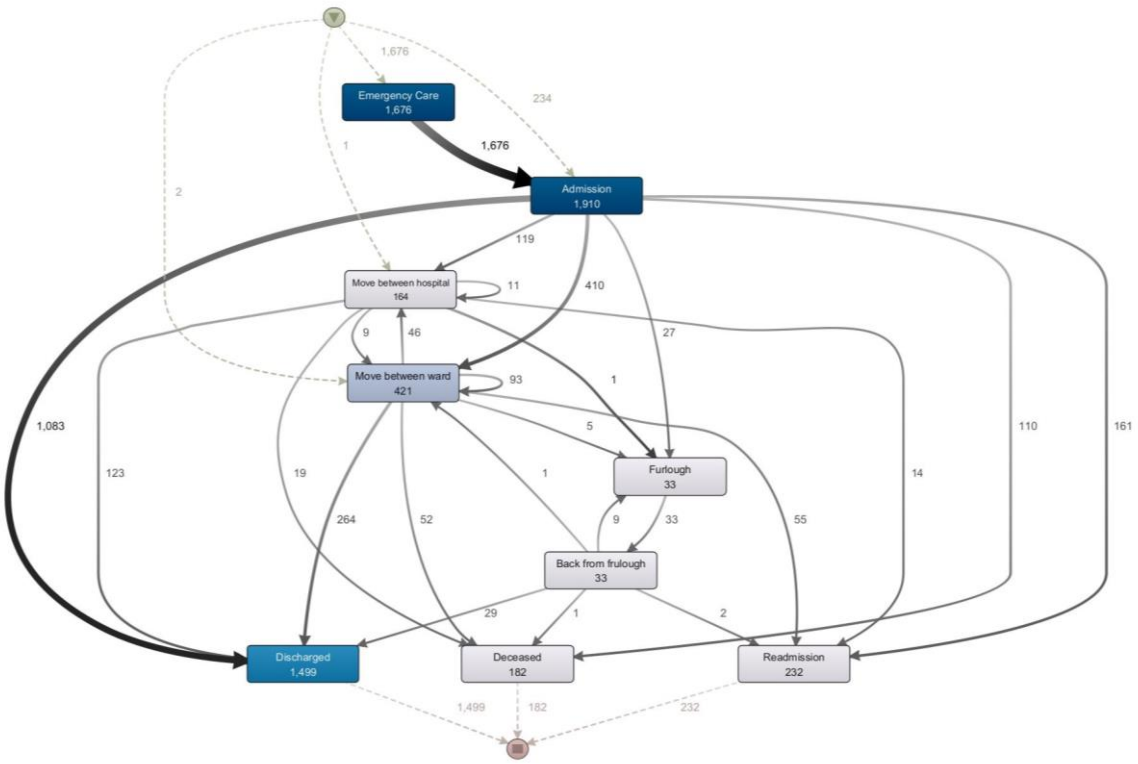

Figure 10 The flow of non-complex patients

Table 5 Comparison of non-complex and complex patients

	N=2682	Non-complex	Complex	Difference	Stat test	p-value
	N	*1913*	*769*			
Age (years)	*mean*	69,64	74,68	5,04	Wilcoxon	0,003
	std dev	21,58	13,52			
Proportion of cases moved between wards	*mean*	0,2201	0,2835	0,0634	Wilcoxon	0,0005
	std dev	0,4144	0,4510			
Proportion of cases moved between hospital	*mean*	0,0857	0,1053	0,0196	Wilcoxon	0,1111
	std dev	0,2801	0,3072			
LOS (days)	*Mean*	6,69	7,70	1,01	Wilcoxon	<0,0001
	std dev	6,95	7,11			
Readmission rate	*mean*	0,1213	0,3433	0,222	Wilcoxon	<0,0001
	std dev	0,3265	0,4751			
Mortality rate	*mean*	0,0951	0,0442	-0,0509	Wilcoxon	<0,0001
	std dev	0,2935	0,2057			
Follows the optimal path	*mean*	0,5661	0,3901	-0,176	Wilcoxon	<0,0001
	std dev	0,4957	0,4881			

The complex patients consist of 769 cases, while the non-complex patients consist of 1913 cases. Similarly for both groups the majority comes in through the emergency clinic before they are admitted to the hospital (see Figure 9 and 10). During the stay the complex patients are more prone to be moved, as can be seen in Table 5. Looking at the complex patients, about six percentage points more of the cases involves a move between wards, compared to the non-complex cases. Furthermore, the complex patient cases are almost three times more likely to end up in a readmission than the non-complex patients and have in general one full day longer LOS (see Table 5).

A bit surprisingly however, the non-complex patient cases have a higher mortality than the complex patient cases (see Table 5). About twice as many of the non-complex patients' cases ended up as deceased, compared to the complex patient cases. However, when looking at the mortality rate one must remember that since we are defining each care episode as a case, each unique patient can have multiple cases. The lower mortality rate in complex patients could possibly be explained by the complex care needs patients having more care episodes. However, when looking at the mortality rate in that way there is still a difference. There are 533 individual patients with complex care needs, and 34 (~6,3%) of these passed away during a pneumonia related care episode. Similarly, there are 1805 non-complex patients, out of which 182 (~10,1%) passed away during a pneumonia related care episode.

4.3 Organization

As noted, SHG consists of hospitals located in Skövde, Lidköping, Falköping and Mariestad. Out of the cases the majority (~66%) was treated in Skövde, about a third (~33%) in Lidköping, and only a small portion (~8%) in Falköping. The reason that the percentages add up to more than 100% is because some patients were moved between the cities during their stay. As can be seen in Figure 11, there were 31 patients that were moved from Skövde to Lidköping, and 22 patients from Lidköping to Skövde. Out of the patients treated in Falköping, the majority (~87%) was first admitted to Skövde and then moved to Falköping.

In interviews it was mentioned that the organizations in Skövde and Lidköping differ from one another. *"...we don't have the same organization as in Skövde where they come to MAVA and then get moved to other wards." (Nurse H, Lidköping)*. In Lidköping there are three medicine wards that in general care for all the pneumonia patients. In contrast, in Skövde the hospital care is more fragmented, where the care network is divided in specialized wards. "*In Skövde we have no geriatric ward*" *(Physician E)*. Instead, there is the medicine emergency ward (MAVA) and the surgical emergency ward (KAVA) which the patients go through, and then gets funneled out to more specialized wards.

These organizational differences are clear when looking at the care network involved in the treatment of pneumonia patients, i.e., where at the hospital the patients are treated. As mentioned, pneumonia patients do not have a designated ward and therefore run the risk of being located at any of these wards in the hospital. Since these organizational differences have been revealed through interviews, quantitative data have been used to investigate how organization affects the care for pneumonia patients. Below are two figures displaying the care network of pneumonia patients in Skövde (Figure 12) and in Lidköping (Figure 13).

What can be noted from these figures is that the care network is more fragmented in Skövde in comparison to the one in Lidköping (see Figure 12 and 13). The patients in Skövde are treated at a variety of places throughout the hospital, and there is no designated ward in which the patient should end up. In contrast, Lidköping has a focused care network of the patients. The majority of the patients get admitted to either of the three medicinal wards, and then stays there throughout the care episode.

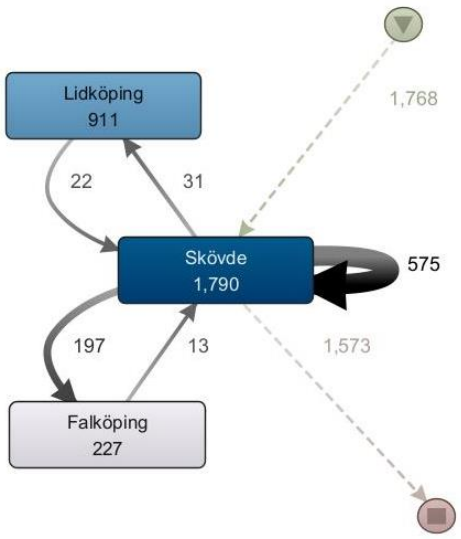

Figure 11 Moves between cities

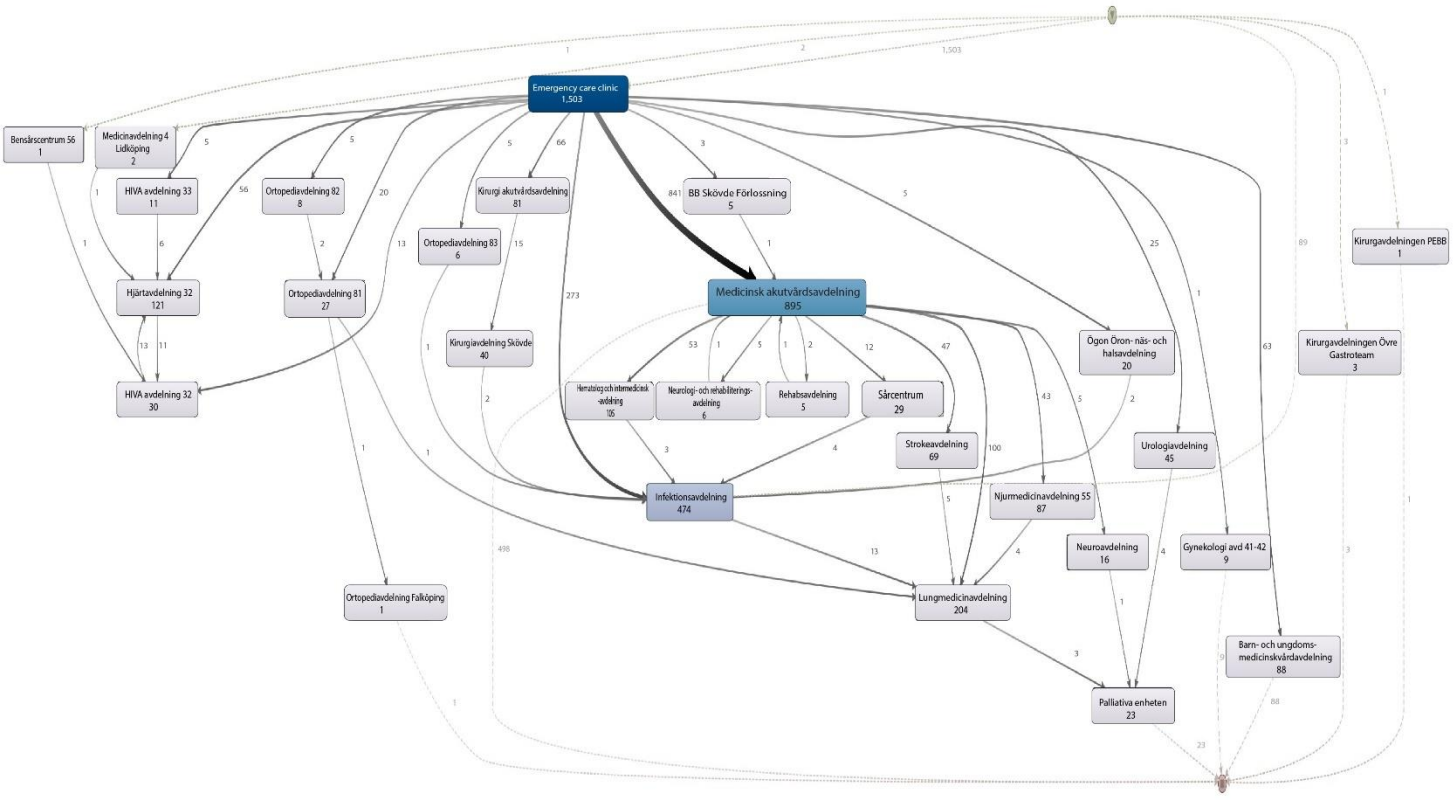

Figure 12 Care network for pneumonia patients in Skövde (for a larger version, see appendix 2)

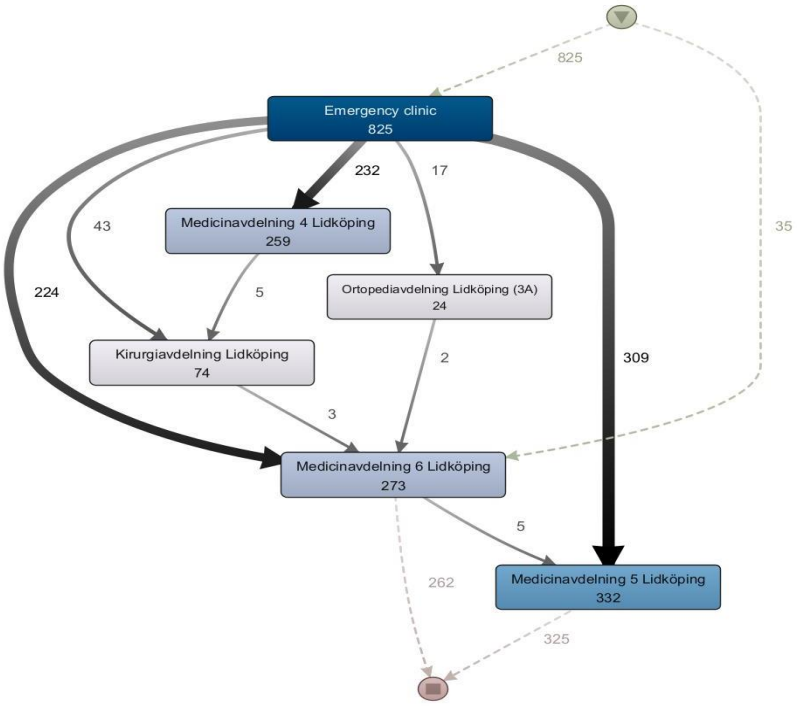

Figure 13 Care network for pneumonia patients in Lidköping

As can be seen in Table 6, the differences between Skövde and Lidköping for the whole patient group seem to contribute to a longer LOS, where the cases in Skövde in general have approximately one day longer LOS. However, the relationship between the organizational structure and readmission as well as mortality rate remains inconclusive. When focusing on the complex patients, the difference in LOS between the hospitals are even more prevalent, with the cases in Skövde having about 1,5 days longer LOS (see Table 7). The relationship with the readmission rate remains inconclusive, but interestingly the mortality rate is higher in Lidköping than in Skövde.

Table 6 Comparison between Skövde and Lidköping for the whole patient group

	N=2701	**Skövde**	**Lidköping**	**Difference**	**Stat test**	**p-value**
	N	*1790*	*911*			
Proportion of cases moved between wards	*Mean* *Std dev*	0,3251 0,4686	0,0714 0,2576	0,2537	Wilcoxon	<0,0001
LOS (days)	*Mean* *Std dev*	7,38 7,59	6,40 6,71	0,98	Wilcoxon	0,0195
Readmission rate	*Mean* *Std dev*	0,1877 0,3906	0,1778 0,3826	0,0099	Wilcoxon	0,5313
Mortality rate	*Mean* *Std dev*	0,0777 0,2677	0,0878 0,2832	-0,0101	Wilcoxon	0,3604

Table 7 Comparison between Skövde and Lidköping for complex patients

	N=775	**Skövde**	**Lidköping**	**Difference**	**Stat test**	**p-value**
	N	*527*	*248*			
Proportion of cases moved between wards	*Mean* *std dev*	0,3814 0,4862	0,0766 0,2665	0,3048	Wilcoxon	<0,0001
LOS (days)	*Mean* *std dev*	8,25 7,55	6,69 6,40	1,56	Wilcoxon	0,0006
Readmission rate	*Mean* *std dev*	0,3472 0,4765	0,3387 0,4742	0,0085	Wilcoxon	0,8158
Mortality rate	*mean* *std dev*	0,034 0,1818	0,069 0,2532	-0,035	Wilcoxon	0,0316

4.4 Care transitions

From the interviews it could be discerned that the organizational differences lead to big differences in terms of care transitions. A common reason for moves that was mentioned by several interviewees was that pneumonia patients are moved since they are not assigned to one specialized medical area. As mentioned, *"... general practice patients are moved around, since they don't have a "home" ward" (Nurse E)* and are therefore moved around to make room in the wards for patients that need specialized care. *"Patients are moved since the care network is organized in highly specialized care units. There are a lot of specialist wards that are specialized in their type of patients. All the patients that have general needs are then moved around between the wards" (Physician E).* Although, pneumonia can be somewhat categorized to be part of the infection and pulmonary areas, since pneumonia is a common diagnosis, there are not enough beds in these wards to treat all patients there. *"This depends a lot on budget cuts etc. If there is a lack of human resources, we cannot keep the hospital beds open. This affects the patients that have a little of everything and don't belong at a particular ward" (Physician E).* When interviewing personnel from Lidköping it was several times mentioned that moves are not such a common occurrence as in Skövde.

> *"We don't see that in Lidköping. In opposite to Skövde, we have an emergency clinic where they are selected immediately to one of the three medicine wards. Once you have arrived at a ward you will not leave that ward. This differs from practices in Skövde where you perhaps arrive at the emergency clinic and are moved to MAVA, and then moved to another ward and after that perhaps another time. But this is not a question for Lidköping, here they are not moved around." (Physician F)*

The fragmented care can be seen when looking at the process flow of the activities. In the whole patient group, a case involved a move ~22,9% of the time, as seen in Figure 14. However, in Lidköping there are considerably fewer moves done compared to in Skövde, as mentioned in the interviews. Figure 15 shows the flow in Lidköping, and Figure 16 shows the flow in Skövde. As can be seen in Table 6, the cases in Skövde are more than four times as likely to be moved between wards than the cases in Lidköping. This can also be seen in Figure 14 that shows that there are significantly less moves between wards in Lidköping.

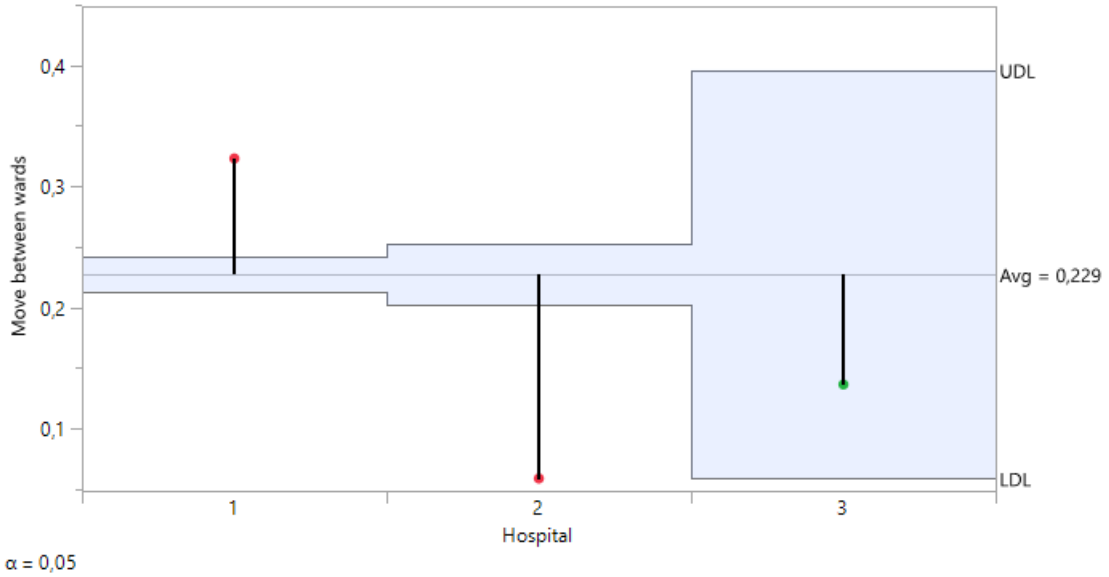

Figure 14 Proportion of cases involving a move (Y-axis: percentage; X-axis; Hospital 1=Skövde, 2=Lidköping, 3=Falköping)

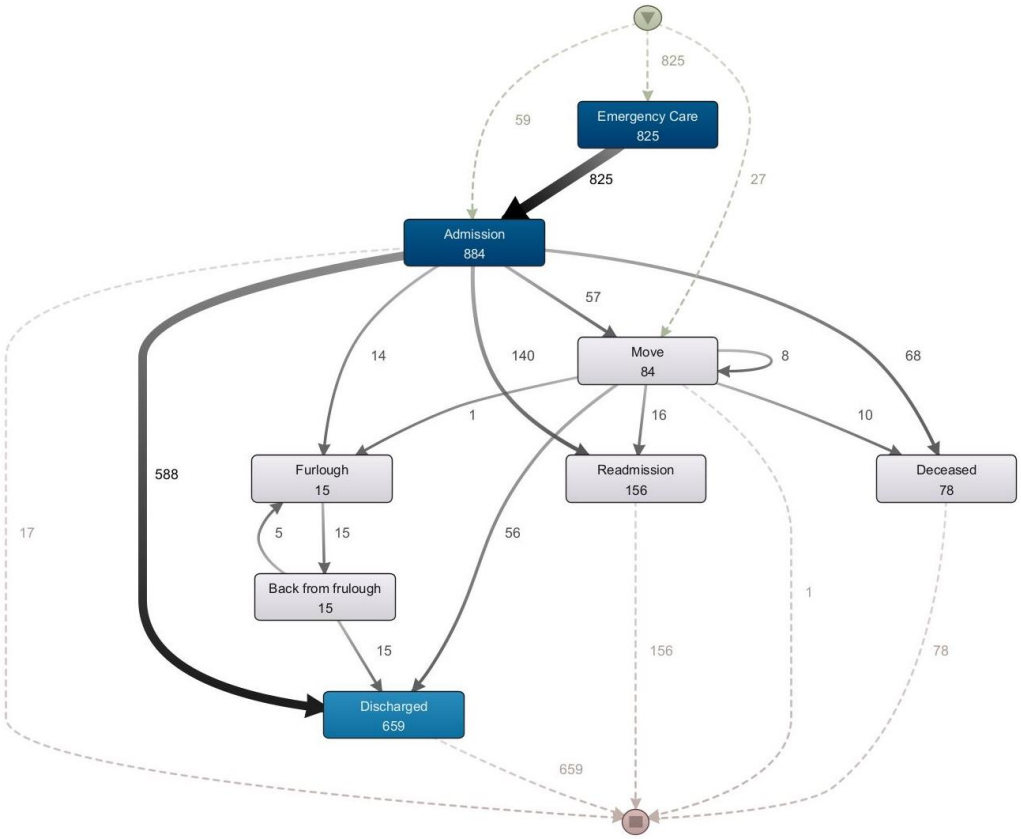

Figure 15 the flow of the whole patient group in Lidköping

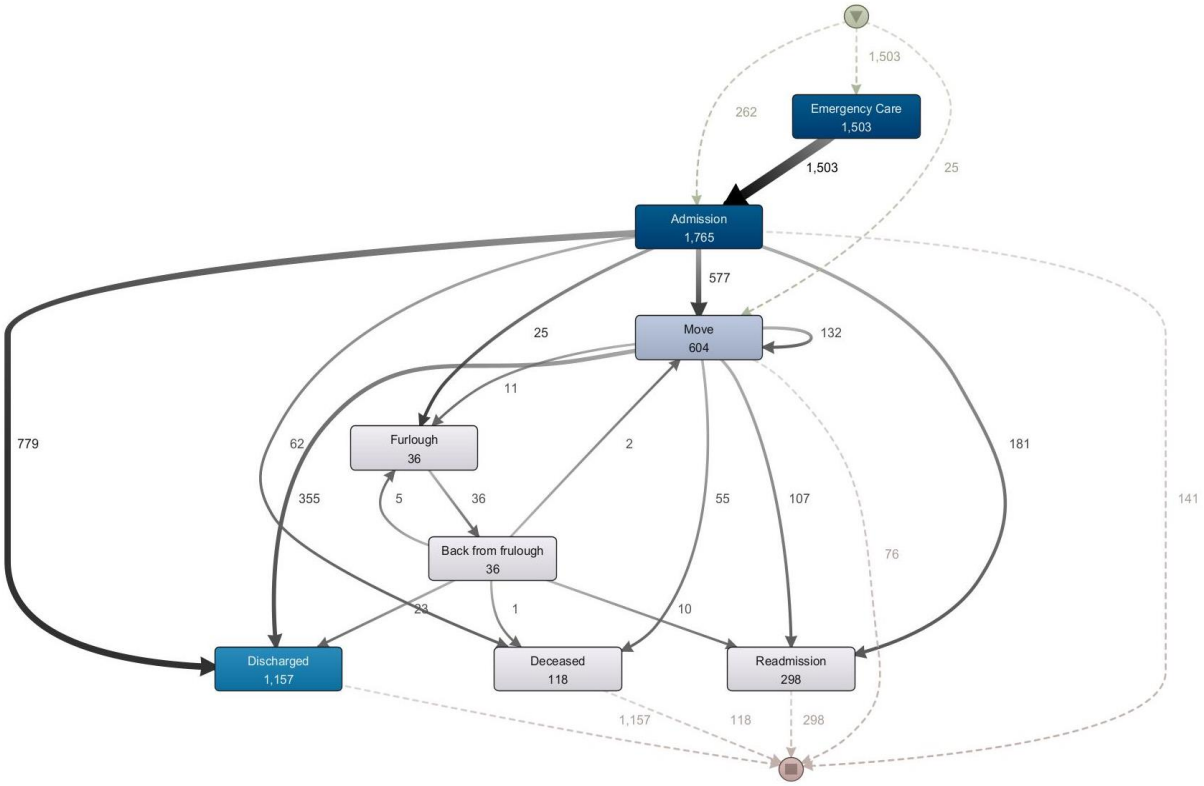

Figure 16 The flow of the whole patient group in Skövde

When including control parameters such as age, gender, and the complexity of the patient into the analysis, it reveals that these factors also influence the likelihood of a patient to be moved (see Table 8). The hospital is by far the biggest influence, further showing the organizational differences at SHG. Moreover, a patient with complex care needs, as well as an older patient has an increased risk of being moved. Males also seem to have an increased risk of being transitioned, although this not being as significant. It is however important to note that this model only shows an R square of 0,13, indicating that there is a lot of variation not accounted for by the model. There are probably several other factors also influencing whether a patient will be moved or not, however these factors will not be addressed further in this thesis quantitatively.

Table 8 Factors influencing the likelihood of being moved

	Y=Proportion of cases involving moves R-sq=0,1295		
Term	***Estimate***	***Std Error***	***P-value***
Intercept	0,3343	0,0346	<0,0001
Complex	0,0367	0,0180	0,0415
Hospital	-0,2870	0,0169	<0,0001
Gender[K]	-0,0145	0,0081	0,0733
Age	0,0039	0,0004	<0,0001
N	2409		

4.4.1 Why does care transitions matter?

Some benefits regarding care transitions were mentioned in the interviews, such as *"It can be good to be moved in the sense that you can get treatment at a place that is more specialized in your certain condition."* (*Nurse C)*. However, the overall attitude towards moves was negative and some even went to the extent to express that "*There are no benefits to this (moves)*" *(Nurse F).* It was agreed upon that optimally there would be no moves in the care, that patients would be admitted to one ward and once their condition improves, they are discharged from the same ward. Despite the negatives with moves, interviewees working in Skövde mentioned that due to their organizational structure in some respects it is inevitable that patients are moved, *"MAVA is a ward where we work to stabilize, diagnose and then move the patient to the correct ward, so it is natural that patients are moved from MAVA." (Physician E)*. Showcasing that the hospital has MAVA as a stop between the emergency clinic and other wards, once the patient is stabilized, they need to prioritize making room for more acutely ill patients, in turn leading to patients moving more often. Although it has been noted that approximately half of the pneumonia patients are moved from MAVA and half are discharged, some benefits of there being a MAVA was described.

> *"I see a great advantage in having such a department (MAVA) that can sort out the patients who can go home quickly and who need to be admitted for longer care. The idea from the beginning was that most people should actually go home. For example, with a pneumonia patient, it is a simple case which generally improves quite quickly, and we know antibiotics work, then the patient can go home already from MAVA. But sometimes the patient needs longer care, not necessarily for pneumonia, and needs care planning, then the patient ends up in some medical department. I see a great benefit from MAVA if it works well." (Physician H, cardiology)*

On the other hand, pneumonia care takes longer than what is expected for the time that the patient is to be admitted at MAVA, as was mentioned by staff working in Lidköping, "*In Skövde at MAVA they think that a patient with pneumonia arrives and needs maybe one day of care and then they are ready to go home, but most often those with pneumonia needs 3-5 care days." (Physician F).* Whilst it was mentioned by a nurse working at MAVA that, *"... MAVA has around an average of 1,2 days care days, the idea is that it's an emergency ward where the patient is located to be stabilized. Once the patient is stable, they should be moved to another ward..." (Nurse B).* This displays what might be a factor to additional moves of pneumonia patients in Skövde.

In the interviewees there were a multitude of negatives that were mentioned to be associated with moves, a statement that encapsulates the overall opinions about moves was as following, *"Moves make the patient confused. It is hard for the personnel to follow up on and have continuity in the care, and it gets difficult to get an overview in progress of the patient's status." (Physician B).* Furthermore, the interviewees showed agreement that moves are a source of losing information in the care, *"There is a risk of the patient falling through the cracks." (Nurse B)*, meaning that some information about for instance the patient's symptoms can be lost during moves.

Further, interviewees mentioned that LOS is affected by moves, *"It is said that it costs at least 1 to 1.5 care days per move, and it is not so difficult to realize that. Because it is difficult to take over where someone else has started." (Nurse K)*, and *"The LOS is prolonged because you change physicians and nurses. New personnel need to familiarize themselves with the patient, so for the patient it is never good. Additionally, these often are old patients, so the risk of confusion is increased." (Nurse J).* This last part of the statement was also something that the interviewees brought up, that due to the patients often being elderly in the pneumonia patient group there is an increased occurrence in patient confusion and decrease in well-being experienced in the care due to moves.

From the information gathered in the interviews it seems that care transitions could affect the care process negatively. Therefore, the impact of care transitions will be further investigated using quantitative data.

4.4.2 The impact of care transitions

As was brought up during the interviews, moving a patient can have several negative impacts such as an increased LOS, problems with information transfer, reduced quality of care and impaired patient safety. By processing the quantitative data, it is possible to highlight a few aspects related to moves. As can be seen in Table 9, care transitions seemingly impact both LOS, readmission rate and mortality rate negatively. Especially the LOS seems to be correlated with if a move has occurred or not, where the cases involving a move has almost twice as long LOS than the cases not involving a move.

These correlations can also be seen when differentiating between the hospitals, as can be seen in Table 10. The LOS is significantly longer for the cases involving a move both in Skövde and in Lidköping. Furthermore, both the readmission rate and the mortality rate are negatively impacted by the care transitions, although the significance of the findings is lower.

Table 9 The impact of care transitions

	N=2682	Cases with no care transition	Cases with care transitions	Difference	Stat test	p-value
	N	*1879*	*803*			
LOS *(days)*	*Mean*	5,29	10,96	5,67	Wilcoxon	<0,0001
	std dev	5,02	9,11			
Readmission rate	*Mean*	0,1772	0,2030	0,0258	Wilcoxon	0,1155
	std dev	0,3820	0,4025			
Mortality rate	*mean*	0,0708	0,1034	0,0326	Wilcoxon	0,0045
	std dev	0,2565	0,3046			

Table 10 Impact of care transitions - differentiating between hospitals.

		Cases with no care transition	Cases with care transitions	Difference	Stat test	P-value
Skövde	*N*	*1208*	*582*			
LOS (days)	*Mean*	5,63	11,01	5,38	Wilcoxon	<0,0001
	Std dev	5,68	9,52			
Readmission rate	*Mean*	0,1813	0,2010	0,0197	Wilcoxon	0,3166
	Std dev	0,3854	0,4011			
Mortality rate	*Mean*	0,0671	0,0997	0,0326	Wilcoxon	0,0158
	Std dev	0,2502	0,2998			
Lidköping	*N*	*527*	*248*			
LOS (days)	*Mean*	5,86	13,49	7,63	Wilcoxon	<0,0001
	Std dev	5,17	15,28			
Readmission rate	*Mean*	0,1738	0,2308	0,0570	Wilcoxon	0,2471
	Std dev	0,3791	0,4246			
Mortality rate	*Mean*	0,0851	0,1231	0,038	Wilcoxon	0,2978
	Std dev	0,2792	0,3311			

4.4.3 Information transfer & communication

As has been shown both from the interviews and the quantitative data, care transitions affect the care process in a negative way. However, it will not be likely that all transitions can be avoided just by the way the organization is structured. As can be seen in the data, moves still occur in Lidköping although to less extent than in Skövde. It was mentioned that a factor to care transitions in general is budget cuts and lack of human resources, which in this case affects the pneumonia patients, *"... If there is a lack of human resources, we can't keep the hospital beds open. This affects the patients that have a little of everything and don't belong at a particular ward" (Physician E).* Given that care transitions to some extent will be a part of the system regardless of the organizational structure it is of interest to investigate what a well-functioning care transition constitutes of. According to literature (Coleman, 2003; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018), well-functioning communication between the different actors involved in the process is a central part of this. Information transfer and communication between wards at SHG will be studied using qualitative data.

Although there is no quantitative data on how information transfers and communication is dealt with at different wards around SHG, it was noted from the interviews that there is no standardized way of sharing information when patients are moved. The main way of information sharing was mentioned as written notes and medical records in Melior. The attitude towards the means of information transfer during patient moves was in general neutral or negative. Moreover, it was mentioned that "*This system is highly dependent on the individual employee and is thus a source for variation in quality." (Physician A).*

Although there are some differences in how information is transferred at different wards. Generally, information transfer when moving patients is done in writing by the physicians and the nurses, making transfer notes containing, *"...the background of the patient, what's been done and sometimes what the future care plan is" (Physician C)*. There is also a possibility for an oral report between nurses during moves, but this was mentioned to differ from case to case. *"We write transfer notes in Melior, you give an oral brief and then you get to read. The medical records are the same for all of the hospital. It is often a very short oral brief."* (*Nurse J).* Something that was mentioned as a negative of this form of information transfer was that *"The quality of these notes is very dependent on who writes them, we don't follow any template, and what is included is up to the individual nurse or physician. There is no standardization." (Nurse G).* Another negative expressed was, *"I feel like we often have to do double work, both documenting the information in text and giving an oral brief. I would prefer if it were only done in text, so that everyone can read up on the case and everyone gets the same information." (Nurse D)*. which was agreed on by others, "*... I don't want a system where you both need to write things down and communicate orally, I don't want to do double work." (Physician D)*. Furthermore, an issue with these oral reports between nurses in Lidköping was as mentioned,

> *"When transferring a patient, the physician writes a transfer note into the medical records. As nurses, we also write a transfer note regarding the nursing of the patient. Often you also give an oral brief by the telephone to the ward that is receiving the new patient, but this does not always work perfectly. It can be that the one calling to give a report doesn't get to talk to the one who will be treating the patient due to such things as lack of time or shift changes. It is really important to get to talk to the right person. I think there should be some kind of system that ensures that you have given a report on a patient and that things have been done." (Nurse H)*

There is also some difficulty in getting an understanding of the patient's condition through the written notes. *"You often have to read up on all the notes in the journal to get a good overview of the patient, otherwise things can be missed. As a receiver you need the whole picture. However, I don't know if this can be done in a better way." (Nurse E).* A belief that was noted in the interviews was that no matter how much is written in the records, the interviewees felt that there was a risk of missing details or small indicators in the care. This was one of the reasons mentioned for there being oral reports between nurses in most of the wards. "*... I think some people don't feel satisfied with this (written) information and due to their need of control, they also request oral briefs. Of course, some information can be hard to get down in text, but I think written notes should be enough". (Nurse D)* and "*Orally, a lot depends on who is to receive the patient. There are nurses who are content with a written note while others want an oral report." (Nurse I).* Nonetheless, it was mentioned that there might be a need for oral reports since one might not want to put in all the info in the journal.

> *"There are many things concerning the patient that lack a place to document, such as small things that you know because you know the patient. You do not want to write something in the medical record that can be perceived as offensive to the patient, since they also can read their medical record. Some things the patient does not need to hear, but the care staff who are to take care of the patient may need to hear it in order to provide the best care." (Nurse K)*

Another aspect that one interviewee mentioned was that some information in the transfer notes might be irrelevant to some wards, different wards might prioritize different information.

> *"There is a lot of documentation. It is difficult when it comes to transfers because you have to include the most relevant things, but it can be easy to miss certain things and it can create an annoyance between the departments to move patients. Everyone is looking for different information that they think is important to find out during a transfer ... Some things are irrelevant to us. So, when a patient is moved between a medical department and a surgical department, we may have different perceptions of what one needs to know. Then we are also different in how we write and how much you can spend time on it. It's very different" (Nurse I)*

Moreover, one physician in Lidköping expressed discontent in the communication between physicians. The following statement elaborates on the negatives with a non-standardized way of writing medical records and transfer notes, *"It is really dependent on the person who is doing the documentation. Some people can summarize the relevant parts in just five sentences, while others write 50 sentences and don't include anything of value. It varies a lot.". (Physician D)*

Several interviewees mention that they use SBAR (Situation, Background, General assessment, Recommendation), as a template of what to include in the transfer notes. Some mentioned SBAR as being a *"comprehensive tool" (Nurse* C), that is useful. However, there is difficulty in that not everyone uses it and that there is no routine or standardized way of writing notes, which was agreed by other interviewees. On the other hand, one interviewee had negative feelings about the use of SBAR, mentioning that it is an awkward tool that is not meant to be used in written notes, *"The point of a medical record is to easily find what you are looking for, that it follows a pattern. But even if SBAR is divided into different points, I believe it is non-transparent." (Physician D)*. There is a desire for the notes to be short, comprehensive and for it to be easy to find the assessment of the patient's condition.

Since the patient clientele and the care at the medical emergency ward (MAVA) and the surgical emergency ward (KAVA) differs from the other wards, their means for information transfer differs some from other wards. When a person is admitted to either MAVA or KAVA they receive information first from the emergency physician, this is done either by phone or in *Melior* (computer medical journal system). Here, similarly to other wards they get the information regarding the patient background, why they seek care, their current state, and the planned treatment. Later if the patient is moved to another ward, they pass on the same information as MAVA/KAVA received from the emergency physician, it was here agreed on that *"The out-information is solely done in writing via the data system." (Nurse A)*, these transfer notes are done by both physicians and nurses.

At MAVA it was also mentioned similarly to at the other wards that, *"Sometimes the communication can be a bit done orally regarding the general state of the patient, but the medical information is in the medical records" (Nurse B)*. Furthermore, "*Personnel does come to collect the patient from the ward, and they have an oral handover amongst themselves. But there are no physicians talking to another physician." (Physician E).* The difficulty with oral reports was mentioned as determining who to report to and that it takes additional time at an already busy ward. Instead, MAVA was the only ward that mentioned that they invest time in teaching new staff in writing notes and what to include, *"We also have templates in Melior that we follow. The notes are in reality very structured on what to include. Usually we follow SBAR." (Physician E)*

4.5 What impacts the performance measurements?

As have been shown, different factors such as age, gender, care transitions, complexity of the patient, and the organizational structure affect the performance measurements in various ways. Worth noting is that although significant relationships have been found, the R square is rather low for all the models, meaning that they only can account for a small amount of the variation by themselves. Therefore, it is of interest to investigate how the different control factors interact to create a model that accounts for more of the variation.

Table 11 shows the parameter estimates while controlling for all the factors mentioned above. Starting with the LOS, the most significant factor is still whether a patient has undergone a care transition. The age of the patient is also significant, although not having as much of an impact. Worth noting is that the complexity of the patient is not as significant for the LOS when controlling for the other factors. This model still only has an R square of 0,125, indicating that there is a lot of variation not accounted for.

When looking at readmissions, there are not as clear relationships as can be seen in Table 11. The only clearly significant factor out of the factors included in this analysis are whether a patient has complex care needs or not. The risk of being readmitted greatly increases if the patient has complex care needs. Being moved between wards is the second most significant factor, although not as significant. Further, this model has an even lower R square of 0,065, indicating that there is variation that is not accounted for. There are most likely several other critical factors also affecting readmissions.

Looking at the mortality rate there are also some points to note, as can be seen in Table 11. The most significant factors are age and whether the patient is complex or not. Naturally, an older patient has a higher risk for passing away. However, as also noted earlier, one can note that complex care patients have a lower mortality rate than non-complex patients in pneumonia related care episodes. Further, gender has a significant impact, with females having a lower mortality rate. Also, although not as

significant, care transitions also seem to impact the mortality rate negatively. However, this model has also the lowest R square of only 0,038, yet again indicating that there are variations that are not accounted for, with most likely several important factors missing.

Table 11 Factors impacting performance measurements.

	Y=LOS			Y=Readmission rate			Y=Mortality rate		
	R-sq=0,1247			R-sq=0,0654			R-sq=0,0376		
Term	*Estimate*	*Std Error*	*P-value*	*Estimate*	*Std Error*	*P-value*	*Estimate*	*Std Error*	*P-value*
Intercept	2,5577	0,5101	<0,0001	0,1594	0,0337	<0,0001	-0,0663	0,0237	0,0051
Complex	0,4271	0,2602	0,1008	0,2204	0,0172	<0,0001	-0,0634	0,0121	<0,0001
Hospital	0,5514	0,2587	0,0331	0,0056	0,0171	0,7424	0,0018	0,0120	0,8819
Gender[K]	-0,1501	0,1166	0,1981	0,0068	0,0077	0,3789	-0,0115	0,0054	0,0335
Age	0,0251	0,0060	<0,0001	-0,0007	0,0004	0,0750	0,0022	0,0003	<0,0001
Move ward	4,8106	0,2947	<0,0001	0,0250	0,0195	0,1995	0,0217	0,0137	0,1126
N	2409								

4.6 Impact of a clinical pathway

As seen above the organizational structure, patient characteristics and the care practice have an impact on the care and the patient outcomes. In literature it has been noted that a way that care can be improved is through a clinical pathway (CPW), which is a means of standardizing care (Rotter et al., 2019). A hospital that has been noted to have implemented a CPW in the form of a standard care plan for pneumonia care and has seen benefits from it is Södra Älvsborgs Hospital (SÄS).

SÄS has been a process-oriented hospital since 2007-2008. According to Physician J working at SÄS, the hospital has a standard organization with a medicine ward, surgery ward, infection ward etc., which is a similar structure to that of SHGs hospital in Skövde. On top of the organization of wards they have processes that transverse and address all the wards in the hospital. These processes are specific to certain diagnoses, and they have located the need for these processes since they have noted that some diagnoses involve many parts of the organization, using processes as a way of standardizing the care. Similar to SHG, the pneumonia patients at SÄS are located at different wards at the hospital, *"... some are in infection, or medicine and sometimes they end up at the surgery ward, and then the pneumonia process is responsible for ensuring that they are cared for and that they get the same quality (of care) regardless of which ward they are in." (Physician J).* These processes are developed by process teams consisting of medical professionals from different areas in the hospital as well as staff from support functions. These teams meet every other week and evaluate the process status and work for the process to be used in practice.

The pneumonia care process at SÄS, involves a standard care plan, which exists in paper form on the physician's desk but also in digital form integrated in the medical journal writing program Melior as an attached document in the patient's file. It is to be used in the care of pneumonia patients to ensure that the care is performed accordingly, *"This standard care plan is a checklist for: what is it? what to do? and is it documented in the medical record in the right place?" (Physician J).* The implementation of a

standard care plan has shown several improvements in the pneumonia care process at SÄS. Looking between the years 2016 to 2020, studying the patients having been treated with the care plan versus those who are not, shows an increase in the quality of care. When comparing the LOS, the patients treated with the care plan have on average about one day shorter care time. The mortality rates looking at 2020 differs with a 15% rate for patients treated without the care plan, and 7% for those treated with it. Furthermore, they have become better at shortening the time to the first dose of antibiotic as well as choosing the right antibiotics, this also when compared to other hospitals in the Västra Götaland region. However, the readmission rate through the years does not show a significant decrease through the implementation of the standard care plan.

SÄS has made a great effort in establishing a uniform way of taking notes in the medical journal, which is a reason why they have not incorporated the standard care plan directly in the journal. Patients can have multiple diagnoses and one needs to be able to find the needed information easily, without having to look through digital journals that run in parallel. *"Sometimes it's a little hard to jump between programs, here the idea is that it should be the easy way that you work in the journal, which is the documentation place. Then you have the paper in front of you as a checklist, that ensures that I do the right things in the journal" (Physician J).* It was noted that in the implementation of a standard care plan, the organization has worked a great amount on standardizing the way of writing notes.

The use of the standard care plan is tracked, as well as the parameters that the plan affects such as: time to first antibiotic dose, if the patient has seen a physiotherapist, readmission rate and mortality rate, LOS etc. The process team has access to journal data and uses this data to visualize how the care plan is followed. It is possible to retrieve data from individual physicians, which are then given feedback on how they are following the care plan and what could be improved. Through the interview with Physician J from SÄS, it has been revealed that through the implementation of a CPW and working towards having a uniform way of writing medical notes they have noted improvements in pneumonia care.

4.7 Care practice at SHG

As shown in the literature as well as by the practice at SÄS it has been revealed that a CPW may be beneficial to implement for pneumonia care at SHG. Therefore, care practice and guidelines in pneumonia care at SHG will be presented in the following section.

It was mentioned that due to the variation in where the patients are cared at there is also variation in the actual care. Although, the degree of variation in care cannot be analyzed using the available quantitative data it is a relevant aspect to consider qualitatively. Interviewees mentioned that there is a need for individualizing the care and having tailored care for patients due to the fact that, *"they are a large and wide patient group, there is no standard routine. There are too large differences to be able to classify them the same way." (Nurse G).* Since they are such a large and wide spanning patient group it can be difficult to set the bar for a common pneumonia care process since the care needs of the individual patient differs greatly.

It was expressed in the interviews that pneumonia is an illness that on one hand, is difficult to diagnose, *"Pneumonia is easy to treat but hard to diagnose." (Nurse A).* The interviewees expressed that the symptoms of pneumonia can be vague, such as fever or as mentioned, *"If older people seek care, they don't seek for the regular signs of pneumonia such as a cough and breathing difficulties, it's other*

things. Then we find out that it is pneumonia when we do our examinations" (Physician B). This was something also mentioned by staff.

> *"Can be a little tricky before they find the diagnosis. It can be difficult to tell if it is a heart failure or pneumonia. This is where the difficulty lies - before they are x-rayed, and the test results are ready and so on. The elderly does not always have a fever. Can take a day before you can determine, depends on the X-ray and so on. If they come in the evening and do not get an X-ray until the next day, it will take a while." (Nurse J)*

On the other hand, pneumonia was described as an easy diagnosis, *"They are the easiest patient group in the hospital…. It's not a very physician intensive diagnosis, it is a rather easy patient group" (Physician F).* This statement was agreed upon by others, "*Pneumonia is generally a fairly simple illness to treat. What can be demanding is when the treatment doesn't give the expected result…" (Physician D).* This was further built on that it is a diagnosis that can be hard to predict the forthcomings of, *"What is difficult with pneumonia is assessing where the diagnosis will progress badly. It is hard to predict whose condition will worsen." (Physician E).* But what was commonly agreed upon was as mentioned, *"It is important to correctly assess the severeness of the illness and make a correct diagnosis" (Physician A)*. Something that one interviewee mentioned was that *"there should be a greater access to x-ray to ease the diagnosing part" (Physician B).*

4.7.1 Guidelines in work

Although pneumonia was described as "easy to treat" as mentioned above, it was seen in interviews that the care is dependent on the individual care practitioner. Also, as shown in the quantitative data, the organizational structure influences the patient outcomes. These effects could therefore be a telltale that guidelines would be of benefit in the care process. Despite the arguments for a guideline, it was agreed on in the interviewees that there currently are no specific guidelines or routines regarding pneumonia care at SHG. "*There aren't any particular guidelines for pneumonia that I know of." (Physician D).* Therefore, the care practice regarding pneumonia might differ, although there were some similarities noted in the interviews. "*We do not have any specially developed routines for pneumonia, we only have general ones. We are not an infection ward, we have routines when it comes to heart problems, but not specific ones when it comes to pneumonia." (Physician H).* For instance, it was believed in one of the interviews that pneumonia patients located outside wards that are not specialized in pulmonary diseases can have a lower quality of care than those who are. The treatment is highly dependent on the individual employees' competence, and there is not a consensus on how these patients "should" be treated.

Although there are no specific pneumonia guidelines or recommendations at SHG, it was mentioned that *"...we do follow national guidelines: what to treat with and the encompassing plan for treating patients with respiratory problems. It's the doctors that prescribe the antibiotics" (Nurse A).* This point was also mentioned by others as well, *"As a nurse there are no guidelines in the care of pneumonia. Physicians might have guidelines using antibiotics" (Nurse E)*.

At SHG they utilize national antibiotic guidelines, STRAMA, in the choice and treatment of pneumonia. *"...we follow the STRAMA guidelines for antibiotics, but these aren't specific for SHG." (Physician D)*. But also, local guidelines regarding antibiotic use were mentioned as being followed when choosing antibiotics. At wards where infection diagnosis is not the specialty, they make use of the infection wards knowledge in the antibiotic treatment. "*We are closely connected to the infection ward. We follow*

antibiotic guidelines, and we try to narrow down the antibiotic once the diagnosis is made. ... We know that we use a little too much of certain types of antibiotics. But we try to think about that." (Physician E). It was also mentioned at the cardiology ward that they follow the advice from the infection consultants *"Infection physicians always want you to do a blood culture before inserting antibiotics, and especially intravenous antibiotics. This is to keep track of resistance and to find which bacterium is causing the disease." (Physician H, cardiology).*

4.7.2 Attitudes towards guidelines

When asked if it would be a benefit if there existed guidelines for pneumonia care the opinions were divided amongst the care personnel. Some mentioned that it would be beneficial to be able to use a guideline as decision making support and to consult with. *"... We work utilizing the personnel experience and by physicians' orders. Although it would be good if there were written down guidelines." (Nurse F)* and to use guidelines as a basis in the work.

> *"... it would have been good to have some so that everyone got correct care and kept track that we are doing the right things the right way and that nothing is missed. To ensure that the important parts in the care is included. A guide that tells us why you do certain things and what not to do. This would also be good since sometimes we work at other wards and then it can be good to be able to walk in and know that it's this type of patient and know what to do." (Nurse D)*

Furthermore, it was mentioned that it might be useful with a system for keeping track of information and tasks. This especially when dealing with patients with complex care needs, where there are several diagnoses to consider.

> *"Details are hidden and only become a row of notes in the medical records that is easy to overlook and scroll past. What is needed is a system to capture and juggle many work tasks. As a physician you have many patients to think about and many thoughts in your head, to be able to work well some of the details are at risk at being simplified or falling away. A help for this would be good" (Physician C)*

In contrast a few interviews were not so positive towards guidelines, some mention them as being obsolete if not incorporated in the care.

> *"Would the care benefit from guidelines? Instinctively no. You talk with physicians about what is to be done. On the other hand, there are PMs and those are good to look at and trust in. But it is then the matter of them being used, or should you just listen to what the physicians say. The existing PMs are used, especially if it is not a common procedure. But it is not very common, it is not every work shift that we use them." (Nurse E)*

Although attitudes to guidelines in general were positive or neutral, it was mentioned that there are some premises for guidelines to be practical and used. One interviewee mentioned that the use of the guidelines would depend on if they could be attached to the digital medical records.

> *"It would be good if a checklist could pop-up on what to be done and checked off. It is very hard to get a care plan that is on the side to be anchored in the daily processes.*

Before we have had papers but now, we work on the computer, if it is not on there it will be forgotten." (Nurse G)

Another factor that was mentioned by an interviewee that should be considered when creating and implementing future guidelines would be that the actions recommended need to be somewhat general to allow for specific routines at certain wards.

"... you ensure that the care is good also for the pneumonia patients who end up at a ward that is not used to treat that kind of diagnosis ...You may want to avoid including the department-specific parts that are adapted to which patients you (the wards) usually have. Because it makes a very big difference if I end up in hospital with a pneumonia or if my grandmother who is multi-sick would do it. You cannot treat us the same." (Nurse K)

Furthermore, it was mentioned that there is difficulty in finding documents on the hospital intranet. Although there might exist certain guidelines, one might not be able to find the needed document due to the database search function.

"I think it is difficult to search and find what you are looking for in our intranet. However, when I googled, I found a very good document from SÄS regarding the care of these patients and what is important to think about, both in the medicinal aspect but also from a nursing perspective. I miss something similar here." (Nurse H)

Comparing SHG to SÄS, with similar organizational structure it should be a possibility for SHG to also implement a standard care plan for pneumonia, as mentioned by Physician J from SÄS. Further, Physician J expressed that the implementation will be made easier if the hospital already has some processes in place. *"... then the processes help each other to legitimize themselves, motivate themselves that they should exist. It would have been more difficult if we only had invented that we should have processes, then it would have been more difficult to get the respective ward with us." (Physician J, SÄS).* A practice that is already in place since SHG is a process-oriented hospital. Moreover, it was mentioned that it is useful to employ a standardized design in how the different care plans look so that they are easy to read, and staff are familiar with the look. Physician J expressed that these processes are something that one has to work on continuously to ensure that they are used and becomes routine, otherwise they will be forgotten. As seen in interviews, this is an aspect that needs to be held in mind, since as interviewees from SHG mentioned guidelines need to be integrated in the work for it to be used.

4.7.3 Tools used in care

A common aspect in the interviews was that they use NEWS to assess the patients during the care episode. NEWS is short for "National Early Warning Score" and is a tool to assess the patient's vital parameters such as breathing, circulation and consciousness. "*When a pneumonia patient comes to us, we look at different values such as vital parameters, breathing frequency, oxygen saturation in the blood, and so on. We follow the NEWS system to assess and handle the patient." (Nurse G, infection ward).* Another tool that was mentioned in the interviews was BAS 90 30 90, also referred to as just BAS. This is a similar tool to NEWS, but where you only measure blood pressure, breathing frequency and saturation. *"We use regular controls such as BAS or NEWS. It is mainly the NEWS scale that we use, both for patients in general and for pneumonia patients. There is a prepared scale that we work*

after when it comes to goal values, but there aren't any specific scales for pneumonia patients, it is more general." (Nurse J).

Although they described that there are some set values for this it was mentioned that *"Even though we use NEWS, these values need to be adapted to the individual patient. All the time we create individual goals that are noted down on the patients target chart." (Physician E).* This was something that several interviewees emphasized, that there is a need for adapting the goal values according to the individual patient. *"We have no specific target values. We keep track of the parameters, but we don't have any specific values for pneumonia." (Nurse D)*

In Lidköping there are three medicine wards, the interviewees from these wards all expressed that similarly to Skövde that they use NEWS as a tool in the care. At ward 6, the attitude was that the NEWS system works well on the other hand in ward 5 it was expressed as follows, "*...it varies how much this is implemented in practice. I would say that we use BAS 90 30 90." (Physician D)*. Furthermore, it was expressed that although they use NEWS as a judgement template in the care as soon as the patient is admitted, you need to have a holistic perspective in the care.

> *"It is the clinical eye as well as NEWS that decides how we handle the patient. You shouldn't only look at measurements when deciding what to do with a patient, there are different aspects to consider as well. You have to ensure that the measurements actually match how the patient looks." (Nurse H)*

Likewise, it was mentioned that pneumonia can be a quite vague diagnosis, meaning that in ward 4 in Lidköping, they will have ruled out other more serious diseases of the heart to come to the conclusion that it is pneumonia. In addition, an improvement that one interviewee mentioned was that in the infection ward they look at the respiratory rate as a good indicator of how sick the patient is, *"It is a measure that I see that we do not put so much emphasis on here, but that it can be good to look at it." (Physician G).*

4.7.4 Care practice at different wards

When it comes to the actual care of pneumonia patients located at different wards at the hospital it appears that there are some differences in approach depending on the location. The infection ward is as shown in the quantitative data, a ward where the pneumonia patients are treated at often, since they are specialized in diagnoses such as pneumonia. Although there are no specific guidelines for pneumonia at the infection ward as well, they are used to treating this patient group and ensuring that the care works. Nevertheless, it was mentioned that *"The treatment is highly dependent on the individual employee's competence..." (Physician A)*

The pulmonary ward is also used to treat patients with lung diseases and have knowledge in treating pneumonia patients. *"We specialize in the lung part, and we know that it is very important with mobilization, breathing technique, mucus mobilization, inhalation training, and so on. This may be missed quite a lot if you end up with a pneumonia at another clinic. (Nurse L).* Although it was mentioned that they know what activities that are meant to take place when a pneumonia patient arrives at the pulmonary ward, the following was mentioned regarding the treatment, *"It largely depends on what doctors you have at the clinic. Because it is largely those who control the treatment strategy." (Nurse K),* which is similar to what other interviewees have mentioned.

MAVA and KAVA for instance are in some respects special where acutely ill patients are admitted to the ward. There they are stabilized and then discharged or if needed moved to another ward in the hospital. As was described *"Pneumonia is common at MAVA so everyone has experience in treating it" (Nurse A).* Furthermore, a Physician from MAVA mentioned that due to their high influx of acutely ill patients they are good at determining the care level the patient should have. On the other hand, when one interviewee was asked if she thinks the care looks the same around the hospital the answer was, *"Probably not, we see the patients at different stages in the illness… The most trying ones are moved to infection. The more geriatric end up anywhere, it is not always the pneumonia that is the hardest to handle then, it is the underlying diagnosis." (Physician E).* Additionally, care practice at MAVA is also characterized by a high physician density where the proceedings at the ward were described as following.

> *"The doctor determines how long the patient is cared for and what tests to run and checking the vital parameters. There are no particular guidelines for the other parts of care. These guidelines are good or bad depending on the patient. Some patients are very sick and not staying at the hospital foremost because of pneumonia. It depends a lot on the patient." (Nurse C)*

At other wards not specialized in infection and pulmonary diagnosis, interviewees expressed that there are no particular care routines specific to the pneumonia diagnosis. *"There is no structured work concerning the care of pneumonia patients. We use our PEP-ventilators and see so the patient gets up and moves above all. Then there is the medical treatment in the form of antibiotics. Otherwise, there is not much else, it's more like the "standard care process" (Nurse I, Surgery Lidköping)*. In the surgery ward in Lidköping it was mentioned that they emphasize further the importance of the patient getting up and moving for postoperative patients, and for pneumonia patients especially. Other interviewees mentioned similarly regarding pneumonia patients. *"They end up here sometimes. Sometimes they get pneumonia when they are here too. Does not work worse than for any other patient." (Nurse J), cardiology*. When asked if the pneumonia care differs from other wards than at the cardiology ward, it was described as,

> *"I don't really know if the pneumonia care differs from our ward and other wards, but I do not think so. Our infection doctors work a lot as consultants in all departments, so I think we have a fairly common view and follow the same type of treatment for patients." (Physician H)*

In Lidköping it was noted that the patients a lot of times arrive from the emergency care unit and are cared for in the medicine wards, where the care process involves antibiotics and oxygen. The choice of antibiotics and level of care was emphasized as the most important of choices. The care was expressed as being quite straightforward with antibiotics and physiotherapy. Although, there is a wide span of severity in the cases where some are treated 2-3 days, whilst others are admitted for several weeks with a severe infection. *"I think the pneumonia care is working well in the sense that we are good at identifying which patients at the emergency ward that need inpatient care. Perhaps we admit a bit too many to be on the safe side, so that the physician feels safe." (Physician D).* To describe a regular care flow for pneumonia patients in the medicine wards in Lidköping, the following procedures were described,

> *"From the emergency care clinic, the patients are assessed, the elderly come in with the ambulance, whilst the younger often come in themselves. So they come in, they are*

assessed according to protocol and then they are given a color depending on how urgent the care is, then the nurse checks in on patient background and symptoms. They are then taken care of according to the color given. If it is a severe pneumonia with low blood pressure and oxygenation, that patient will be red, then it is quick to get the patient in, do an early evaluation and already send for an ICU physician. Or if it is cool, they are sent to a ward. You take tests, blood pressure, oxygenation, you do blood cultures if the patient will be given intravenous antibiotics. When everything is done you report the patient up to a ward, oftentimes in between an x-ray will be done." (Physician F)

In Lidköping it was mentioned that there can be differences in the routines put in depending on the physician working. *"I experience that there are some differences in routines depending on what physician is working. Some are very strict: "take these tests, call in a physiotherapist". As a new nurse it can be hard to learn what to look after since the treatment can look so different." (Nurse D).* Moreover, a tendency that might be present in ward 4 was mentioned, *"I think we are probably used to keeping care times quite short because we have a high turnover of heart patients who come in with chest pain … so I can imagine that we keep care times a little shorter than general" (Physician G)*

4.7.5 Follow-up of pneumonia care

Although pneumonia has been expressed to be an easy diagnosis to treat, it is seen in quantitative data that a number of the patients are readmitted, however the readmission does not necessarily have to be related to the previous pneumonia diagnosis. Nevertheless, to ensure that not something more sinister underlies the pneumonia diagnosis such as cancer, it can be good to have a follow-up of the care after discharge. Both the infection ward and pulmonary ward have follow-up on pneumonia patients with a lung x-ray. With interviewees from the pulmonary ward, it was mentioned the following about the patients at their ward. "*Often they are already lung sick from the beginning and may be followed up at our lung clinic. So, when you have had an inpatient care opportunity, you are followed up through our reception, with perhaps an X-ray, a spirometry or the like." (Nurse K).* Another option for the patients is that they are referred to their health center for a follow-up. "*We may send them to take new samples two weeks after discharge to see that it goes in the right direction. Usually, also a follow-up lung X-ray, but it is further away because it takes time before you can see anything in the pictures." (Nurse K)*

The follow-up of care at MAVA was mentioned that they follow up the care with a lung x-ray on the patients discharged from MAVA. *"... Those we follow up on are the ones that we discharge at MAVA, not the ones that are moved and then cared for at other places." (Physician E).*

Similarly, in Lidköping the follow-up of care consists of a lung x-ray. This is usually done a couple of weeks after their care stay in cases where there is concern for something underlying the pneumonia, *"... quite often we follow up with plain X-rays after 4-6 weeks to see that we do not miss any tumor disease or so. If it's just uncomplicated cases, maybe younger people with severe pneumococcal pneumonia, you may not need to follow up." (Physician G).* On the other hand, it was mentioned that they are not good at following up on pneumonia patients, *"We are not so good at following up on pneumonia patients. It is not at all like when we have a heart patient where we always book in a follow up meeting at the hospital, we never do this for pneumonia." (Nurse F)*, showing that there could be a difference in the interviewees' perception of the care, or a lack of conformance in care at the hospital.

At specialized wards around the hospital there was an inconsistency in what routines they follow concerning follow-up of pneumonia patients. For instance, at the surgery ward in Lidköping, the following was mentioned, "*After the care episode, we usually don't follow up on the care ourselves. It is very rare that we follow the patient after discharge. It is only if there is a specific thing like a fibrosis or if the patient has an underlying disease, we usually refer them to the pulmonary medicine ward." (Physician I).* Similarly, at the cardiology ward it was mentioned that although there are no specific routines for the follow up of pneumonia, they issue recommendations to the patients. *"We usually recommend that they go to the health center to get an assessment. Sometimes it is recommended that you do a lung x-ray a couple of weeks later to ensure that it was not a cancer that was hiding behind the pneumonia. It is very much from case to case… It is also not uncommon for infection doctors to then do a follow up on the patient at their reception a few days after discharge for an additional check-up." (Physician H).* Regarding physiotherapy follow-up is not done on patients in that sense, as mentioned by Support Function A, *"During the incare stay the patient is followed up upon, however after discharge this is dropped.".*

4.8 Support functions

From the interviews it can be understood that there are several functions besides the personnel working at the ward that can be necessary to involve in the care process. *"We collaborate with other areas such as physiotherapists, occupational therapists, and so on" (Nurse H)*, and *"The care often takes place in consultation with an infection doctor" (Physician H)* if the patient is treated at a ward not specialized in infections. Both care personnel and interviewees working with support functions mention the importance of involving support functions in the care.

In interviews the most frequently mentioned support function was physiotherapy (and occupational therapy), but also functions such as infection consultants, dieticians, and welfare officers were mentioned. The argument for involving the support function when developing processes was motivated by Support function B.

> *"It's important to involve support functions when developing new processes at the hospital. Often the processes are created only with the primary functions such as medicinal and doctors in mind. The other supporting functions such as dietitians, welfare officers, physiotherapists, and so on often get overlooked. These functions have limited resources and difficulties to determine what to prioritize. When developing new processes, it is important to have this in mind, involve them in the development process, and make directions on how to prioritize between different diagnoses etc." (Support function B)*

In contrast to SÄS where data regarding the patient accessibility are recorded, collected, and used to improve the care process, this is not done at SHG. Therefore, it has not been possible to assess the following aspects quantitatively.

4.8.1 Physiotherapy

Although it is not a diagnosis that has been expressed to be difficult to treat, physiotherapy is one aspect that was mentioned as an important part of the treatment. *"Physiotherapists are a very important part of the treatment. It is important to mobilize the patient and give the patient respiratory training."*

(Physician D). Physiotherapists are involved in the care allowing for informing patients how to rehabilitate through physiotherapy exercises. *"Physiotherapists are involved in the care, with respiratory training. sometimes occupational therapists if there is a need. They are given a morning report and visit patients that need it. They visit the ward daily, Monday to Friday." (Nurse F).* At large the two approaches to physiotherapy in pneumonia care were mentioned as mobilization and respiratory training. *"Physiotherapists can be an important part for the breathing technique. If you have a low oxygenation, it is good to take part in breathing exercises." (Physician F)* and *"Physiotherapists are a very important part of the treatment. It is important to mobilize the patient and give the patient respiratory training." (Physician D).* For respiratory training, the patients can be advised to use a PEP-valve which is a tool that patients blow into with resistance.

An obstacle for physiotherapy in general at the wards is the follow up that the exercises are done, where there are not enough resources to do so. *"Regarding breathing exercises, there are people who can manage it well by themselves, but it is up to us to see to that it gets done. I don't think it is only because of staff shortage this gets down-prioritized and is missed, but also because we lack a good routine to rely on, who is responsible and how we should work with this." (Nurse H).* The physiotherapy therefore in part falls in the hands of the patients that need to be informed and held responsible for doing these exercises which are important for their rehabilitation.

> *"How do you get the patient to do their pep-valve exercises? It is basically a matter of informing the patient about the purpose of using the pep valve so that they understand the connection and what situation they are in, and what benefit the pep valve does for them. Because without information and understanding, I think the patient often thinks that they are just blowing and that it may be enough to get up and go, but it does not. Then you have to explain it to them. You must not take it for granted that you just put in a pep valve and say "here - blow"." (Nurse I)*

Since the care personnel cannot check that the exercises are performed every time it is to be done, some interviewees mentioned solutions that might encourage patients to take responsibility and be held accountable to do them. *"Sometimes we give them paper and pencil and they get to cross off every time they have done their exercises." (Nurse G)*.

> *"I ... try to give the patient a schedule that they can fill in if they want to. When I think of it, maybe we should have some kind of a brochure that we could give to the patient where they could read information about this. Perhaps there already is one, but I have never used it." (Nurse I)*

On top of the above mentioned there are no guidelines for treating pneumonia and there are no guidelines on when to call in physiotherapy in the case of pneumonia. Instead, this is done depending on the knowledge of the care personnel and the ward that the patient is cared at. *"... you have to think about the idea of breathing training. I can imagine that it varies between departments and between cases and depending on who works. I do not think we have a clear document to follow. They (the physiotherapists) are connected to the wards, and you are asking them to go to patients." (Physician G).* The background to this might be that there is a knowledge gap in that not all care personnel know the importance of physiotherapy in pneumonia care. *"Unfortunately, there is a lack of knowledge amongst nurses and assistant nurses on when to call in physiotherapy. This is especially the case where physiotherapy is an on-call service." (Support function C).* On the other hand, interviewees mentioned

that routines regarding this part of the treatment might be beneficial. *"I think it could be a good idea to implement a system to ensure that this is a more regular activity." (Nurse C)*

Physiotherapy at the infection and pulmonary ward

As noted in the qualitative data both the infection and pulmonary ward see a lot of pneumonia patients. In the interviews it was mentioned that the physiotherapy practices at these wards in all were working well.

> *"They come daily. Most often, they already have been informed of which patients they may need to get to and what is needed to be done, but it is the responsible nurse who directs where they should go and what efforts may be needed. Then they work here daily and also rotate between other wards and make different contributions to the patients." (Nurse K)*

This was also something mentioned as working well by the physiotherapists themselves.

> *"Departments where physiotherapy has a clear role is cardiology, pulmonary and infection. They have the resources and efforts pretty well established. On other wards where the patient group doesn't have the same need of physiotherapy generally, the procedures are not so well established, and it is dependent on the personnel to call in physiotherapy." (Support function C).*

Also, the importance of physiotherapy was emphasized. *"The physiotherapist is a great resource at the infection clinic. Respiratory training is highly prioritized for these patients. Everyone gets an individual schedule over how they should train. But a lot of responsibility is put on the patient" (Nurse G).*

However, it was mentioned by the care personnel working at the infection ward and the pulmonary ward that these practices might not be as efficient at other wards. *"It functions well at the pulmonary and infection wards, but other wards are not as good at this." (Physician B).* When asked why physiotherapy might be missed at other wards it was expressed that *"Maybe it's because you haven't seen it often enough. We see lung problems all the time, it's not just those who have pneumonia who need mucus mobilization, for example, so we have that habit." (Nurse K).*

Physiotherapy at MAVA

A ward where physiotherapy is complicated is the medical emergency ward (MAVA), where the patients are expected to stay for a short period and then either be discharged or moved once stabilized. *"Usually, the patient is not at MAVA enough time for them to call in a physiotherapist. But if there is an emergency, they are called in." (Nurse A).* This leads to patients not receiving physiotherapy.

Although physiotherapy has been mentioned by interviews as an important part in pneumonia care this has shown to be a resource that is not fully used, or if it is needed it can be initiated with the resources already present at the ward. *"MAVA calls in physiotherapy. But since the patients that are located here are often in an emergency state, it is not always possible to connect them to a physiotherapist. If needed, we can put in respiratory training and similar ourselves." (Physician E).* As noted, before, MAVA has short care times which makes it more difficult for pneumonia patients to meet a physiotherapist at the ward. The reason mentioned why physiotherapy practice is in areas lacking in MAVA was as following.

"... the patient clientele at MAVA is not as susceptible to this type of treatment. Since MAVA has around an average of 1,2 days care days, the idea is that it's an emergency ward where the patient is located to be stabilized. Once the patient is stable they should be moved to another ward where for example physiotherapy can be received." (Nurse B)

Physiotherapy in Lidköping

Regarding physiotherapy practice in Lidköping it was generally mentioned as working well. Although the medicine wards are involved in general care, they are also somewhat specialized, where physiotherapy is called in depending on the patient's individual needs. Although physiotherapists are at the wards daily, it was mentioned in the interviews that the responsibility of ensuring that the patient receives physiotherapy lies with the care personnel. *"Every morning we brief our coordinator all our requests, and she then brings this up with the physiotherapists and so on. They are at our ward the bigger part of the day, and only leave for brief periods of time." (Nurse D).*

Although, the communication and the general practice with physiotherapists was described as working well in Lidköping. *"A benefit at the medicine ward is that they have close contact with physiotherapy since we are a stroke ward too. Which is good for pneumonia patients" (Nurse D),* in contrast making sure that the exercises are done was another topic, something that was mentioned as a struggle at all other wards as well.

"... we might not always be so good at carrying out the recommendations we get from the physiotherapists. I think it often is because of stress and lack of time ... There is a bit too few people to really care for the most seriously ill patients and it is hard to have time for all the peripheral tasks, even if they are part of the care. You don't really have time, and it is difficult to prioritize what is most important." (Nurse H).

Physiotherapy at Specialized wards

Similarly, to the medicine wards in Lidköping the specialized wards at SHG usually have physiotherapists that come to the ward every day and help with mobilization and breathing exercises. *"The physiotherapists come to the ward daily and receive a report about the patients that they need to check up on." (Nurse J).* Here it was mentioned that *"The actual access to physiotherapists is quite good, but I think it's important to make sure there is an awareness of how important this is for pneumonia patients as well." (Physician I).* As in general there was a difficulty in ensuring that the patients are performing their planned exercise routine, but also that there might be some knowledge gaps in the need for physiotherapy for pneumonia patients among the staff. Which was mentioned as a particular concern when dealing with patients with multiple diagnoses.

"A risk that may be prevalent for patients with several diagnoses is that the pneumonia treatment mainly focuses on antibiotics and oxygen, but you forget the part with mobilization and physiotherapy. It is not certain that this is always the case, but there is a risk that it will be so because you may have other diagnoses that also need to be treated." (Physician I)

Physiotherapy improvements

It was mentioned both by care personnel and interviewees working as a support function that there are a limited number of resources when it comes to support functions such as physiotherapy. This leads to

some wards not having their own physiotherapists or them being there a limited time. Interviewees then mentioned that there is a wish for there to be greater access to these in the work since they believe that it is an important part of the treatment. For instance, at the pulmonary ward, although making for patients to meet a physiotherapist is working, they wish for more resources in it.

> *"We would like to have our own physiotherapist in the department, who can work here full time. They are very helpful in mobilizing the patient, and they investigate what needs the patient has, how much help he needs, what aids that can be used, and so on. But then they leave, and we do not always have time to continue their work. If we had our own physiotherapist here full-time, it would greatly benefit the patients." (Nurse K)*

The same was mentioned at the infection ward where they mentioned that physiotherapists are only working Monday to Friday, so if a pneumonia patient arrives on a Friday night, they will not be given a physiotherapy plan until Monday, something that they wish to improve.

> *"Unfortunately, PT is not available on weekends. If I could wish I would want assistants, that were non-trained PT's that were given instructions of the physiotherapy and when to follow-up on patients and go to them if there is a need to help with the treatment. Someone that helps ensure that the ordinations are followed." (Nurse G)*

Looking at the impact of the standard care plan at SÄS, regarding physiotherapy this care plan has amounted to a significant improvement in physiotherapy for pneumonia patients. Figure 17 shows the percentage of patients that have seen a physiotherapist without the use of the standard care plan, Figure 18 notes the patients that have been cared for with the standard care plan and has seen a physiotherapist. One can note that the use of the standard care plan leads to a significantly higher chance of meeting with a physiotherapist.

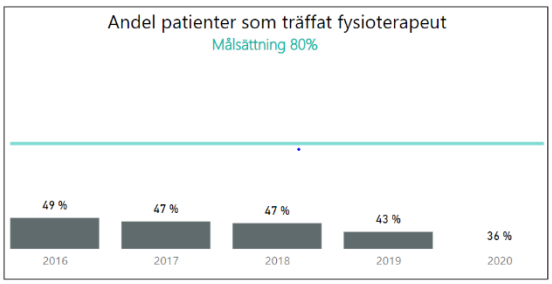

Figure 17 No standard care plan, percentage of patients that have seen a physiotherapist (Södra Älvsborgs Sjukhus, 2021)

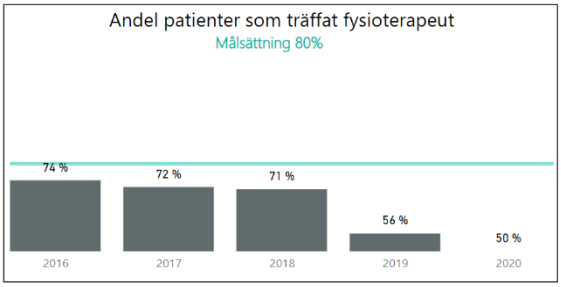

Figure 18 With standard care plan, percentage of patients that have seen a physiotherapist (Södra Älvsborgs Sjukhus, 2021)

4.8.2 Infection consultants

At wards where infection and pulmonary diseases are not the specialty there is access to infection consultants. These are physicians that are specialized in infection and pulmonary conditions and are available on call if there is a need for specialist assessment at another ward.

The personnel interviewed from MAVA and KAVA mentioned that they are used to pneumonia patients. In the case that more guidance in the care is needed they have the possibility to involve infection consultants in the process. *"To ensure that patients with pneumonia are treated correctly in wards not specialized in Infection and pulmonary diseases, MAVA has infection consultants that are here daily." (Nurse A).* It was mentioned that they are in closed contact with these consultants to ensure that the care is sufficient. The practice of involving infection consultants was also something mentioned at the specialized wards in Skövde. This involvement is done to make the right ordination regarding the choice of antibiotics.

> *"The focus is not on pneumonia at my ward. The care often takes place in consultation with an infection doctor in that case. It's not that we cannot handle it ourselves, but it's more to choose the right antibiotics that the infection doctor recommends. It is important to avoid antibiotic resistance. We try to take great account of this, the right antibiotics for the disease that the patient has. We have contact with infection doctors on a consulting basis." (Physician H)*

Similar to the practice in Skövde, at the medicine wards in Lidköping it was mentioned that if needed they keep in contact with pulmonary or infection doctors that are on call. It was mentioned that being in contact with them when a pneumonia patient is admitted is the *"usual thing" (Nurse F).*

4.8.3 Dieticians

There is sometimes also the need to call in dieticians to help pneumonia patients in ensuring they are getting enough nutrition. *"You shouldn't forget about the dietitians as well. One of the biggest problems with inpatient care generally is that the patient doesn't get enough calories." (Physician D).* The role of dieticians in pneumonia care was mentioned by the personnel working as a support function in the care as well as a few interviewees that works at the wards.

> *"...dieticians aren't part of the standard procedure when treating pneumonia but depending on the individual needs of the patient there can be of great importance to engage these in the treatment. Pneumonia, for example, can bring complications such as eating difficulties, malnutrition and weight loss, and in these cases, it is important to involve a dietician." (Support function B).*

5
Discussion

This chapter makes reflections on working with process mining. Furthermore, empirical findings are discussed in relation to the literature. Lastly, improvement areas and recommendations are presented and elaborated on.

5.1 The value of process mining

In this thesis process mining has acted as a springboard for further statistical analysis as well as a guide for what to include as questions during interviews. By applying the process mining approach, it has been possible to create a visual overview to show the reality of the care process (van der Aalst, 2010). The thesis has mainly been concerned with the type of process mining called process discovery (Martin et al., 2020, Mans et al., 2008). Previous to this study, SHG had limited knowledge of what their care process concerning pneumonia patients actually looked like, and process mining has proved to be an effective way to observe the order of activities and gain further understanding of the process, its organizational context and properties of execution (Martin et al., 2020, Mans et al., 2008).

There are three different perspectives of process mining; the control flow, the organizational perspective, and the performance perspective (Agostinelli et al., 2020; van der Aalst, 2010). This thesis has to some extent provided insights into all three of the perspectives. Concerning the control flow, the thesis has shown how the patients flow through the hospital, and that a significant portion of the patient group deviates from the optimal sequence (see Section 4.2.1). Due to lack of access to detailed quantitative data regarding the specific care actions such as tests taken, meeting with physiotherapists, and so on, the focus has instead been to show how the patients are moved around the hospital.

The most important insights the process mining has brought has probably been in the organizational perspective. Even though it is the least common perspective to take in a process mining project within health care (Rojas et al., 2016), the tool has proved quite useful. By applying process mining it has been possible to effectively visualize the differences in organizational structures within SHG, show the care network involved in the process, what actors are involved in the care, and what this implies for the care.

Lastly, there has also been some insights to the performance perspective of the process (Agostinelli et al., 2020; Rebuge & Ferreira, 2012). Through statistical analysis in JMP it has been possible to analyze the different characteristics of the process and patient group to understand how these influences the performance measurements. With this combined approach to process mining, the work has been an iterative process of studying the process maps, locating aspects of interest to further investigate through statistical analysis, as well as locating important aspects in the qualitative data.

5.2 Organizational aspects

As seen through the quantitative data and process mining on the pneumonia care process at SHG, the setting could be described as having a spaghetti structure (van der Aalst, 2011). The patients are spread widely around the hospital and there is no clear and easy way to describe what the process flow looks

like. The process is unstructured and the conditions of the activities within are poorly defined (see Section 4.2). On the other hand, as the qualitative data shows it is known how the pneumonia patients should be treated. In fact, many consider this to be one of the most basic patient groups. However, there is no standardized way of working with these patients, and there are no specific measures for pneumonia ensuring that all patients get the same quality of care (see Section 4.7). It has been revealed that depending on which hospital and which ward the patient is admitted to the care practice differs, but also which care personnel that is responsible affects the care.

Considering the pneumonia patients, SHG is structured according to the value shop logic (Stabell & Fjeldstad, 1998; Hwang & Christensen, 2008; Fjeldstad et al., 2020), with a high dependence on the intuition of the individual care practician. There is no standardized way of working with the patients or attempts to incorporate a value chain logic specifically for these patients, and although the patients are widely spread around the hospital there is not much communication or collaboration between the different actors i.e. wards (see Section 4.4.3).

Looking at the impact of organizational structures when comparing Skövde and Lidköping it was revealed through process mining that Lidköping has a more Lasagna-like process when compared to Skövde (see Figure 12 and 13). In Lidköping pneumonia patients are treated at fewer wards and moved less often than in Skövde, where the care is more fragmented and shows a heavily interconnected network. In Skövde, pneumonia patients are treated all over the hospital, without any designated ward in which to be treated at. On top of that, qualitative data revealed that there is no standardized means of information transfer between wards, and therefore no way of ensuring that all patient information is transferred sufficiently between wards if the patient is moved (see Section 4.4.3).

Literature on the topic of organizational structure in relation to pneumonia care shows that it has an impact on the LOS (Laing et al., 2004; Menendez et al., 2003; Epstein et al., 2010). As Epstein et al. (2010) mention, fragmentation in the care leads to a longer LOS. When observing the quantitative data from SHG, it was noted that there is a significant difference in the LOS between the hospital in Lidköping and that in Skövde (see Table 6). The patients treated in Lidköping have a significantly shorter LOS than in Skövde. This could indicate that the less fragmented organizational structure in Lidköping contributes to a shorter LOS. Another possibility might also be that the more severe pneumonia cases get admitted to Skövde, and therefore increases the LOS. As can be seen in the literature, the initial severity of the illness also impacts the LOS, but according to previous studies only to a limited extent (Menendez et al., 2003; Garau et al., 2008; Laing et al., 2004). For example, there seems to be no clear difference in LOS between the patient group as a whole and the complex patients in Lidköping, while the complex patients have an even longer LOS in Skövde (see Table 7). This could indicate that patients with complex care needs are more vulnerable to a fragmented care structure. In terms of LOS there seem to be a clear benefit of a less fragmented organization.

When looking at readmissions it has not been possible to find any clear parallels with the organizational structure of the hospital (see Table 6). Although De Alba & Amin (2014) mention the organizational structure as a factor that affects the readmission rate, there were no significant differences between the hospitals, and it was not something that was mentioned in the qualitative data either. Similarly, to readmission rate, it was not possible to link the organizational structure to the mortality rate. This could possibly be because of other factors canceling out the effect of the organizational structure.

It could be argued that the spaghetti like structure of the care process indicates that value shops are not the most suited model for value creation in the process. The process involves a wide variety of actors,

with patients spread over several places, which matches the fundamentals of a value network. The reason behind a value network is to facilitate a flexible interaction among people, places, and things (Stabell & Fjeldstad, 1998; Hwang & Christensen, 2008; Fjeldstad et al., 2020), which could be largely beneficial for the pneumonia care process at SHG.

5.3 Care transitions

Looking at literature, quantitative and qualitative data it is ascertained that care transitions contribute to reduction in the quality of care as well as impact the LOS negatively (see Section 4.4). In general, the quantitative data shows a significant difference in LOS between those who had been moved versus the ones who had not (see Table 9 and 10). This also agrees with the qualitative data where interviewees mentioned that moves contribute to a longer LOS. As pointed out during the interviews, the reason for this is that the continuity is lost during a move, and personnel must start over when the patient is moved (see Section 4.4.1). Literature also supports this finding, where patients being moved between wards and meeting multiple physicians during their care stay can lead to a longer LOS (Epstein et al., 2010; Escobar et al., 2011).

The fact that moves have such a profound impact on the LOS is also an indicator that the value creation in the process is centered around value shops. The care is very dependent on the individual care practitioner (Hwang & Christensen, 2008), where a value shop logic, in parts, makes the care fragmented. The patient is located at one ward where one physician is responsible for the treatment, creating a treatment plan. However, when the patient is moved to another ward, it is not certain that this plan will continue. It is the new physician taking over the care that is free to make a judgement on what they see best to include in the treatment, creating a new treatment plan. This can make it difficult to gain continuity in the care, as well as cause unnecessary confusion for the patient.

In literature it has been noted that inadequate transitional care is related to the rate of readmission (Coleman, 2003; Hume et al., 2012; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018; De Alba & Amin, 2014; Jack et al., 2009; Hansen et al., 2013; Marks et al., 2013). This could possibly also be noted in the quantitative data, although the factor being not as significant as for the LOS (see Table 9). There might be other factors at play in the transitional care and the care in general that may indicate that the patient will have a greater risk of being readmitted which would need to be studied further.

As shown in the comparison between Lidköping and Skövde, many care transitions could likely be avoided by the structure of the organization (see Section 4.3 and 4.4). As noted in the interviews it is most often the patient that does not have any “home ward” that gets moved around, due to the beds being needed for patients with more special needs. In this sense, the pneumonia patients are especially vulnerable, given that they often do not belong to any particular medical area. They are regarded as an easy patient group that can be treated by anyone, as described in the interviews. By providing a more general medicine ward as they have done in Lidköping, these patients would have a home, and would thus be less likely to be moved around.

Despite the negatives noted with moving patients, and although many transitions can be avoided by the structure of the organization as shown in the comparison between Lidköping and Skövde, it will likely not be possible to avoid all care transitions. Even in Lidköping patients get moved around in some cases, although to a much less extent than in Skövde. There will still be a need to divide the care into different specialties to some extent. For instance, it may be the case of a patient in a medical ward that needs surgery, then it is only natural that they are moved to a surgery ward. If the needs of a patient shifts

during the stay they will need to be moved. There can also be a need for care transitions due to economic aspects and lack of resources.

Since all moves cannot be avoided, there is a need to investigate what a good care transition involves. One aspect that needs to be considered is the means of communication and information transfer when transitions are made, which according to literature is essential for well-functioning transitions (Coleman, 2003; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018). Something that was mentioned in qualitative data was that although the current practice of information transfer is acceptable, there is no standardized way of doing it (see Section 4.4.3). There are no standards for information sharing, uncertainties in who information should be shared with, as well as missing information where different wards have different views on what should be included in the notes. The quality of the information transfers is largely dependent on the individual expertise. This is yet again a manifestation of the value shop organization, where all problems are treated as individual, needing customized responses (Fjeldstad et al., 2020).

There are several negative aspects of not handling care transitions adequately, such as reduced quality of care (Coleman et al., 2006), increased LOS (Epstein et al., 2010; Escobar et al., 2011), readmissions rate (Coleman, 2003; Hume et al., 2012; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018; De Alba & Amin, 2014; Jack et al., 2009; Hansen et al., 2013; Marks et al., 2013) and unnecessary use of resources (Coleman, 2003). It is therefore of importance for SHG to ensure that moves are dealt with in a manner that ensures quality of care and patient safety. A possible remedy could be to incorporate a more standardized process for information transfer. It is recommended that SHG work to standardize writing medical journal and transfer notes. How this would be done and what to include will however not be elaborated on further due to lack of knowledge and insights into the healthcare profession.

When observing the issue of fragmented care caused by patients moving between wards, it could be of benefit for healthcare to be arranged in a value network logic. Adopting a value network logic would help in connecting wards and care personnel (Myllärniemi & Helander, 2012), in turn making for a more unified process. Incorporating a value network would also help with the uncertainties of whom to contact for the information transfer, as well as different views between the wards on what is needed to include in the transfer notes. By doing this it would be possible to improve the communication and collaboration between wards, understand one another better, and learn from each other.

5.4 Guidelines

There could be benefits of introducing a general guideline in the form of a clinical pathway (CPW), for the pneumonia care process to shift from a value shop logic, towards a value chain logic (Fjeldstad et al., 2020). This is something that has been done at SÄS, where they have incorporated a standard care plan for the pneumonia patients, showing promising results (see Section 4.6).

In the literature, several benefits can be seen with implementing a CPW. A well-functioning CPW has a positive impact on the LOS (Rotter et al., 2019; Hauck et al., 2004; Nicasio et al., 2010; Meehan et al., 2001), reduces the risk of mortality (Hauck et al., 2004; Dean et al., 2001; Meehan et al., 2001), as well as the rate of readmissions (Meehan et al., 2001). In relation to this, SÄS has seen an improvement in both the LOS and rate of mortality for the patients treated with the standard care plan (see Section 4.6). However there has not been any significant change of the readmission rate. Introducing a guideline could potentially also work to reduce hospital costs (Rotter et al., 2019; Nicasio et al., 2010) and

improve patient safety (Rotter et al., 2019). Moreover, At SÄS it has been noted that the standard care plan has led to a reduction in time to first antibiotic dose, likewise this effect can be noted in literature (Hauck et al., 2004; Benenson et al., 1999). The mentioned factors further motivate why SHG should work towards developing a CPW, that guides care practitioners with pneumonia care, in turn improving patient outcomes.

Attitudes towards guidelines in general in the interviewees was positive (see Section 4.7.2). However, it was expressed that for it to be used and incorporated in regular care practice the implementation needs to be adapted to the current ways of working i.e., easily accessible, digital. As the care is performed now it is dependable on the individual care practitioner in how the treatment is shaped (Laing et al (2004). Through implementing guidelines in care, it is believed that this variation in care practice can be reduced.

A further benefit to introducing a guideline in pneumonia care, is that it could be used in the training of new staff. A standard method of care could therefore be used as a mediating tool in the training. CPW as a guideline in care would also bring the opportunity to collect specific parameters as data, which could then be used to evaluate and improve the care process continuously. Evaluating data retroactively as is done at SÄS, gives an opportunity to improve care proactively for patients.

On the other hand, to develop a CPW for pneumonia care demands a deliberation in how general or specific the CPW should be. As mentioned in interviews pneumonia care is individual and most often based on the patient's individual situation and need (4.7). Related to CPWs there is value chain logic which aims to create a process with set activities and order of action (Fjeldstad et al., 2020). Although this logic is used in healthcare it has shown that the diverse needs of patients may not be adaptable to the set ways of working with CPWs (Fjeldstad et al., 2020). It is therefore a topic of interest to consider what can be generalized and put into a guideline and what areas of the treatment there needs to be room for adaptation, to accommodate individual needs.

5.5 Support functions

There are several parties involved in the pneumonia care process. Not only in the sense that the patients are treated at a wide variety of wards and often are moved (see Section 4.4), but also in the sense that there is a need to involve actors working outside of the ward (see Section 4.8). For example, interviewees have emphasized physiotherapy as an important part in pneumonia care. Due to economic aspects, it is not viable that all wards have their own physiotherapist. Instead, the physiotherapists are required to move around the hospital, visiting the patient that has a need for physiotherapy (see Section 4.8). However, this requires great coordination as well as communication between the wards and the physiotherapists to ensure that each patient's needs are seen to.

From the qualitative data, practices regarding physiotherapy are not uniform around the hospital, where in some wards it was mentioned to work well whilst in others the practice was not as established (see Section 4.8.1). In literature it was shown that physiotherapy has a big role for the quality of the pneumonia care process. Mobilization of pneumonia patients both reduces the LOS (Larsen et al., 2019; Melgaard et al., 2018; Khanna & Almulla, 2012; Rice et al., 2020; Chebib et al., 2019) as well as mortality (Momosaki et al., 2015). Furthermore, it also has an effect in preventing pneumonia (Chebib et al., 2019). This goes in hand with the qualitative data where it was mentioned that physiotherapy aids in the rehabilitation and recuperation for pneumonia patients.

Although it would be good for all pneumonia patients to meet with a physiotherapist during their stay this is not the case. There is both a knowledge gap amongst the staff regarding the role of physiotherapy for pneumonia patients, but also an issue with lack of resources in support functions (see Section 4.8.1). Yet again, the problem with a lack of knowledge could be attributed to the fact that the hospital is organized around value shops. By instead incorporating a value chain, with a clear standard care plan it could be easier to spread this knowledge throughout the organization.

Incorporating physiotherapy into the standard care plan is something that SÄS has put into practice. The standard care plan has contributed to more of the pneumonia patients getting to meet with a physiotherapist. Significantly more patients treated with the use of the standard care plan get to meet with a physiotherapist than those who are treated without it (see Figure 17 and 18). Although it can be hard to discern the individual impact of each part in the standard care plan, there has been an increase in the performance in terms of LOS and mortality for the pneumonia care process, with the implementation of a standard care plan at SÄS.

In this study there has not been a possibility to quantitatively assess the impact of physiotherapy at SHG due to not being able to access data from the medical record systems as well as restrictions in how data is compiled at SHG. One improvement that is therefore pushed in this thesis is that SHG collects and compiles information regarding the usage of physiotherapy for specific diagnoses, as well as makes use of this data to visualize and understand the process further to improve it. As mentioned in the literature, it is important to collect data about the process to be able to improve the process (Holweg et al., 2018). Without a proper baseline it is impossible to analyze any potential improvements.

Other than the physiotherapists it was also mentioned that functions such as dietitians and welfare officers sometimes need to be involved in the care. Also, many of the wards that are not specialized in infection diagnosis consults infection physicians in the pneumonia care to ensure that the patients are treated in accordance with recommendations. The organizational structure with regular care personnel needing to collaborate with various forms of support functions further shows that the healthcare process is in need for a coordinated care network. Establishing a network would help in making the process more efficient and make the interactions between personnel more effective (Stabell & Fjeldstad, 1998; Hwang & Christensen, 2008; Fjeldstad et al., 2020)

5.6 Complex versus non-complex care needs affecting care

A combined value chain and value network logic would also benefit the care of patients with complex care needs. As noted in quantitative data complex patients are moved significantly more than non-complex patients (see Table 8). Since complex patients have multiple diagnoses, it brings the need for even further individualized care mentioned in the qualitative data. As noted in the empirical findings (see Section 4.2.1) there is a relationship between the complexity of the flow and whether the patient has complex care needs, which indicates that there needs to be an integrated care system in practice to make care for complex patients more effective and efficient. There is a need for a combined value network and value chain with guidelines for pneumonia care that is standardized, ensures good quality of care, and yet is adaptable to the individual care needs of complex patients. Although as mentioned by Fjeldstad et al. (2020) there can be difficulties in employing a value chain logic for patients with complex care needs, one can argue that a value network logic would help in making a value chain logic work more efficiently through the hospital organization.

In quantitative data it has been noted that the mortality rate for non-complex patients is higher than that of complex patients (see Table 5). One possible reason for this might be that the general state of non-complex patients once admitted to the hospital possibly is more serious than what is needed for complex patients to be admitted. However, there were no markers indicating the severity of the pneumonia diagnosis in the quantitative data. Therefore, it was not possible to analyze this possibility. If the non-complex patients are in a more severe state once admitted, it could be explained why a greater percentage of these patients pass away due to pneumonia.

Further, it has been noted in the quantitative data that the readmission rate for patients with complex care needs is higher than that of the non-complex patients. As noted in literature there are several factors such as age, sex, co-morbidities etc. that play a part if a patient is readmitted for pneumonia (De Alba & Amin, 2014). One can argue that in the case of the higher readmissions rate it cannot necessarily be attributed to that pneumonia care for complex patients is deficient. The reality is that oftentimes these patients are more frail, have more comorbidities, and in general have a higher degree of general morbidity. Correspondingly interviewees mentioned that complex care needs patients are oftentimes older and more vulnerable. It is therefore not uncommon for them to seek care more often than non-complex patients; in turn this being noted as a readmission that can be unrelated to a previous pneumonia episode.

Generally, when comparing the care of complex and non-complex patients, numbers from the quantitative data shows that complex patients in general have worse numbers in terms of LOS, moves and readmission rate. This may indicate that the current manner of arranging care is insufficient to satisfy the needs of patients with complex care needs. As the care currently is organized, it centers around value shops and experienced professionals (Hwang & Christensen, 2008). The care is fragmented which does not agree with the network shape of care that is needed for patients with multiple diagnosis to experience high quality of care, where all their conditions are seen to accordingly.

5.7 Improvement areas & recommendations

In this section the improvement areas and recommendations for SHG will be presented. The recommendations are based on the empirical findings in combination with the literature. Further, the topics are presented in the order in which they should be implemented which also is evaluated based on the willingness versus the potential value of the recommendations (see Figure 19). The recommendations are somewhat connected to one another, see table 12. The first and second recommendations are more connected to each other, while the third, fourth and fifth recommendations are connected to each other. The reasoning behind this order will be further elaborated on under each subheading.

Table 12 Connections and suggested order of recommendations

Recommendation	Connection & order
1. Reorganize hospital	1st
2.Standardize Information transfer	2nd
3.Integrate Support Functions	1st
4.Introduce CPW	2nd
5.Measure the process	3rd

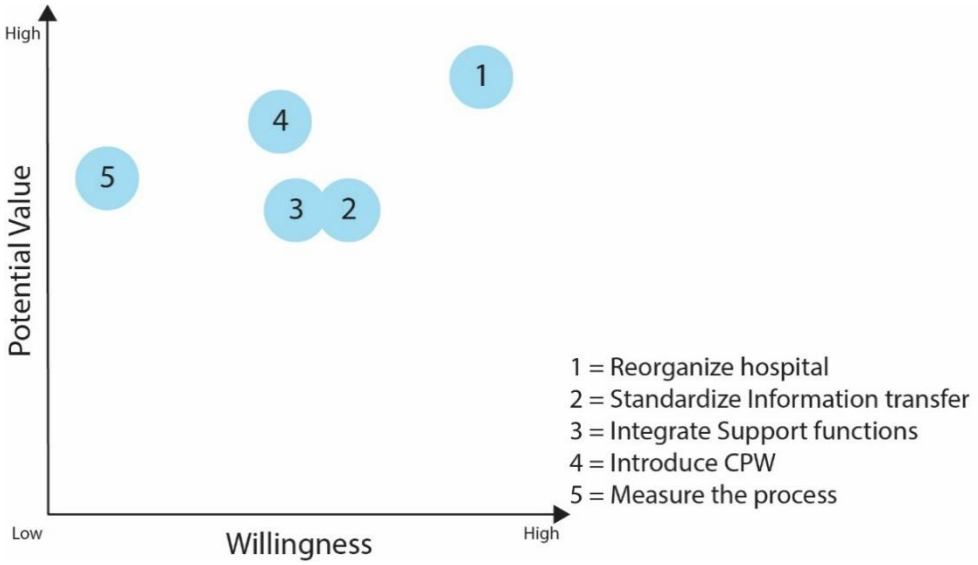

Figure 19 Chart over willingness vs potential value of the different recommendations

5.7.1 Reorganize the hospital organization

The first recommendation for SHG would be to reorganize the organization in Skövde similarly to the organization in Lidköping. As can be seen in the empirical findings (see Section 4.3), the organizational structure is connected to how fragmented the care is as well as the rate of care transitions. As stated in the interviews (see Section 4.4), providing a more general medicine ward would especially benefit the patient groups that right now do not have any home ward and thus are more vulnerable to being moved, such as pneumonia patients. Immediately ending up at the final ward without being moved has several positive effects, ultimately improving the quality of care for the patients. From the literature (Laing et al., 2004; Menendez et al., 2003; Epstein et al., 2010; Wilson & Birch, 2018; De Alba & Amin, 2014) one can see that a less fragmented system with fewer care transitions would be able to reduce the LOS, freeing up resources and cutting costs, as well as increase the patient safety and reduce unnecessary confusion for the patient, which is also supported by the empirical findings (see Section 4.3 and 4.4).

Reorganizing the hospital requires great effort and it is a big undertaking. However, a reorganization is already underway at SHG (Javid Gholam, personal communication, March 12, 2021), showing a willingness to make the change happen (see Figure 19). One should therefore join forces with the reorganization that is underway and make for it to also benefit the pneumonia care process. There is great potential value from this change and implementing it firstly would facilitate for a smoother and more efficient implementation of the other recommendations, given that the organization will get a more uniform structure. This in combination with the willingness to make the change happen is the basis for implementing the reorganization first (see Table 12).

However, although a hospital reorganization would most likely result in a reduction in care transitions amongst pneumonia patients, there is now way to eliminate all patient moves. There will still be several actors involved in the care process, and it would therefore be recommended to improve upon the value network in the organization, which allows for improved communication and integration in the care network (Fjeldstad et al., 2020)

5.7.2 Standardize information transfer.

Since it is not possible to eliminate all moves there needs to be work done to standardize the way information transfer is done (see Section 4.4.3). By doing so it would ensure that sufficient information is available and accessed that is useful for staff at the new ward in making assessments of the patients and the upcoming care. This uniform way of thinking when writing notes does not only apply to the writing of transfer notes, but this is also an issue for when writing the medical journal, where care personnel utilize different templates and manners of what is included in the medical records (see Section 4.4.3). Standardizing information transfer is a recommendation that is built on the premise that the reorganization of the hospital has already been performed. This order is advised since to standardize information transfer before a reorganization, the improvements then might be erased in a new organizational setting. Furthermore, given that Skövde and Lidköping has a similar organizational structure, the same practices could be implemented at both locations, simplifying the process.

A complication that one might meet when working to standardize the information transfer, as mentioned in interviews, is that writing is dependable on the person writing the notes, but also that different information is relevant and prioritized at different wards (see Section 4.4.3). It can therefore be hard to standardize the manner of writing the medical records and transfer notes that enables all wards to optimize the information-gain from the notes. Nonetheless, since a level of dissatisfaction from interviewees regarding how information transfer is done might possibly indicate a willingness in changing the processes and improving the system of information transfer (see Figure 19). In addition, going through with this recommendation holds potential value for SHG in terms of improving transitional care which would lead to reduced LOS (Epstein et al., 2010; Escobar et al., 2010), readmission rate (Coleman, 2003; Hume et al., 2012; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018; De Alba & Amin, 2014; Jack et al., 2009; Hansen et al., 2013; Marks et al., 2013) and improved quality of care (Coleman et al., 2006).

This recommendation would require further studies and analysis of how information transfer is handled, how medical records and transfer notes are written at the hospital, and work to make out how it could be standardized. This thesis has not investigated how notes and medical records are written and therefore do not have the information to assess what could be improved. Moreover, this is no easy task and would require a great effort by SHG. However, a more standardized way for information transfer one can argue would result in more efficient care transitions and improved communication in practice. Further, the implementation of this would also facilitate the following recommendations.

5.7.3 Integrate and connect support functions to the pneumonia care process.

In the making of a more standardized care process for the pneumonia patients it will be important to make sure that all the support functions are properly connected. There are, and will continue to be, several actors outside of the general care team at the ward that will need to be involved in the care (see Section 4.8). For instance, physiotherapists play an important role in pneumonia care, other roles are infection consultants, dietitians, and welfare officers. For the pneumonia care to be as well-functioning as possible, and to ensure that every patient gets the right level of care it will be important to improve the value network, by facilitating communication, coordination, and learning from each other.

As it is right now, one of the major problems mentioned in interviews is the lack of knowledge amongst the care personnel of what role the different actors play in the pneumonia care (see Section 4.8). It is not common knowledge at all wards that it is important to involve physiotherapy in the care process for

example. Knowledge sharing will thus be an important part of a value network, seeing so that the same knowledge is available throughout the whole organization. It should not matter where the patient gets treated, there should still be the same quality of care. The interviewees that work as support functions has mentioned that there is a willingness to be a part of the pneumonia care process. In addition, interviewed care personnel have noted the importance of physiotherapy and making use of infection consultants, see Section 4.8. One might therefore assume that there is a willingness to further integrate support functions in the care, see Figure 19. The recommendation also bring value for the pneumonia care since support functions' resources would be made better use of and for the quality of care in terms of reduced LOS (Larsen et al., 2019; Melgaard et al., 2018; Khanna & Almulla, 2012; Rice et al., 2020; Chebib et al., 2019) and mortality rate (Momosaki et al., 2015) if physiotherapy practices are improved.

Integrating support function is recommended to be done ahead of implementing a CPW since it facilitates the creation and implementation of it. Since the support functions have limited resources, it is important to incorporate them in the process before initiating a CPW, this would allow for input on where they are needed and how they should work. Furthermore, this step is simplified if information transfer has been standardized, since care staff will then be informed when support functions have been involved in the care process or if they need to be called in.

5.7.4 Introduce a guideline (CPW) in the care of pneumonia patients.

The next recommendation for the pneumonia care process at SHG is to implement a guideline for the care in the form of an CPW that could act as a checklist. As noted in literature a CPW could potentially work to reduce the LOS (Rotter et al., 2019; Hauck et al., 2004; Nicasio et al., 2010; Meehan et al., 2001), readmissions (Meehan et al., 2001), mortality (Hauck et al., 2004; Dean et al., 2001; Meehan et al., 2001) and patient safety (Rotter et al., 2019), as well as work in favor of the hospital organization in reducing costs (Rotter et al., 2019; Nicasio et al., 2010). Further, SÄS has seen an improvement in the overall quality of care in terms of antibiotic choice and treatment, reduced LOS, and mortality rate, as well as an increased access to physiotherapy for pneumonia patients since they introduced a CPW for pneumonia patients (see Section 4.6 and 4.8.1).

Right now, there is no general guidelines in the pneumonia care at SHG (see Section 4.7). Implementing a CPW for this diagnosis would likely result in similar improvements at SHG as the ones seen at SÄS. An implementation of a CPW would shift the value creation in the process from the current value shop structure to a value chain. In turn, the CPW with set assessment activities as well as treatment routines would aid in reducing variance in care (Meehan et al., 2001) in the hopes of increasing the quality of care. Implementing a CPW would potentially be especially beneficial for patients with complex care needs, given that the disparity of their condition makes it difficult to keep track of the treatment and that all the care needs are met. A guideline would work as a checklist for both physicians and nurses to ensure that the required steps of pneumonia treatment are assessed and executed.

From the empirical findings one can note that the attitude towards guidelines varies between the care personnel (see section 4.7.2). There are many who see a great benefit from having a general guideline to lean on and help you make choices in the care. However, others mean that such a guideline will not work since each patient has individual care needs. When creating a CPW it will be important to find the right balance between how general or specific it should be in order to get value from it. Further, there is a fear that new guidelines would just lay unused and forgotten if they do not get anchored in the daily process. To increase the willingness to incorporate a guideline it will be important to make it easy to find and to incorporate it in the work (see Figure 19).

This thesis will not present what a future pneumonia CPW could look like, and it is recommended to draw inspiration from the existing practices and standard care plan at SÄS in the future development. Since the two hospitals act in the same context in the same region with a similar care setting, the practices at SÄS could likely be adapted to work at SHG. Moreover, utilizing already existing information and solutions reduces the amount of work needed from SHGs organization, making work more efficient.

In the creation of a CPW, it will be important to incorporate all the care personnel involved in the process, including support functions such as physiotherapists, to ensure all aspects are covered. As mentioned by Rotter et al. (2019) it is critical to engage the care practitioners that are involved in the care process to establish a well-functioning CPW. As Rotter et al (2019) suggests one should involve so-called "local champions" that can help in identifying barriers, gaps in care practice, engage in education sessions and be involved in the CPW's design and implementation. In turn, by involving the personnel in the creation of the CPW the willingness to incorporate it into the care could be increased. For this reason, creating a CPW is much connected to integrating and connecting support functions. Thus, it will be important to have completed the previous recommendation before creating and implementing a CPW.

Creating a CPW would also come with the added bonus of gaining greater clarity and understanding of the care of these patients, where an implemented guideline gives the possibility for retrieving specific information on the care. This information could then be evaluated and used for working continuously to improve the care and in turn the patient outcomes, connecting to the last recommendation.

5.7.5 Measure the process.

Lastly, it is suggested that SHG start to collect and compile available data about the pneumonia care process. As is described in the literature it is not possible to assess if a change has brought any improvements, if a baseline measurement does not exist (Holweg et al., 2018). Some measurements that could be collected to further see any improvements could for example be the number of patients that have gotten to see a physiotherapist, time to the first antibiotic treatment, LOS, readmission rate, mortality rate etc. Moreover, this recommendation involves following the data over time, as a means of not only identifying key factors but also to facilitate continuous improvement in the pneumonia care process, this is a practice that is used at SÄS and has shown to benefit the pneumonia care process there (see Section 4.6).

There is possibly not a great amount of willingness in care staff to initiate this recommendation since this would lead to further tasks to perform in a setting where there is already a lack of resources (see Section 4.4.3). However, measuring the pneumonia care process using data as well as using it to evaluate the process is a prerequisite for reaping benefits from the CPW and improving the process, which is a source of potential value in the pneumonia care process (see Figure 19). As indicated this recommendation relates to the implementation of a CPW, where one could emphasize that there needs to be purpose in collecting data and to use it for improvement. In this scenario, measuring the process would be done with the purpose of evaluating and continuously improve the CPW and the pneumonia care process.

5.8 Process mining potentials for SHG

This thesis could be used as a means of motivating why process mining should be introduced more into the healthcare field. Although process mining in healthcare has seen a rise in the last decade, this is something that the authors have not observed in Sweden. One can argue that process mining would be a good tool for process improvement work in Sweden, providing a comparatively easy means of mapping what the process looks de facto. As has been mentioned in literature, process mapping is cost and time consuming, whereas process mining is a more efficient way to gain results more quickly and less costly (Martin et al., 2020). Furthermore, the work introduces another approach to process mining, where it has been used as a steppingstone for qualitative data gathering in determining which wards in the process are most important to gain more information from. Process mining and qualitative data gathering as well as statistical analysis has contributed to one another to enrich understanding of the pneumonia care process. This way of working has allowed the authors to gain a good understanding of what the care process looks like in a short amount of time and with little resources.

Hospitals in Sweden, including SHG, collect immense amounts of data in their databases regarding the patients, the treatments, and the care flows. It would be beneficial to use this collected data for process mining to improve the healthcare system. This thesis has shown a way that the hospitals could utilize this data to better understand their current care processes. By investing in the ability to do process improvement work in healthcare through process mining it would not only be beneficial for operation improvement work where process mining makes the work easier, but it would also lead to increasing the quality of care. In turn this could contribute to better care for patients, as well as reduced costs in healthcare, meaning increased value for taxpayer money.

However, as witnessed by the authors, gaining access to more in-depth details of the processes at hospitals can be difficult. As seen in the literature this is not the case for other countries in the world, which has made it possible for improvement work to be made more efficient. The thesis authors therefore believe that these databases should be made more accessible for improvement work, otherwise these records lose their potential to be of benefit in improving healthcare. On the other hand, there is the difficulty with ethics, not causing harm to the patients and the information that exists in the data.

Looking at previous literature there has not been previous studies done looking at pneumonia patients and their movements around the hospital. Although there has been a study regarding the steps made in treatment (Arias et al., 2020), which also discusses some on the topic of gender and age of the patients, there has not been any studies over how these patients transition between wards, and where specifically they are located at the hospital. This thesis contributes to showing an image of the pneumonia care at SHG and understanding the flows of pneumonia patients throughout the hospital. Furthermore, improvement areas for the pneumonia care process are identified making it useful in the following development of a pneumonia care process at SHG.

6
Conclusion

The aim of this thesis has been to explore and understand the care process for pneumonia patients at SHG with an additional focus on patients with complex care needs. Through combining empirical data and literature it has been possible to get an overview on the care process and discern what variables affect the care as well as identify areas of improvement for the pneumonia care at SHG, thus fulfilling the aim. In this section the conclusion of the thesis is summarized by answering each of the research questions.

RQ1: What does the pneumonia care process currently look like at SHG?
The pneumonia care process can generally be described as having a spaghetti structure (van der Aalst, 2011). The process is unstructured and the conditions of the activities within are poorly defined. According to qualitative data, there is no consensus throughout the hospital of how pneumonia patients should be treated, and practices vary between wards as well as hospitals. The organizational differences between the hospitals have an impact on how the patients are treated, where the care process in Skövde is significantly more fragmented than in Lidköping. Further, the quality of the care is largely depending on whether the patient has complex care needs or not, where the process works less well for the complex patients.

The organization is structured around value shops, with a high dependence on the intuition of the individual care practitioner. There is no standardized way of working with the patients or attempts to incorporate a value chain logic specifically for these patients, and although the patients are widely spread around the hospital there is not much communication or collaboration between the different actors, i.e., wards.

RQ2: What variables in the pneumonia care process influence the quality of care and performance measures?
Through the empirical findings in combination with literature it has been revealed that several aspects affect the quality of care and performance measurements such as the organizational structure, the way care transitions are performed, differences in care practice, if there is a clinical pathway in place, mobilization of pneumonia patients, and patient characteristics (see Table 13). Literature show that the organizational structure affects the LOS (Laing et al., 2004; Menendez et al., 2003; Epstein et al., 2010), which is also supported by qualitative and quantitative data, see Section 4.3. Further, the rate of care transitions is also affected by the organizational structure, which both can be seen in the empirical findings and in literature (Wilson & Birch, 2018). De Alba & Amin (2014) mentioned that the organizational structure affects the readmission rate, however this relationship remains inconclusive in the quantitative data.

Literature has shown that inadequate care transitions affect the quality of care (Coleman et al., 2006), unnecessary use of resources (Coleman, 2003), prolongs the LOS (Epstein et al., 2010; Escobar et al., 2011), as well as raises the readmission rate (Coleman, 2003; Hume et al., 2012; Fuji et al., 2013; Knisely et al., 2015; Wilson & Birch, 2018; De Alba & Amin, 2014; Jack et al., 2009; Hansen et al., 2013; Marks et al., 2013). These negative impacts are also supported by the empirical findings, where especially the LOS seem to be most heavily impacted, see Section 4.4.

Laing et al. (2004) and Menendez et al., (2003) reveal that differences in care practice affect the LOS. Although this is difficult to reveal in quantitative data, several interviewees confirm that differences in care practice affects the care and in turn LOS (see Section 4.4.1). The readmission rate has also been revealed in literature to be affected by differences in care practice (De Alba & Amin, 2014; Lindenauer, 2010; Epstein et al., 2011), however it has not been possible to support this statement in empirical data (see Table 6).

Implementing a clinical pathway has been shown to positively affect the LOS (Rotter et al., 2019; Hauck et al., 2004; Nicasio et al., 2010; Meehan et al., 2001), mortality (Hauck et al., 2004; Dean et al., 2001; Meehan et al., 2001), readmission rate (Meehan et al., 2001), hospital costs (Rotter et al., 2019; Nicasio et al., 2010), time for antibiotic administration (Hauck et al., 2004; Benenson et al., 1999) and patient safety (Rotter et al., 2019). Similarly, information and data from SÄS confirm that a CPW or guidelines in pneumonia care affects beneficially the LOS, readmission rate, mortality, time to first antibiotic treatment and if a patient has seen a physiotherapist, (see Section 4.6 and 4.8.1).

According to literature, mobilization of pneumonia patients affects LOS (Larsen et al., 2019; Melgaard et al., 2018; Khanna & Almulla, 2012; Rice et al., 2020; Chebib et al., 2019), mortality (Momosaki et al., 2015) and prevention of pneumonia (Chebib et al., 2019). This has however not been investigated in quantitative data due to inaccessibility. Nevertheless, interviewees confirm that mobilization and physiotherapy have significance in the pneumonia care process, although not any specific measures were mentioned, see Section 4.8.1.

Lastly, the care process is also affected by patient characteristics such as age and complexity of care needs (see Section 4.2). Quantitative data show that the LOS is affected both by the complexity of the patient and the age (see Section 4.2). Complex patients have a higher readmission rate, and the mortality correlate with the age, where the greater the age the more likely one is to pass away. However, surprisingly it was noted in the data that non-complex patients had a higher degree of mortality.

Table 13 Summary of findings

Variable	Performance measure	Literature	Quantitative data	Qualitative data
Organizational structure	LOS	Supported	Supported	-
	Rate of care transitions	Supported	Supported	Supported
	Readmission rate	Supported	Inconclusive	-
Inadequate care transitions	Quality of care	Supported	-	Supported
	Use of resources	Supported	-	Supported
	LOS	Supported	Supported	Supported
	Readmission rate	Supported	Supported	-
Difference in care practice	LOS	Supported	-	Supported
	Readmission rate	Supported	Inconclusive	-
CPW (guideline)	LOS	Supported	Supported (data from SÄS)	-
	Mortality	Supported	Supported (data from SÄS)	-
	Readmission rate	Supported	Supported (data from SÄS)	-

	Hospital costs	Supported	-	-
	Time for antibiotic administration	Supported	Supported (data from SÄS)	-
	Patient safety	Supported	-	-
	Physiotherapy visit	-	Supported (data from SÄS)	-
Mobilization of patients	LOS	Supported	-	-
	Mortality	Supported	-	-
	Prevention of pneumonia	Supported	-	-
Age	LOS	-	Supported	Supported
	Mortality	-	Supported	-
Complexity of care needs	LOS	-	Supported	Supported
	Readmission rate	-	Supported	-
	Mortality	-	Supported	-

RQ3: What are the areas of improvement in the care process?
Five main improvement areas have been found from the thesis; these are elaborated on further in Section 5.7. The improvement areas are presented in the order in which they are suggested to be executed.

Reorganize the hospital in order to defragment the care and reduce care transitions.
The organizational structure in Lidköping seems to be more suited for the pneumonia care process and reorganizing the hospital according to this could be beneficial for the pneumonia patients.

Introduce a standardized way for information transfers.
Even if the hospital is reorganized, it will likely not be possible to avoid all care transitions. In order to avoid problems associated with communication it is advised to introduce a standardized way for information transfer throughout the hospital.

Integrate and connect different support functions into the care process.
Although pneumonia is a relatively straightforward diagnosis to treat, there are several actors that need to be connected into the care process, such as physiotherapists. It will be important to integrate and connect all the actors into the care to not miss valuable parts. When establishing a general process, it will thus be of importance to also develop a well-functioning value network surrounding the process.

Introduce a general guideline for the pneumonia care in the form of a clinical pathway (CPW).
Introducing a general guideline has been shown both by literature as well as the practices at SÄS to improve the quality of the care process. Given that pneumonia is a relatively straightforward diagnosis to treat, it could be recommended to introduce a specific CPW to guide the care and ensure less variation in the care process, incorporating a value chain logic.

Make sure to measure and compile the data regarding the process to establish a proper baseline.
Lastly, it is advised that SHG make sure to measure and compile all the data regarding the pneumonia care process. Without a proper baseline it is impossible to assess any potential improvements, and further develop and improve the process.

6.1 Further research topics

Further research topics that have been noted in this thesis include to investigate and analyze in depth how information transfer at SHG is performed and how they could work to standardize it. Another topic that would need to be investigated is what aspects and steps would be included in a future CPW. Moreover, a quantitative study on the impact of physiotherapy on the pneumonia care would be of interest. Lastly, a deeper dive into the process mining where greater detail is taken could be a subject of interest to further make out other factors that account for the low R square in the statistical tests.

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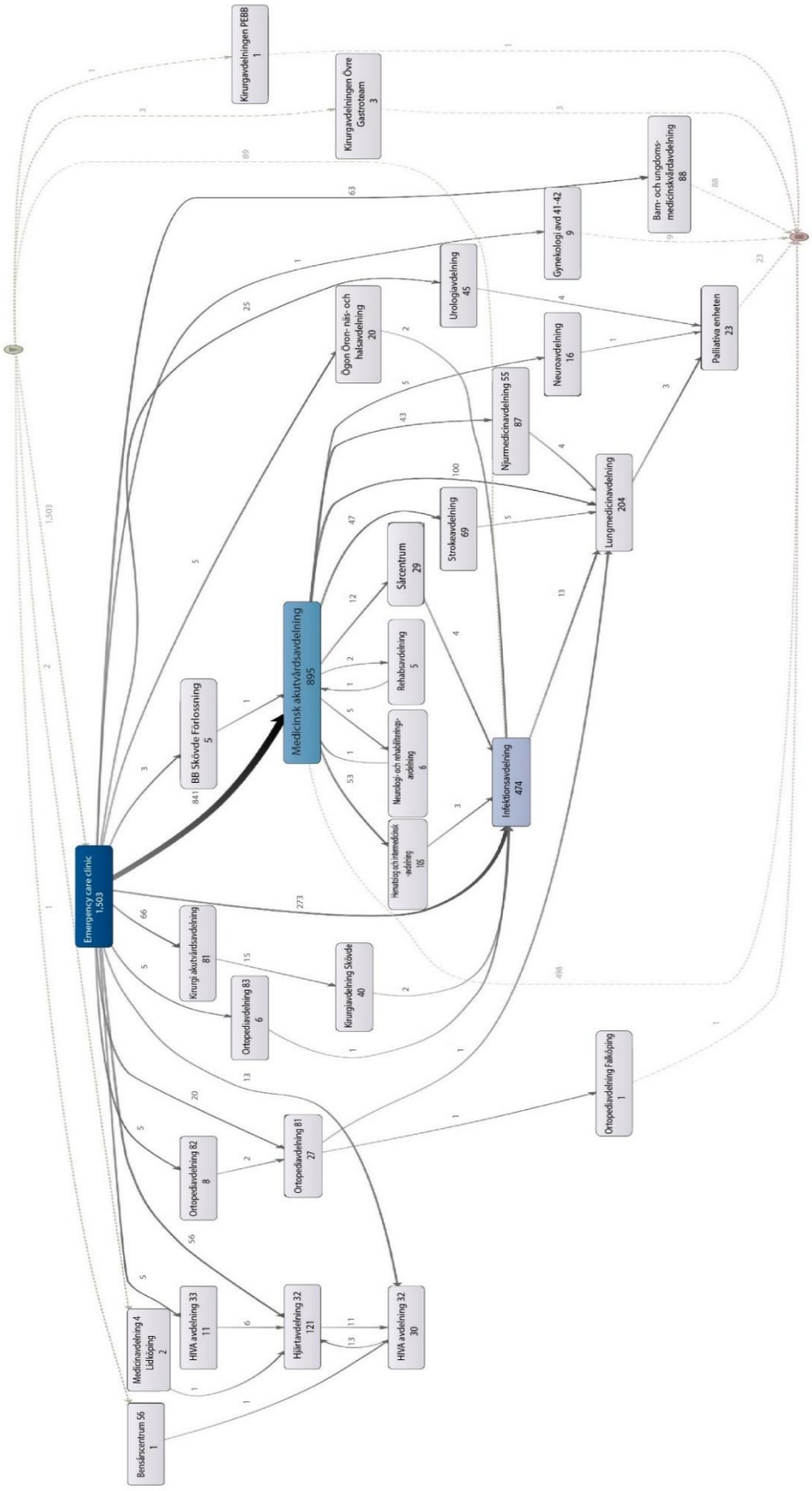
Appendices

Appendix A: Interview Guide

1. Vilken avdelning jobbar du på? *(which ward are you working in?)*
2. Vilken funktion har du i vården av patienter (SSK, USK etc, yrkeskategori…) *(What function do you have in the care of these patients?)*
    a. Hur länge har du arbetat med pneumoni patienter? *(How long have you been working with pneumonia patients?)*
3. Vad är dina tankar om hur vården av pneumoni-patienter fungerar där du jobbar? *(What are your thoughts on how the care of pneumonia patients works where you are working?)*
    a. Finns det någon del som är lätt eller fungerar bra? *(Is there any part that is easy or works well?)*
    b. Finns det någon del som är särskilt svår/ utmanande? *(Is there any part that is particularly difficult / challenging?)*
4. Med vad och hur följer ni upp vården av pneumoni patienter under och efter behandling? *(With what and how do you follow up on the care of pneumonia patients during and after treatment?)*
    a. Hur ofta? *(How often?)*
    b. Vilka typer av mått? *(What types of measurements?)*
    c. Har ni några målvärden? *(Do you have any target values?)*
    d. Hur används data för att förbättra processen? *(How is data used to improve the process?)*
5. Vi har sett att många patienter flyttas mellan avdelningar. Vad tänker du om det? *(We have seen that many patients are moved between wards. What do you think about it?)*
    a. Varför flyttas patienter? *(Why are patients moved?)*
    b. Finns det för- resp. nackdelar med att flytta patienter? *(Are there benefits or disadvantages of moving patients?)*
    c. Kommer det några svårigheter med att flytta patienter? *(Are there any difficulties in moving patients?)*
6. Hur fungerar informationsöverföringen i samband med flytt av patienterna? Kan du beskriva? *(How does the information transfer work in connection with the transfer of patients? Can you describe?)*
    a. Vad fungerar bra/mindre bra? Vad kan göras bättre? Hur får ni den informationen? Hur ser kommunikationen ut? *(what works well / less well? What can be done better? How do you get that information? What does the communication look like?)*
7. Har ni några riktlinjer som ni följer i vården av pneumoni? *(Do you have any guidelines that you follow in the care of pneumonia?)*
    a. vad tänker du om dessa?
    Bra/dåliga? Lätta/svåra att hitta? Följs dessa? Om ej, varför inte – kan dom bli bättre *(what do you think about these? Good / bad? Easy / hard to find? Are these followed? If not, why not - can they get better?)*

8. Har ni några särskilda rutiner som ni följer i vården av pneumoni? Vad tänker du om dessa? *(Do you have any special routines that you follow in the care of pneumonia? What do you think about these?)*
    a. Vet du om ni har samma rutiner när det gäller behandling av pneumoni som andra avdelningar? *(Do you know if you have the same routines when it comes to treating pneumonia as other departments?)*
9. Hur är andra yrkeskategorier involverade i vården av dessa patienter? Hur fungerar det? Vad är bra/mindre bra? Vad kan förbättras? *(How are other professional categories involved in the care of these patients? How does it work? What is good / less good? What can be improved?)*
10. Hur hanteras det när en person med flertalet diagnoser behandlas för pneumoni? Skiljer det sig åt från om patienten bara har en pneumonidiagnos? *(How is it handled when a person with multiple diagnoses is treated for pneumonia? Does it differ to if the patient only has a pneumonia diagnosis?)*
11. Om du har andra synpunkter eller input som du anser kan vara relevanta får du gärna dela med dig! Gärna: Vad ska vi tänka på om vi nu ska förbättra processen för dessa patienter på SkaS? Vad ska vi undvika? *(If you have other views or inputs that you think may be relevant, feel free to share! What should we think about if we are now to improve the process for these patients at SHG? What should we avoid?)*

Appendix B: Care network, Skövde



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