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A forecasting process for the amount of patients in need of dedicated time slots

A case study of the Standardized Care Process initiative at NU-sjukvården's x-ray division

Master of Science Thesis
in the Supply Chain Management Programme

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Sincerely,

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Abstract

In September 2015, a national initiative called Standardized Care Processes (SCP) was launched as an attempt to decrease the waiting times and regional variation in the Swedish cancer care. A facilitator to the SCP initiative, that some hospitals use, is to have dedicated time slots at the x-ray division to ensure fast access to a resource that is considered to be a bottleneck activity in the Swedish healthcare. These dedicated time slots consume capacity at the x-ray division, and the amount patients in need of these time slots, per different cancer diagnosis, is estimated without a pronounced forecasting process, hence only based on judgment. In this study, four of the SCP cancer diagnoses affecting NU-sjukvården's x-ray division have been used as cases to study the impact. These cancer diagnoses are: Urinary tract and bladder cancer, Prostate cancer, Esophagus and stomach cancer, and Head and neck cancer.

NU-sjukvården's x-ray division is affected by long waiting times, and in order to manage their queues, and to be able to offer patients their treatments within the time span set by the healthcare guarantee, NU-sjukvården either outsource patients to other medical facilities, or occasionally extend their opening hours. The SCP dedicated time slots consume capacity at an already constrained situation, and since these time slots do not have a pronounced forecasting process in place behind it, it affects the x-ray division situation even more.

This study will therefore develop a forecasting process for the amount of patients in need of an SCP dedicated time slot at NU-sjukvården's x-ray division. Results showed that a mix between qualitative and quantitative factors should be included in a forecasting process in order for the process to become as accurate as possible. The study also showed that in order for a forecast process to become as accurate as possible the following factors need to be considered: what is the forecast's objective, who will use the forecast, and what input data is needed. Further, suitable aggregation levels and forecasting horizons are needed that supports the overall objective of the forecast process. When the forecast is produced, monitoring and evaluation of the forecast is needed.

This study's resulted in that the process owner for each diagnosis is the owner of the forecast, and by a collaboration with the production planner, the generated forecast from the developed forecast process is determined. The forecasting horizon should be the same as the overall planning of the x-ray division, namely using a 12-month rolling forecast. The quantitative data should be updated every month to include the latest information, and the qualitative input is discussed quarterly, on NU-sjukvården's steering committiees, to make sure that factors that may affect the outcome of a forecast is not missed. The forecast should be carefully monitored by calculating the forecasting error.

Keywords: *Forecasting process, Standardized Care Process (SCP), Swedish healthcare, Swedish cancer care, X-ray division, Qualitative factors, Quantitative factors, Aggregation levels, Planning horizon*

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Abbreviations

SCP - Standardized Care Processes (Swedish SVF - Standardiserade VårdFörlopp)
CT - Computed Tomography
MRI - Magnetic Resonance Imaging
SALAR - Swedish Association of Local Authorities and Region
MDK – Multi Disciplinary Conference

1. Introduction

This chapter introduces the background to this study and why the problem that has been analyzed exists. From the background description, a purpose that will be answered in this study is presented, as well as what the limitations to the study have been. The introduction ends with an outline description consisting of what will be covered in which chapter throughout the study.

1.1 Background to the SCP initiative

“Every day counts!” These are the leading words to a national initiative in Sweden called Standardized Care Processes (SCP). Every year, in Sweden alone, there are approximately 60,000 people diagnosed with cancer, a number that has been steadily growing for the last 40 years (see Figure 7 in section 4.4) (Socialstyrelsen.se, 2016). Receiving information about a suspicion of cancer from a doctor is, for most individuals, equivalent to stress and anxiety, not only for the patient itself, but also for the patient’s family members, relatives and friends. Having to deal with these concerns are difficult enough, and an additional factor that adds stress to an already stressful situation is the ongoing long waiting times before the patient can get properly examined.

The SCP initiative has been launched by the Swedish government and SALAR (Swedish Association of Local Authorities and Regions) based on results from a study, which concluded that cancer care in Sweden is suffering from long waiting times and regional variation (Socialstyrelsen and SKL, 2014). Regional variation means that waiting times fluctuate depending on where in Sweden a patient choose to seek medical care. For example, the waiting time variation for a patient with Prostate cancer was ranging between 117-271 days, and for a patient with Breast cancer the variation differed between 7-28 days (Socialstyrelsen and SKL, 2014). In other aspects, such as cancer survival rates and life expectancies, the Swedish healthcare system performs well (OECD, 2013) but waiting times are according to Health Consumer Powerhouse (2015) an area of concern. Due to these findings, the SCP initiative has been introduced as a project stretching over four years with the objective of standardizing processes within the cancer care to reduce waiting times and regional variation (Cancercentrum.se, 2015; Cancercentrum.se, 2016a; Socialstyrelsen, 2015). The SCP initiative was inspired by a similar project in Denmark called Pakkeforløben, which improved the Danish healthcare system (Cancercentrum.se, 2016a; Socialstyrelsen, 2015).

1.1.1 The SCP initiative process

The medical processes within the cancer care, that are to be standardized, begins when a doctor suspects that a patient may suffer from cancer, and ends when the suspicion of cancer is dismissed, hence the patient did not suffer from cancer, or when the patient starts their treatment (see Figure 1).

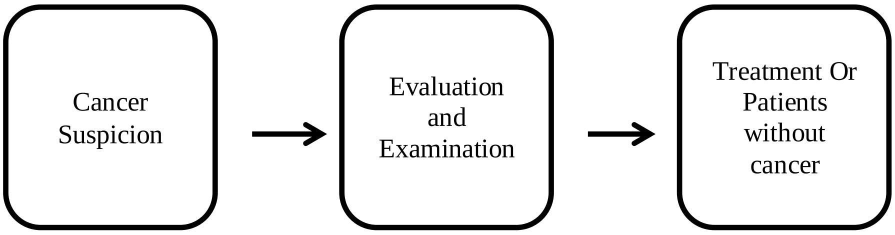

Figure 1 - The Standardized Care Process

To support the standardization, which means enabling shorter examination times and equal treatment for everyone, the doctors are provided with guidelines consisting of special criteria for each cancer diagnosis. These criteria have to be fulfilled in order for a patient to be considered as an SCP patient, and included in the SCP process (Cancercentrum.se, 2016a). Medical experts for all the different cancer diagnoses have carefully developed these individual guidelines. The counties in Sweden had to hand in an action plan regarding implementing the SCP by the 15th of March 2015, and the initiative was launched on the 1st of September 2015 (Regeringen.se, 2015). The SCP initiative started with five different cancer diagnosis in September 2015, these were: Acute myeloid leukemia, Esophagus and stomach cancer, Head and neck cancer, Prostate cancer, and Urinary tract and bladder cancer. In 2017 the initiative will include 28 different cancer diagnoses and by 2018 the initiative will continue to grow.

The SCP initiative has introduced new requirements in how the referrals for cancer patients are to be processed. When a doctor discovers a symptom, specified in the SCP guidelines for different cancer diagnoses, the referral should be marked as an SCP referral. These SCP marked referrals will get a high prioritization for the upcoming examinations. The reason for this mark is to ensure that these cancer diagnoses get faster access to the resources and examinations needed. This standardization should result in shorter waiting times and less regional variation in the Swedish cancer care.

1.1.2 Dedicated time slots for SCP patients at NU-sjukvården's x-ray division

The cancer diagnoses involved in the SCP initiative, together with many other medical diagnoses, are in need of shared resources provided by the healthcare system. Examples of such resources are surgery, biopsy and x-ray examinations. As the world's population is growing and humans have longer life expectancies, pressure on these resources, from all different types of patients, is increasing. This result in large queues, hence long waiting times to access the resources, and the shared resources are considered as bottleneck activities (Agerberg, 2010). As a result, this study will focus on one of these shared resources, namely the x-ray. This decision is also supported by an investigation of potential bottlenecks in the SCP initiative, which confirms that the x-ray division is a bottleneck activity for the SCP processes (Standardiserade vårdförlopp, 2015).

To get faster access to x-ray examinations, it has on a national level been suggested to use dedicated time slots for the cancer patients in need of an x-ray examination (Cancercentrum, 2015). This is something that the Region of Västra Götaland, and thereby the x-ray division at NU-sjukvården, where this study was performed, has adopted in their daily operations. The requirement creates a different demand situation for the x-ray division. From a planning perspective this means that time slots that were previously used for any type of examination are now only dedicated to SCP patients. At NU-sjukvården, these dedicated time slots for x-ray examinations related to the SCP patients are decided and estimated based on judgment and experience from local doctors, local SCP process owners and local SCP coordinators (SCP coordinator, 2016).

Presently, the majority of the dedicated time slots for the ongoing SCP diagnoses are handled on an individual diagnosis level, which means that they are planned without any aggregation of diagnoses (Chief Physician and Head of the Radiology department, 2016). The majority of these diagnosis' dedicated time slots are estimated based only on qualitative data and therefore it is a risk of mismatches between estimations and actual demand, which is a problem from a planning perspective at the x-ray division. If these time slots are unused it is difficult to reschedule a new patient due to time constraints (Operative Booking Staff, 2016). As a result, there is a risk that a time slot is not filled, and an unused slot would in turn result in longer waiting times for all medical diagnosis in need of an x-ray examination. Out of the five cancer diagnoses that were started in September 2015, only four are using x-ray examinations in their processes. These cancer diagnoses are: Urinary tract and bladder cancer, Prostate cancer, Esophagus and stomach cancer, and Head and Neck cancer.

1.1.3 The x-ray production planning at NU-sjukvården

The significant challenge of matching capacity, meaning available resources, and demand is common in many industries (Kaipia and Holmström, 2007; Heikkilä, 2002). In the healthcare industry it is present by the problem of balancing available resources to variation in demand (Alvekrans et al., 2016). This is especially evident from an x-ray division's perspective dealing with demands, in the form of referrals, from several sources where patients with different diagnoses are in need of examinations. All incoming referrals are prioritized by a doctor depending on what medical condition a patient is suffering from, and this prioritization specifies how fast a patient needs, and should, be examined. This prioritization, together with the availability of educated staff and number of available x-ray scanners, determines the capacity schedule for the x-ray division.

The problem that the x-ray division at NU-sjukvården faces is that it does not have enough resource capacity to satisfy all incoming referrals, the demand (SCP coordinator, 2016). An explanation to this, according to the Chief Physician and Head of the Radiology department (2016), is that there is a shortage of educated staff, i.e. x-ray nurses and radiologists. The problem generates long waiting times, which is not acceptable for patients' expectations on availability of x-ray examinations.

NU-sjukvården's x-ray division presently uses a planning tool named Prosit for their master planning and forecasting. Prosit is built upon a quantitative forecasting method called Holt-Winter approach (see section 2.4) which roughly means that the forecasting method considers three components; level, seasonality and trend. The tool uses a rolling forecast horizon of 12 months (Group Staff Performance Control and Coordination, 2016). The planning and forecasting that Prosit considers is the total amount of x-ray examinations during one month. Prosit separates the different x-ray examinations based on type, which means that the forecast for the CT and the MRI is conducted separately. Prosit compares the available capacity with historical and upcoming expected demand to visualize what the planning situation will look like in the future. Based on this information, decisions are taken regarding how many examinations that can be performed in-house, and how many examinations that need to be outsourced to other medical facilities in Sweden. What can be observed from Prosit (see Figure 13 and 14) is that the available capacity is never enough to cope with the incoming demand each month, which further motivates the general problem discussed.

For the overall planning and forecasting of the x-ray division, NU-sjukvården is although rather satisfied with the present situation. However, the planning and forecasting for the amount patients in need of SCP dedicated time slots is not included in NU-sjukvården’s x-ray division's master planning and forecasting (Chief Physician and Head of the Radiology department, 2016).

The relevance of this master thesis from an academic point of view is to contribute with supply chain and logistics knowledge to the Swedish healthcare industry. There has been previous studies conducted within the healthcare industry (Vissers et al., 2001a,b, Alvekrans et al., 2016, Harris et al., 2016), and also specifically towards forecasting processes (Plantin and Johansson, 2013), but academia still lack research on the design of such processes and specifically towards an x-ray divisions challenges with dedicated time slots connected to the SCP initiative.

1.2 Problem description of NU-sjukvården’s x-ray division and the purpose of the study

A problem for an x-ray division is that the incoming demand is larger than the available resource capacity (Agerberg, 2010; Production planner, 2016). Since not all demand can be satisfied directly, the obvious result of queues and waiting times are automatically created. One of the reasons why the SCP initiative was launched, with a suggestion of using dedicated time slots, was because the x-ray resource is considered a bottleneck activity, which contributes to long waiting times (Socialstyrelsen and SKL, 2014).

At NU-sjukvården’s x-ray division, the planning and forecasting for the overall production is created using a quantitative forecast method, with judgmental correction. However, the forecast process and method for the SCP dedicated time slots is created using only a qualitative method based solely on judgment. Only using a quantitative or a qualitative forecast method may lead to problems, since factors that will affect the outcome of the forecast can be missed. Using only a qualitative forecast method, as for the SCP dedicated time slots, may yield in the forecast being too opportunistic, hence becoming bias (Jonsson and Mattsson, 2009, p.117). However, only using a quantitative method may result in a lack of qualitative factors that will affect the outcome. When creating a forecast it is, in many cases, a good idea to combine quantitative and qualitative data to make the forecast as accurate as possible (Sanders and Ritzman, 2004; Caniato et al., 2011). The combination of these methods are aspects that need to be considered when deciding on how a forecast process should be designed.

The study’s research problem is directed towards developing a forecasting process for patients in need of SCP dedicated time slots at NU-sjukvården’s x-ray division. By understanding factors affecting the demand, there is an opportunity to include qualitative factors in the process, and to determine what quantitative data to collect for certain contexts to make the forecast and decision of dedicated time slots reliable. The forecasting process can assist with more structured decision-making arguments on patient volumes for the amount of dedicated time slots that each SCP cancer diagnosis requires of the x-ray division. As the forecasting process will be more comprehensive, compared to present methods used at NU-sjukvården, it will also support the overall aim of the SCP initiative, as the process of deciding the number of dedicated time slots will be suggested to become more standardized.

Due to the arguments presented above, the purpose of this study is to develop a forecasting process for the amount of patients in need of an SCP dedicated time slot at NU-sjukvården's x-ray division.

1.3 Scope and limitations

The study will be limited to case studies of the four initial cancer diagnoses connected the x-ray division at NU-sjukvården. NU-sjukvården is consisting of two hospitals; Uddevalla Hospital and Norra Älvsborg's Hospital (NÄL). This means that NU-sjukvården has one x-ray division but at two locations. The planning of the x-ray division is done together since these hospitals are seen as one from a planning perspective. The study is conducted both with RCC Väst (facilitator of the SCP initiative in the region of Västra Götaland) and NU-sjukvården. This study is conducted primarily with the objective of developing a forecasting process that can act as more structured decision-making arguments for the amount patients in need of an SCP dedicated time slot at NU-sjukvården's x-ray division, for the four initial cancer diagnoses (Urinary tract and bladder cancer, Prostate cancer, Esophagus and stomach cancer, and Head and Neck cancer) involved in the SCP initiative.

Other challenges, such as understaffing, capacity, etc. will not be included in this study and is thereby not more than occasionally mentioned as factors that affect the situation. Since the majority of the cancer diagnosis involved in the SCP initiative use CT and MRI examinations, the study will be limited to these two types of x-ray processes. As mentioned previously, the four first SCP initiative diagnoses were launched in September 2015 and these diagnoses' "SCP historical data" is only approximately one year old. This, in itself, is not sufficient enough to draw conclusions from, but the data will be validated together with historical data from other data sources, such as The National Board of Health and Welfare's database and the Cancer Register. This will make the data analysis trustworthy and reliable. The reason for only including the first four cancer diagnosis is because they have characteristics that differ slightly depending on the cancer diagnosis, and as a result, they can serve as good examples of how the qualitative and quantitative parts of the forecasting process may differ depending on the context.

1.4 Outline

The outline of this study is built on several chapters that will cover the topic in different ways. First a frame of reference chapter is introduced to review existing literature of the studied topic. This section is important because it is essential to understand the current state of the research and to present optional views to related problems. The next chapter is the methodology chapter, which introduces how the study has been designed and was conducted, and why this design was appropriate to use. It introduces the various ways of data collection and research used in the study. The method chapter is followed by the empirical findings, which present the data collected at NU-sjukvården for this study. From the previous chapters, an analysis regarding the current research and the empirical findings is conducted. The analysis is made from a theoretical and practical way to form a path towards the results, which will be found in the following chapter. From introducing the results a more general approach to the studied topic will be presented in the discussion chapter. The next chapter presents the conclusions made from this study. From the conclusions, some applicable recommendations are presented to NU-sjukvården. A section of references used together with relevant appendices finalize the outline and form the last chapter of the study.

2. Frame of reference

This chapter will introduce important theoretical topics from previous studies connected to this study's problem analysis and purpose.

2.1 Definition of a forecasting process

Depending on an individual's perception, the word "process" can be perceived in different ways. Therefore it is in this study important to have a definition of it. According to Berman (2014) a process always has a customer and is a set of activities that transform inputs into outputs. The process is done to get from the present situation to a future point where an organization wants to be.

Input, in relation to the process, is something that is possessed or can be found in order to start the first activity of the process (Berman, 2014). Armstrong et al. (1987) state that factors to consider for a forecast can for instance be what data that is relevant and available, which is related to what Berman (2014) call input. Connecting this to the SCP initiative and a process of forecasting the amount of patients in need of SCP dedicated time slots, input can, for example, be the Cancer Register data that provides information about the volumes of patients that have been diagnosed with cancer each year. Input can also be the qualitative factors that the cancer process owners at hospitals contribute with in order to make the forecasted patient volumes more reliable.

Output, is according to Berman (2014) the deliverables that the customer can use so that the next activity can be performed. Relating the output to this study, and the intended forecasting process, it means that the activities performed in the forecasting process should create an output that contains a way to forecast the volumes of SCP cancer patients in need of dedicated time slots at NU-sjukvården's x-ray division.

Berman (2014) also mention the word procedure, which is defined as a way of performing a process or activity. The procedure outlines who should perform the activity and in what order it should be performed. This is related to the article written by Armstrong et al. (1987). The authors stated that a forecasting decision-making should consider who will prepare the forecast, and how much time and resources will the task require. A procedure refers to a standardized and documented way of ordering activities, while a process refer to the activities in a procedure. Making a forecasting process for the amount of patients in need of SCP dedicated time slots at NU-sjukvården's x-ray division will have to contain both the terms process and procedure as all activities of forecasting need to contain standardized information on what the inputs are, who does what, in what order and what the output to the customer should be.

Armstrong et al. (1987) also mentioned that a forecast should consider what the forecast is needed for, what planning horizon that is suitable, how often it should be revised, who should use it, when it is needed and what uncertainty measures that are needed. Sanders and Reid (2011, p.266-267) stated that a forecasting process is consisting of five steps. The first step is to decide the objective of the forecast, namely what to forecast. The second step is to analyze and evaluate the choosen/available data. This step is very important since it reflects the validity and availability of the data, which will have a great impact on the model that is being chosen for the forecast. The third step is to decide the model to used, based on the two above-mentioned steps. Once the data is in place and the model chosen, the forecast is produced, which is step number four. The last step is to monitor the forecast by monitoring the forecast error (Sanders and Reid, 2011, p. 266-267).

2.2 Forecasting factors are contextual

Cote and Tucker (2001) state that demand forecasting is important in order for an organization to make decisions for the future. The goal of a forecast is to reduce the uncertainty level for decision-making in the future (Purwanto et al., 2011). In order for a company to achieve advantages from forecasts, it is important that they understand the forecast process itself and factors that are used as an input to actually create the forecast (Daim and Hernandez, 2008). Chambers et al. (1971) argues that successful forecasts start by a collaboration between the forecaster and the manager. Together they answer the questions such as “what is the purpose of the forecast, what factors affect the forecast, and how good past data can estimate the future? (Chambers et al., 1971). To decide an amount of SCP dedicated time slots at an x-ray division it is important to understand what the volumes of SCP cancer patients will be and thereby understand what the SCP initiative will demand from the x-ray division.

There are numerous factors affecting the accuracy of a forecast, some which are easier to identify, and some which are more difficult to identify and handle. Therefore, forecasters have to be aware that the forecast will contain certain degrees of error, and the ambition should be to minimize this error, hence making the forecast more accurate. There are many reasons a forecast may deviate from the actual demand. For instance, an inaccurate forecast may be due to inaccurate data, poor data quality, insufficient forecasting methods (Jonsson and Mattsson, 2009, p.104), or because the data is aggregated on an insufficient level (Plantin and Johansson, 2013).

“A forecast is almost always incorrect” (Jonsson and Mattsson, 2009, p.104). These words are quite common within the world of logistics since a forecast is merely an assessment of future demand and can be fairly difficult to calculate and estimate. There are several forecasting methods available today, and they are either categorized as qualitative or quantitative. For a quantitative forecast, the data is based on historical demand as a starting point, while a qualitative forecast is based on judgment and estimations. In most situations, a combination of the two methods is being used, which is although not the case when it comes to the amount of patients in need of SCP dedicated time slots at NU-sjukvården. In the sections below, the two different types of forecasting methods will be described in detail.

2.3 Qualitative forecasts

The qualitative methods are based on individuals’ experience, hence are judgmental. Croxton et al. (2002) states that people working with the products or services that are being forecasted need to be involved to provide more realistic input since they are the ones with knowledge from the field. Qualitative forecasts do not consider data, such as statistics of historical data, to the same extent as the quantitative methods. Qualitative forecasts are useful when the number to be forecasted is comparatively small, the forecast horizon is long and when it is more difficult to use data (Croxton et al., 2002).

Two commonly used qualitative forecasts used are the Delphi method and the Nominal group process. The Delphi method combines experts’ opinions regarding a certain objective individually. The opinions are gathered, compiled and sent back to the experts again. The experts then have the opportunity to change their opinion based on the compiled information from others. The idea is that the experts should arrive at a common forecast after a couple of rounds. Suitable prerequistes for the Delphi method is a small amount of available data, the validity of the data is quite low, and when there are a numer of factors and variables affecting the objective of the forecast (Levary and Dongchui, 1995). The Nominal group process (GNP) is similar to the Delphi method where a group of experts express their opinion regarding a certain objective. However, what differs between this method and the Delphi method is that the opinions are discussed together. The idea of the GNP is the same as the Delphi method, namely consensus. In the GNP method, a leader is chosen to coordinate the discussion. With the GNP there is a risk that the group leader may affect the opinions of the other members. The prerequisites for the GNP method are the same as the Delphi method (Levary and Dongchui, 1995).

The qualitative factors that affect forecasts are a lot more difficult to detect, and depend on the forecast's context and surrounding environment. On a general basis, there are some qualitative factors that may influence the outcome of a forecast. Some of these factors are (Pierskalla and Brailer, 1994; Grossman, 1972):

- Socio-economical factors, such as income
- Payment factors, such as insurance or governmental aid
- Availability of services
- Demographical characteristics in the surrounding areas

For instance, from a study conducted on the U.S population correlations between income and cancer rates were shown. The study displayed that Lung cancer and Cervical cancer was more common for families with lower income (Clegg et al., 2009). Monitoring these factors, and including them in the forecast, is important for the healthcare industry since these factors can provide better healthcare service in terms of preventive medical care (Soyiri and Reidpath, 2013).

Other qualitative factors that are connected to the healthcare industry may be new technology, and new regulations (Daim and Hernandez, 2008). What was rather surprising from a study conducted by Mentzer and Cox (1984) was the more advanced and sophisticated quantitative forecasting models had no effect on the forecast accuracy. This shows that the accuracy is more affected by the environment, hence contextual factors, rather than the model itself (Daim and Hernandez, 2008).

2.4 Quantitative forecasts

Quantitative forecasts are to a large extent only based on numbers and calculations, for example on time series. Time series is defined as "chronological ordered data that may contain one or more components of demand" (Jacobs er al., 2011, p.60). The components of demand may be trend, seasonality, random, etc. This section will cover the following quantitative forecasts; moving average and exponential smoothing with or without trend and seasonality (Jonsson and Mattsson, 2009, p.118), and regression analysis. Jacobs et al. (2011, p.67) call these methods simple short-term forecasting approaches since they are included in many commercial software programs and can be performed at a low cost with little management involved. There are of course a lot of sophisticated forecasting methods, but comparative studies have shown that simple forecasting methods, such as moving average and exponential smoothing, works very well, sometimes even better than sophisticated models, especially for short-term and detailed forecasts (Jacobs et al., 2011, p.67). A commonly used forecasting method is the Percentage adjustment, where the assumption is that the following period's demand will be equal to the previous demand's (usually 12 months) increase or decrease. This method is simple to use but needs to be carefully dealth with since it may lead to inaccurate results since it ignores both seasonality and consideres a limited amount of historical data (Cote and Tucker, 2001). Quantitative forecasts are in many cases used for products with low demand variation (Croxton et al., 2002).

<u>Moving average</u>: This is the simplest form of a time series quantitative forecast method. It is based on the assumption that the following periods' demand will be equal to the historical periods' demand. It is simple to perform but there is a risk of it being too sensitive to random variation that exists within the data. Benefits of using the moving average approach is that it is simple to understand, and when a forecast is needed, the moving average will always include the most recent data, making the forecasting reliant upon updated data (Jacobs et al., 2011, p. 68-69). The number of periods included in the moving average formula is decided based on contextual factors (Jonsson and Mattsson, 2009, p.118-119), but the smaller the number of periods to include in the forecast is, the more reliant the forecast becomes upon only recent data, which may make it inaccurate.

<u>Regression analysis</u>: Regression analysis is a common alternative when forecasting for the future. The regression analysis is based on investigating the relationship between a dependent and one or more independent variables (Cote and Tucker, 2001). Briefly explained, the dependent variable is the object that is being forecasted, and the independent variable(s) are the factors that are affecting the objective. Regression analysis is suitable to use when availability of data is moderate to large and the validity of the data is medium to high (Levary and Dongchui, 1995).

<u>Exponential smoothing:</u> This approach is based on values being given weights, indicated by the letter alpha (α), which is a number between $>0\leq\alpha\leq1$. The exponential smoothing can use a high or a low α to put more or less emphasis on more recent data. If a large α is chosen then it will put more emphasis on more recent data and will respond better to systematic changes in demand, but it will be more sensitive to random variation. A smaller α will provide the opposite results (Jonsson and Mattsson, 2009, p.120). The number of periods to include in the formula is correlating to the α that is being chosen. For instance, a small α provides a larger number of periods to include in the forecasting horizon, and a large α provides the opposite. This means that when α is large, the number of periods to include in the forecast is small, and when α is small, a larger number of periods will be included in the forecast (Jonsson and Mattsson, 2009, p.120). The exponential smoothing approach is suitable when the availability of data is moderate and the validity of the data is medium (Levary and Dongchui, 1995).

<u>Holt-Winter's approach to exponential smoothing:</u> As mentioned above, exponential smoothing is when the values are being given weights to emphasize on either historical data or more recent data. The Holt-Winter approach is a type of exponential smoothing forecasting approach and is the one that NU-sjukvården is using in their planning tool Prosit. Since this study is based on case studies of NU-sjukvården, a short description of

the approach will be presented below. For more information about Prosit and the Holt-Winter approach at NU-sjukvården, see section 4.4.2.

Many organizations use the Holt-Winter approach since it takes both trends and seasonality into consideration when the forecast is being produced. This means that the method can quickly respond to changes on the market or changes that occur due to seasonality. According to Goodwin (2010) the method is a popular choice because it is easy to understand and use, requires little data storage and can be easily automated. When producing a forecast using the Holt-Winter approach, three components have to be estimated in order to perform the calculations. These three components are as follows:

- Level: The current underlying level of demand after the data has been deseasonalized and the random noise has been eliminated
- Trend: The current trend in demand
- Seasonality: The seasonal index for the month that is being forecasted

Besides the level, trend and seasonality the Holt-Winter approach contains a smoothing constant ranging between 0 and 1. Similar to the original exponential smoothing, a larger value on the smoothing constant means that more emphasize is given to more recent data, and a smaller value would result in the opposite (Goodwin, 2010). Using a quantitative forecasting approach such as the Holt-Winter, at NU-sjukvården's x-ray division is suitable since the overall demand for the x-ray division is affected by very small demand variation. It has been mentioned that quantitative methods were suitable when the demand contained little variation, hence the argument.

2.5 Quantitative forecasting considering trends and seasonality

When the data collected includes a systematic change that cannot be negligible, it is called a trend. If it reoccurs with certain time intervals it is most likely that the demand is affected by seasonality. The health care industry is affected by seasonality with for example reduced number of hospital visits during summer vacation and by this a forecasting method that takes trend and seasonality into account is necessary. Forecasting considering trends and seasonality can be done by using the moving average approach as well as the exponential smoothing approach (Jonsson and Mattsson, 2009, p.122-123).

The moving average including trend is one of the simplest models to use when calculating a trend. The trend is calculated by taking the difference, an average, between two following demand values. The benefit of this model is that it is simple to perform, however, it may be too sensitive to random variation and detecting a trend when the data is just affected by random variation (Jonsson and Mattsson, 2009, p.124). Trends can also be calculated using the exponential smoothing approach. By using this approach, the risk of the data being influenced by random variation is mitigated. The downside is, however, that the calculations are far more complicated to perform (Jonsson and Mattsson, 2009, p.124).

Regarding seasonality, these forecasts need to include a seasonal index that is calculated by taking the actual demand for a certain period and dividing it with the average demand for all periods during the year. Once the seasonal index is calculated the forecast per month is adjusted accordingly (Jonsson and Mattsson, 2009, p.125-127). To get an accurate forecast for seasonality it is preferred to calculate seasonal indexes for several years. However, there is a possibility to only use data based on a one-year collection and calculate a seasonal index. If this is done, there is a possibility of forecast being inaccurate, or it may become too sensitive to random variation (Jonsson and Mattsson, 2009, p.125-126).

As seen from the discussion above, the data that may be needed to include in a forecast comes from a wide variety of sources. Quantitative data that may be used to predict future demand, depending on the situation, can be (Fildes et al., 2006):

- Time series data, such as past sales on product type, individual product, geographical area, country, etc.
- Customer activity information, such as promotions, etc.
- Previous forecasts
- External forecasts made from other departments
- Additional factors that may affect the forecast, such as the weather forecasts, for instance

2.6 Combination of qualitative and quantitative forecasts

As mentioned above, many organizations use a combination of qualitative and quantitative methods when forecasting. Sanders and Ritzman (2004) stated that a study showed that a combination of qualitative and quantitative forecasts yield a reduction of forecast errors. A reason for this is because they use different sources of information as input, which makes them ideal to combine. According to Morgan (1998) there is a general idea that combining qualitative and quantitative methods is the most suitable way since combining methods means that a study, for instance, would include strengths from both methods. However, this is not always the case due to the difficulties in combining the different methods. In the article written by Morgan (1998) it is stated that the reasons why combining qualitative and quantitative methods exist is due to technical issues of actually combining the different sources of data, and due to conflicts in how knowledge is generated. The latter statement means that different people make different assumptions; hence the information and data provided by them are conflicting at times (Morgan, 1998).

In the article written by Sanders and Ritzman (2004) four methods of how qualitative and quantitative factors could be combined is presented. The methods are briefly presented below:

1. Method 1 - Judgmental adjustment of quantitative forecasts: This is a quite common method used in the industry. The main reason for adjusting the forecast with judgmental input was because the forecast should be influenced by the latest knowledge of the environment or product, or to include past experience that could not be captured by numbers (Sanders and Ritzman, 2004). Also, adding qualitative information to quantitatively produced forecast can make the forecast easier to understand since statistical findings may at times be difficult to understand without any information about the environment (Kelle, 2006). Conclusions from this practice are that judgmental adjustment of quantitative forecasts should only be done when certain contextual information about the

situation is available. The reason for this is because adding judgment to quantitative data may result in the forecast becoming too bias due to opportunistic behavior from the people who are involved in creating the forecasts (Sanders and Ritzman, 2004).

2. Method 2 - Quantitative correction of judgmental forecasts: This methods means that the forecast is at first based only on judgment and then corrected using quantitative numbers. Using this method has been shown as contributing to a less bias forecast. A risk that may emerge when using this method is when contextual factors, such as environmental changes, change rapidly. If these factors are not considered by the forecaster, the forecast will become inaccurate. This method is preferred when there is little historical data to access (Sanders and Ritzman, 2004).

3. Method 3 - Combining judgmental with statistical forecasts: This method combines two separately created forecasts using a mathematical model. They can be combined using either simple approaches, or more advanced, depending on what objective the forecast is suppose to fulfill. This method has been shown to reduce the forecast error quite substantially. Studies have shown that it is very effective in combining series with different levels of forecast difficulties and seasonality (Sander and Ritzman, 2004).

4. Method 4 - Judgment as input to model building: The last method uses judgment as an input when selecting parameters and variables to include in the forecast, and deciding the model structure, hence before the forecast is actually created (Sanders and Ritzman, 2004; Kelle, 2006). A benefit with using judgment as input is that it can help identify statistical associations captured by quantitative data (Kelle, 2006). This method is considered as the most effective method since this models can include qualitative factors that could affect the outcome of the forecast, that could not be captured using only statistics, before the forecast is created (Sanders and Ritzman, 2004).

Many companies want the ability to change their forecast due to market dynamics, economical factors and other contextual factors. Combining qualitative and quantitative forecast methods can help companies change their forecast according to the above-mentioned factors since the forecast becomes more flexible (Caniato et al., 2011). There is although not a universal solution on what method to use and when. Morgan (1998) states that the ideal way of combining qualitative and quantitative data depends on the subject being studied, and the purpose of it. As mentioned above, Method 1 is more suitable when certain contextual information exists, and by using this method non-numerical information will be taken into account. However, there is a great risk of the forecast becoming bias. If looking at using Method 4 instead, this method has been proven to be highly effective, however it requires that the forecaster have a lot of quantitative and technical experience (Sanders and Ritzman, 2004). The study conducted by Sanders and Ritzman (2004) and Morgan (1998) showed that depending on the objective of the forecast and the contextual factors, different combinations are more suitable than others. Combining quantitative and qualitative forecasts were also a result in the study based on four cases within the Swedish healthcare, written by Plantin and Johansson (2013). Their study showed that using simple quantitative forecasting methods may predict the future in a satisfactory way, but there is a need to include qualitative factors to dected rapid changes that may occur.

2.7 Aggregation and forecasting

The decision-making process, for instance production planning or budgeting, determines the level of aggregation for the forecast (Zotteri et al., 2005). Considering one commonly used planning framework called Manufacturing Resource Planning (MRP II), different levels of aggregation will be used depending on what item and what time horizon the forecasting shall support (Jonsson and Mattsson, 2009, p.33 and 37; Jacobs et al, 2011, p.55). Quite common in industries today is the usage of rolling forecasts with the same time horizon all the time. Using rolling forecasts means that the forecast is always reliant upon the latest information and can quickly respond to changes in the demand, or changes that affect the market. By frequently updating the forecast, waiting times and inventory can be minimized (Huang et al., 2010). As stated above by Jonsson and Mattsson (2009, p.37) and Jacobs et al. (2011, p.55), the length of the forecast horizon depends on what purpose the forecast is supposed to support. If the rolling forecast horizon is four weeks, it means that the forecast will generate information about week 1 and renew the forecast for the following four weeks. Once week 1 has passed, the forecast will provide information for week 2 and renew the forecast for the following four weeks, and so on (Huang et al., 2010).

The MRP II is divided into four levels; Sales and Operation Planning (S&OP), Master Production Scheduling (MPS), Order Planning, and Shop-floor level (Jonsson and Mattsson, 2009, p.38). The S&OP is the most aggregated level of planning and is supporting a long-term planning perspective, usually one year or longer. The Master Production Scheduling has a planning horizon of six months to one year, the order planning has a planning horizon of one to six months and the shop-floor level has a planning horizon of one to four weeks (Jonsson and Mattsson, 2009, p. 33; Jacobs et al., 2011, p. 55-56).

The time horizon is correlating with the level of aggregation for the forecast. Briefly explained, the shorter the planning horizon, the more detailed the planning will become, which means that if the planning horizon is one to six months, the level of aggregation for the planning will, in most cases, be done on individual items-level (Jonsson and Mattsson, 2009, p.33; Zotteri et al., 2005). Daim and Hernandez (2008) refer to Mentzer and Cox (1984) stating that the accuracy of a forecast tends to be higher when it is produced for a higher level of the organization, and for a longer time period. At a more aggregated level of planning the forecast can be seen as more flexible because the planning objective is not done on individual items.

Zotteri et al. (2005) states that the level of aggregation for a forecast depends on the demand generation, meaning factors that influence variation within the demand. Seasonality is one factor that results in variation in the demand. Looking at examples from the fashion industry, variation may occur from different fashion seasons, such as winter and summer collections (Zotteri et al., 2005). For a hospital setting, variation such as seasonality may occur due to, for instance, certain weather condition, such as cold weather and slippery roads or different types of vacation periods (Landstinget i Östergötland, 2011).

As one can see, forecasting cannot be done using a “one size fit all”-type of approach. Everything depends on the context, and how the demand is behaving. Zotteri et al. (2005) concludes that in some context, where the information from individual stores are insufficient, making estimations based on these stores will lead to inaccurate forecasts. The authors mention that the more heterogeneous the demand is, the less suitable the aggregated approach, and the less information available, the less suitable the disaggregated approach is (Zotteri et al., 2005).

Jonsson and Mattsson (2009, p.112-114) states that forecasting on product group level may be sufficient enough where the planning horizon is fairly long-term, hence S&OP, while there may be a need to forecast on individual products for the operative level, such as the daily operations. If turning to the MRP II-model (see Figure 2) (Jonsson and Mattsson, 2009, p.179) it is clear that a forecast is used as an input on all levels of planning. What differs from each level is the level of detail and the planning horizon.

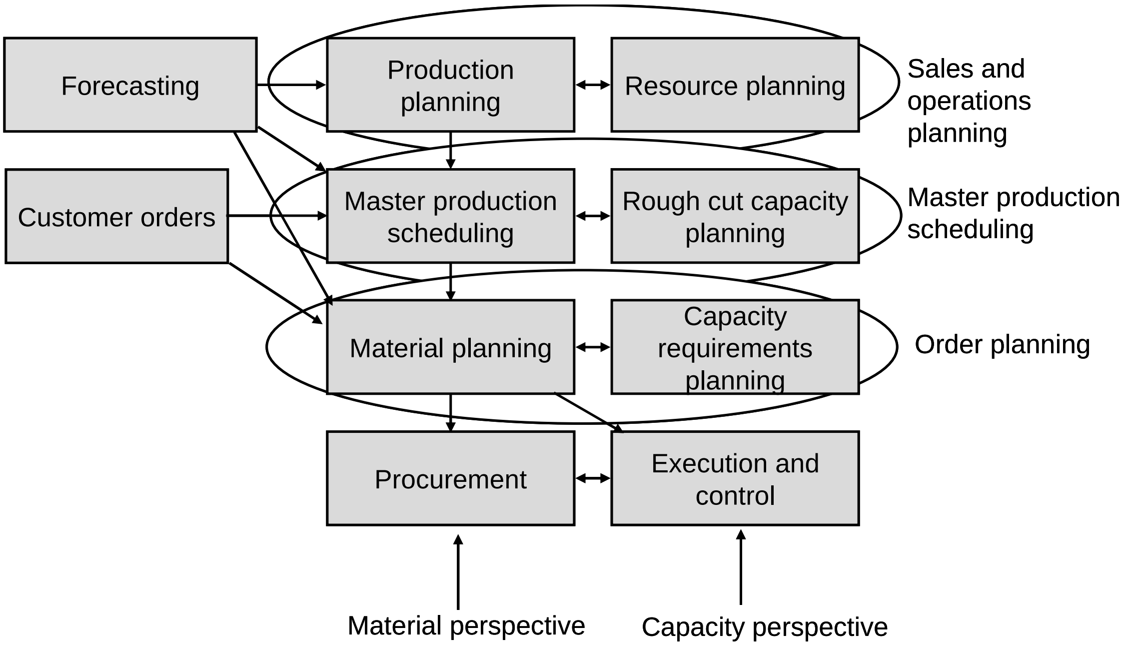

Figure 2 – MRP II model

From the information provided in the sections above, forecasts are used as an input for all levels of planning, but the level of aggregation of the forecast may differ (Jonsson and Mattsson, 2009, p.112; 179). The further up in the planning (such as S&OP) the less detailed the forecast has to be. For the S&OP, and sometimes for the MPS-level, it may be sufficient enough to forecast on product group-level. The level of aggregation depends on contextual factors, and what the forecast is supposed to support (Zotteri et al., 2005).

2.8 Forecast monitoring

An important criterion for the forecast is that it is built upon honesty, hence realistic goals (Jacobs et al., 2011, p. 72). For this purpose it is good to validate and monitor the forecast by calculating the forecast error. By checking the forecast error, one can see if the forecast lies within a reasonable error range that is decided based on contextual factors. By monitoring the forecast, one can see if there are random errors occurring, or if the forecast is too high or too low. Forecast errors are measured over decided periods of time and are calculated by comparing the estimated forecast with the actual demand for the decided time period (Jonsson and Mattsson, 2009, p. 127). By checking the forecast error, companies can avoid unexpected surprises, and lost sales or increased costs, depending on what is being forecasted.

There are different ways of calculating the forecast error. A commonly used formula is to calculate the mean error (ME), which is done by summing the forecasted demand and subtracting the actual demand, and dividing this by the number of periods that are included in the time period, hence the number *n* (Jacobs et al, 2011, p. 72). Other forecast error method used are the mean square error (MSE), the mean absolute deviation (MAD) and the mean absolute percentage error (MAPE), which all express the same results, namely how inaccurate the forecast is, but they are all calculated differently (Jonsson and Mattson, 2009, p. 127-128). The forecast error can be monitored by the use of control charts, where the forecast error is plotted against an upper and lower control limit. As long as the value falls in-between the upper and lower control limit, the forecast is under control and therefore reasonable (Jonsson and Mattsson, 2009, p. 130).

2.9 Theoretical summary

Figure 3 below describes what questions and factors that needs to be considered when a forecasting process is designed. Figure 3 is connected to Figure 4, which explains the forecasting process more detailed. These two together represents the forecasting process. A reoccurring statement presented by the different authors was that it is important to decide the forecast objective, meaning what should be forecasted and who should use it. Once the objective is decided, the level of aggregation and what data to include should support the forecast's objective. The figures below show that both qualitative and quantitative data should be included in a forecast. This is, as mentioned by Sanders and Ritzman (2004), to make the forecast as accurate as possible and to include the strengths of both methods. The model describes different way how the data could be collected, and these are just a few ways of collecting data. When the data is collected, a suitable model needs to be decided. In section 2.3 and 2.4 different forecasting models were presented. Depending on how much data that is available, and how valid/reliable the data is, different models were more suitable than others. Again, these are only a few of the forecasting models available on the market. These models are, however, said to be commonly used on the market (Levary and Dongchui, 1995). When the model is decided, the forecast is to be produced.

Figure 4 displays the detailed forecasting process when the forecast is to be produced. Since the objective of the forecast, the level of aggregation, and a suitable model already is decided, the detailed forecasting process starts with what Sanders and Reid (2011, p.266-267) labeled as step two, namely to analyze the data. When the data has been analyzed and validated, the forecast is produced. The forecasting process ends by monitoring the forecast and updating it, based on the forecast horizon that was chosen. See Figure 3 and 4 below.

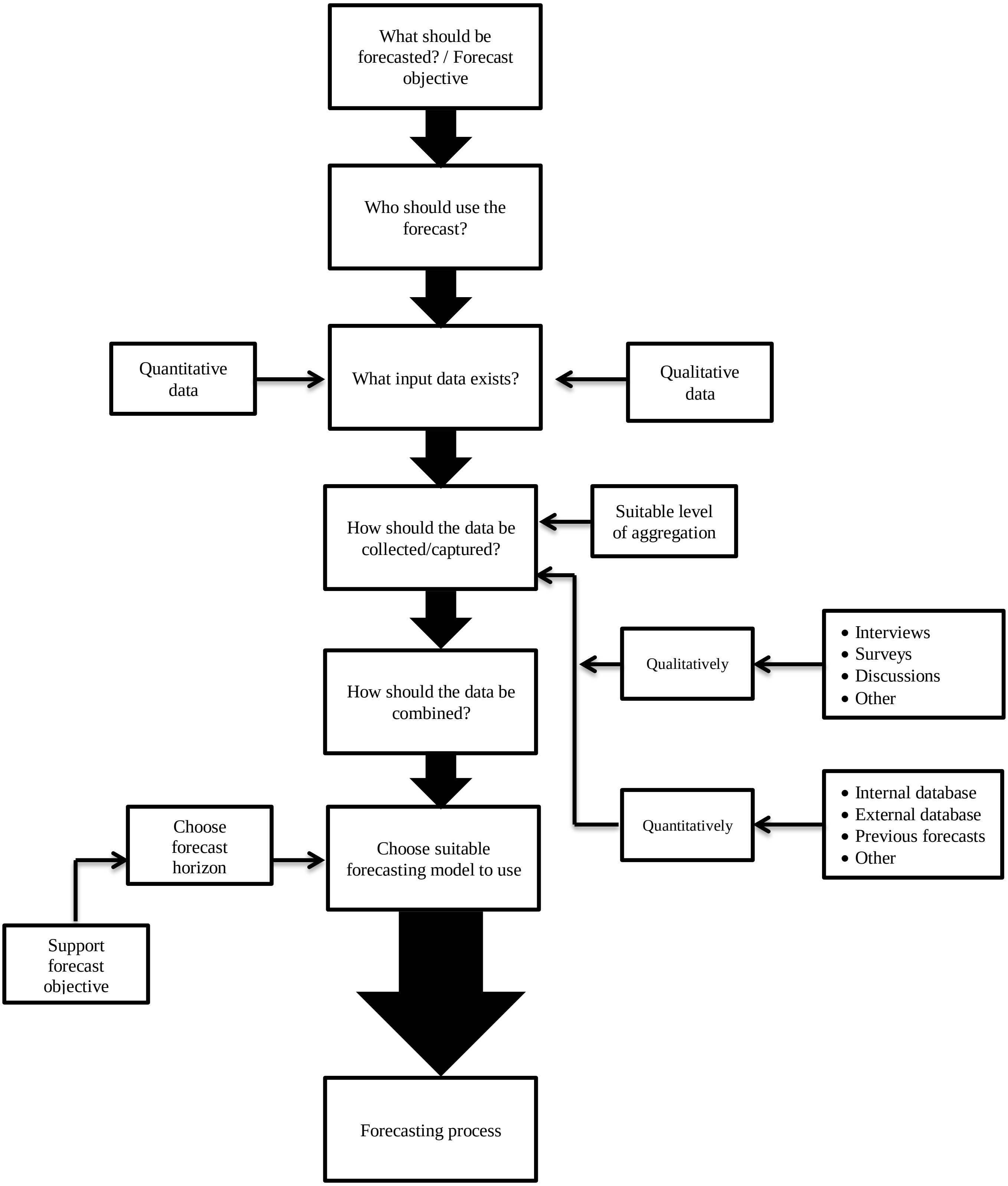

Figure 3 – Input to include in the design of a general forecasting process

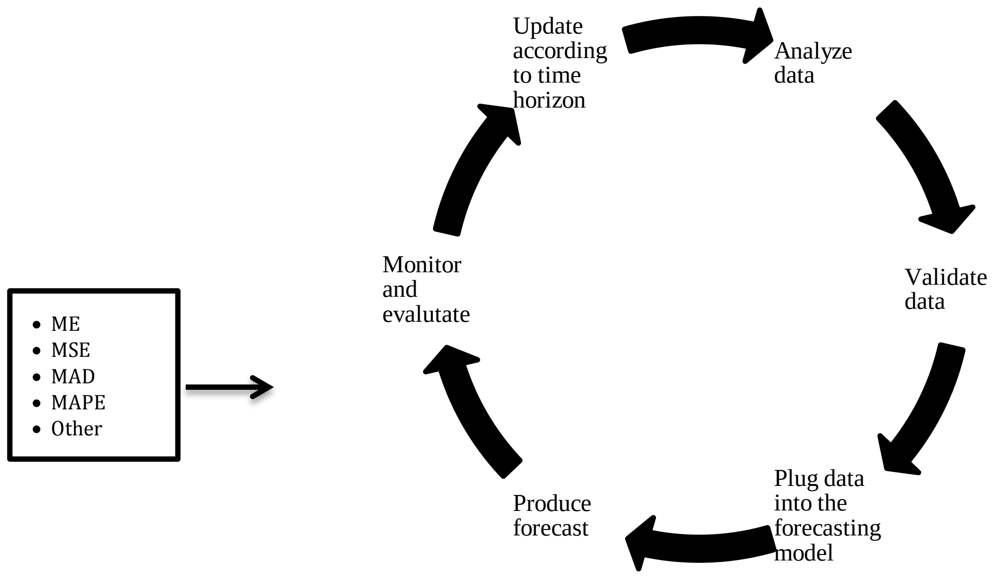

Figure 4 – Forecasting process based on Sanders and Reid (2011)

3. Methodology

This chapter presents the method used to conduct this study in order to reach the goal of developing a forecasting process. The first section, 3.1, contains a structure description to introduce the approach on how this report was conducted and what is important to include in this study. Section, 3.2, describes how the data-collection was made and what was included. The third section, 3.3, contains an analysis of the method and why the selected cases were appropriate to use in this study. This chapter ends with two sections, 3.4 and 3.5, which handle the importance of source validity and ethical issues needed when conducting a study in this context.

3.1 Structure and approach of the study

The research structure should present and describe the overall picture of how this research has been performed. According to Bryman and Bell (2015) research structure is a general orientation of how to conduct the research. In order to understand how a forecasting process is built up, the first action was to study relevant theory within the area. The theory that was found most useful to understand a forecasting process, and the different parts that forms it, was presented in chapter 2.

The theoretical knowledge gained from the theory could then be used as a basis for how to proceed with the data collection connected to NU-sjukvården. Quantitative and qualitative data collections were made in accordance with what theory suggested to include in a forecasting process. This data was presented, for the context of this study, in chapter 4.

Quantitative methods handle data that can be observed and written down using numbers. The method is narrow-focused and has a limited relationship with the participants (Malagon-Maldonado, 2014). The quantitative data is either considered as primary data, which means that it is based on observations and experiments to collect new data, or it is considered as secondary data that is provided from someone else’s research (Bowling and Ebrahim, 2007). Qualitative data is on the other hand information that cannot be measured using numbers, and is more suitable when the researcher wants to explore and understand the participants feeling towards the studied situation. This method is based on words rather than data and is dependent upon the context of the study. This method initially has a broad focus so that a wide range of information can be captured, and a direct relationship with the participants can be obtained (Malagon-Maldonado, 2014).

Bowling and Ebrahim (2007) states that quantitative methods are no longer sufficient enough due to great complexity within the health care industry with large variation between individual’s behavior and outcomes. Instead a combination of both quantitative and qualitative research is needed in the healthcare industry. In this study, as suggested by Bowling and Ebrahim (2007) a combination of qualitative and quantitative methods were used in terms of existing relevant theory, interviews, and secondary sources of information for the data collection.

Having the theoretical foundation set and data collected accordingly, a combination of the two formed a way to understand how a forecasting process at NU-sjukvården should look like. The combination of theory and empirical findings was done in the analysis chapter (chapter 5). From the analysis chapter a result could be presented to answer the purpose of the study. This result was decided to be presented on its own in chapter 6 to emphasize the findings from the entire study.

From presenting a result connected to NU-sjukvården the following chapter 7, which is the discussion, covers overall connections to the studied topic where the developed forecasting process could be discussed from different perspectives. Following chapter 7, was a conclusion in chapter 8, and some recommendations to NU-sjukvården in chapter 9. These two contributed with conclusions drawn from the purpose of developing a forecasting process for NU-sjukvården's context. Figure 5 below summarizes the structure and approach used throughout this study.

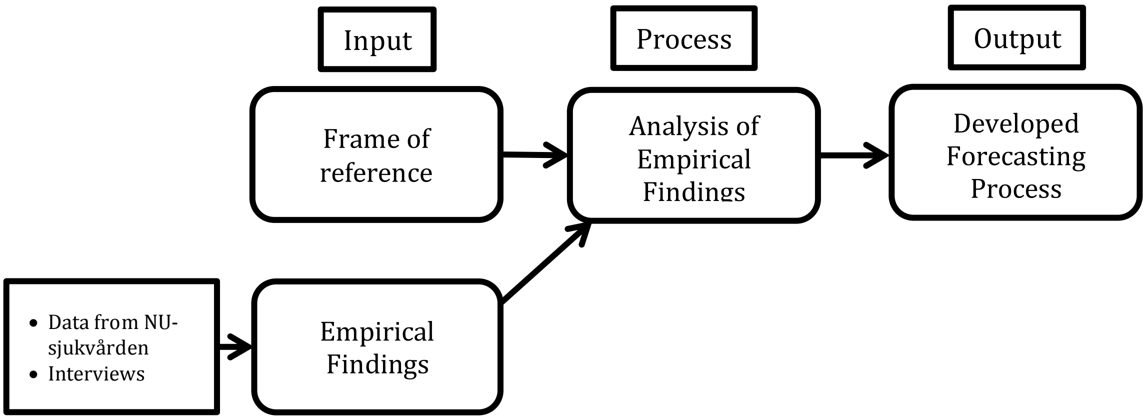

Figure 5 - The study structure of how the study was conducted to fulfill the purpose of this study

3.2 Data Collection

This section presents how different types of quantitative and qualitative data was collected to fit the purpose of this study.

3.2.1 Interviewing

In this study, interviews were used as a qualitative way of collecting data. According to Bryman and Bell (2015) interviewing is most likely the most common method used for qualitative research, and according to Yin (2014) it is the most important source of case study evidence. The qualitative interviewing method puts a lot of emphasis on the interviewees' opinion and their point of view, which results in information rich content (Bryman and Bell, 2015). Since the interviewee push the interview in the direction they like, interviews can be seen as flexible (Yin, 2014).

In this study, interviews played an important role. They were used to gain information about the SCP initiative, and how this initiative has affected, or will affect, and information regarding the current daily operations of the interviewed people. The interviews were also an important source of information to gain knowledge of how different staff involved view their current and future working situation. Since a large part of this study was to look into different qualitative factors that affect a forecast, the interviews assisted to capture these types of factors. The interviews were conducted in a semi-structured way. This allowed the researchers to keep an open mind about the questions being asked in order to get a broad insight to the researched subject (Bryman and Bell, 2015). The questions in the interviews were based on open-end questions, which, according to the same authors as above, is a great way of collecting information when one is exploring new areas, which was the case for the researchers. The interviews were based on a standardized interview template that was modified to fit each individual interview. By doing so, the interviews were better connected to the context. The standardized interview templates can be found in Appendix A-D.

In order for the researchers to get access to qualitative factors affecting a forecast within the healthcare industry, a range of different professions were interviewed. To gain access to the current production situation at the x-ray division at NU-sjukvården, the head of the Radiology department was interviewed. To see how this strategy was conducted at an operational level, the staff handling the booking system for the x-ray division, together with the x-ray coordinator, was interviewed. To get information about the production planning and the tool Prosit, a production planner and the group staff performance control and coordination at the Region of Västra Götaland were interviewed. In order to gain access to qualitative factors affecting the different cancer diagnoses, process owners for each individual cancer diagnosis at NU-sjukvården were interviewed. In order to validate the input from the local process owners, the regional owners, in the region of Västra Götaland, for the same diagnoses were also interviewed. The following diagnoses' local process owners were interviewed: Prostate cancer, Urinary tract and bladder cancer, Head and neck cancer, and Esophagus and stomach cancer. In all of these diagnoses, the process owners are also specialist doctors at NU-sjukvården. All regional process owners for the same diagnoses were interviewed except for the regional process owner for Head and neck cancer. The reason for this is because the researchers could not contact the regional process owner for Head and neck cancer during the time frame of this study.

To get general information about qualitative factors that may affect planning and forecasting within the healthcare industry, an industrial PhD student at Chalmers, who also is the Head of education at Skaraborg's Hospital Group (SKAS) and MD Consultant Vascular Surgeon, was interviewed. He provided the researchers with vital information about how the healthcare industry in Sweden may be affected by qualitative factors on a more general level, which was important input to the study.

To summarize: This study used anonymous interviews to ensure that the study was done in an ethical manner (see section 3.5). The following persons in Table 1 were interviewed in the study:

Table 1 - Persons interviewed including location, date and type used in this study

Table 1 - List of interviewed people			
Interviewee	**Location**	**Date**	**Type**
Standardized Care Process Coordinator at NU-sjukvården	Uddevalla and Trollhättan, Sweden	14 June, 21 June, 20 July, 4 August, 2016	In person
Operative Booking Staff; X-ray division at NU-sjukvården	Uddevalla, Sweden	21 June, 2016	In person
Chief Physician and Head of the Radiology department at NU-sjukvården	Gothenburg/Uddevalla, Sweden	1 July, 2016	Phone
Group staff performance control and coordination in the Region of Västra Götaland	Gothenburg, Sweden	3 October, 2016	E-mail
Production planner at NU-sjukvården	Trollhättan, Sweden	4 August, 2016	In person
Process owner Urinary Tract and Bladder Cancer at NU-sjukvården	Uddevalla, Sweden	31 August, 2016	In person
Process owner Prostate Cancer at NU-sjukvården	Uddevalla, Sweden	31 August, 2016	In person
Process owner Esophagus and Stomach Cancer at NU-sjukvården	Trollhättan, Sweden	31 August, 2016	In person
Process owner Head and Neck Cancer at NU-sjukvården	Trollhättan, Sweden	31 August, 2016	In person
Industrial PhD student at Chalmers University of Technology/ Head of education at Skaraborg's hospital group	Gothenburg, Sweden	2 September, 2016	In person
Quality coordinator; x-ray division at Kungälv's Hospital	Kungälv, Sweden	17 June, 2016	In person
Medical manager at the Radiology Department at SÄS	Borås, Sweden	7 June, 2016	In person
Regional process owner Urinary Tract and Bladder Cancer	Gothenburg, Sweden	6 November, 2016	E-mail
Regional process owner Prostate Cancer	Gothenburg, Sweden	10 November, 2016	Phone
Regional process owner Esophagus and Stomach Cancer	Gothenburg, Sweden	4 November, 2016	E-mail

3.2.2 External Hospital Visits

Some comparative interviews with staff at other hospitals outside of NU-sjukvården were conducted to gain more information about the healthcare industry. These interviews were also helpful in order to validate the information to make sure that this study's purpose and scope was relevant. The same approach, as mentioned above, was used for these interviews, meaning that open-end questions were used to support the semi-structured interviewing approach. The hospitals that were visited for interviews were Kungälvs Hospital in Kungälv, and Södra Älvsborgs Hospital in Borås. The goal of these interviews was to see how different hospitals work with their x-ray division and with the SCP initiative. The reason why they were chosen was because they are located within the Region of Västra Götaland and differ in the way they are planning the x-ray division and handling the SCP initiative. They are also different in size, with one hospital being smaller (Kungälv Hospital) and the other being fairly the same size as NU-sjukvården (Södra Älvsborg's Hospital) and being located in the same region means that they have the same regulations to attend to.

During all of the interviews notes were taken, and during some of them, recordings were made to make sure that all possible information was registered and collected. These recordings were made in consent with the people involved in the interviews to ensure awareness.

3.2.3 Observations

According to Bryman and Bell (2015) there are different types of observations; structured observation, participant observation, non-participant observation, unstructured observation, and simple observation. To observe a physical process will contribute with valid information and result in a more accurate picture of the researched subject.

In this thesis the majority of the observations were done in an unstructured manner, which is one of the commonly used methods for data collection within qualitative research. The goal of the unstructured approach was to get as much information as possible on the participants' behaviors (Bryman and Bell, 2015). Since the researchers did not directly collect any numerical data themselves, observation and interviews were suitable for the purpose of this study. What was observed in this study was how the x-ray daily operations were conducted, and how the examination rooms were designed, at Kungälv's Hospital and at Uddevalla Hospital. The observations were done during the summer of 2016 where less daily operations were conducted due to vacations (seasonality). Due to less operations being performed, the researchers had the opportunity to stay in an empty examination room for a longer time and observe how the x-ray rooms looked like and ask questions to involved staff about the specific machines without having to ask a patient for consent. By observing this, the researchers gained knowledge about how a typical examination is performed at NU-sjukvården.

3.2.4 Secondary Quantitative Information

According to Bryman and Bell (2015) secondary information, or secondary data analysis, consists of data that the researchers probably not participated in collecting themselves, as briefly mentioned above. The secondary data is beneficial since it can save time and costs. Also, in many cases, the data provided by secondary sources are of high quality, for instance, if it comes from a well-known database. However, when using secondary information, the data has to be carefully evaluated to make sure that it is reliable, which will be covered in section 3.4. It is quite common that secondary data provided by large databases are sampled on a national level, and sometimes broken down into regional levels.

In this study, data from The National Board of Health and Welfare was used to provide the total amount of cancer diagnoses in the region of Västra Götaland. For this data, all reported cases of cancer, regardless tumor type, for patients between 0-85+ years old, both female and male, in the Region of Västra Götaland, from the year 1970 to 2014 was used. This data was used to see how the overall situation of cancer diagnosis at the Region of Västra Götaland has developed over the years. The data was helpful as it displayed how the cancer situation in the Region Västra Götaland has been like historically, and it also displayed if the data contain systematic changes, such as trends. The data collected from The National Board of Health and Welfare's database can only be broken down to a regional level, i.e. the Region of Västra Götaland. Since this study focused on NU-sjukvården additional data was needed.

In order to access historical cancer data from NU-sjukvården statisticians working with another database called the Cancer Register were contacted. From them data from NU-sjukvården related to the four initial SCP cancer diagnosis was provided. To use this data, some criteria were excluded. For the four initial SCP cancer diagnoses only data from the year 2013 to 2015 was provided. This was decided on a meeting with the statisticians and the researchers since the different cancer diagnoses' data intervals differed. For Head and Neck Cancer, Thyroid Cancer was excluded. For Esophagus and Stomach Cancer, Canceroids were excluded. All data of the cancer diagnoses excluded cancer that was found during an autopsy. By using the collected data, the researchers were able to see how the initial four cancer diagnoses had developed historically, on a monthly basis, from the year 2013 to 2015.

This study also included data in the form of withdrawals from the database ELVIS, which is used in the Swedish healthcare industry. This data provided the researchers with the data related to the SCP initiative from the 1st of September 2015 to the 1st of September 2016. This data was broken down from a national level, down to the individual organization, namely NU-sjukvården. From NU-sjukvården, data related to how many weekly estimated dedicated time slots, per cancer diagnosis, were collected. Lastly, internal data, and data from the tool Prosit used at NU-sjukvården, was used to display the current capacity and demand situation at the x-ray division at NU-sjukvården. This data is used by NU-sjukvården for their forecasting and planning, and has been internally collected by experienced staff. The data was collected from the year 2011 to 2016, but also showed a forecast for how the x-ray production was planned for the year 2017- 2019.

The data from the tool Prosit was collected separately for different x-ray procedures such as CT, MRI, Ultrasound, etc. In this study, only the data collected for the CT and MRI was of interest due to the limitations and the scope of this study. Besides data from Prosit, a document displaying the opening hours for the x-ray labs at NU-sjukvården, for a general year, excluding holidays, education, service and other meetings affecting the production, was provided. This data also provided how many CT and MRI-machines NU-sjukvården has. By knowing the general operating times for each procedure and how many machines NU-sjukvåren has, in relation to how much staff each machine requires, the total available capacity for each type (CT or MRI) was provided. All together, this data provided the researchers with the overall picture of the x-ray division at NU-sjukvården and was used to understand how the SCP data is related to the total capacity and demand situation at NU-sjukvården's x-ray division.

Other types of secondary information that was used in this study were: information about the different types of x-ray procedures and how the machines function, general information about the Swedish healthcare and informative documents provided by the national webpage for the SCP initiative, www.cancercentrum.se, was used to get national information regarding various types of cancer diagnoses. These documents provided information about how each individual cancer process is conducted, general information about the SCP initiative and each individual process lead times. Status reports from SALAR regarding the cancer situation in Sweden, from a more general point of view, was also used to gain more initial knowledge.

3.3 Analysis

This study aimed at developing a forecasting process for the amount of cancer patients in need of an SCP dedicated time slot at NU-sjukvårdens x-ray division. One reason why a patient is being considered as an SCP patient is because a doctor, or specialist, has considered the patient's symptoms to be of relevance to examine further. As mentioned previously, the doctors can get help from national guidelines when determining if the patient should be considered as an SCP patient or not. As the guidelines to detect cancer symptoms are different for each cancer diagnosis involved in the SCP initiative it is important to investigate how this amount of patients should best be forecasted to support the daily operations. To understand how each cancer diagnosis can differ from each other and thereby also understand how the demand for the amount of patients in need of SCP dedicated time slots can differ the first four SCP cancer diagnosis were used as case studies.

The analysis in chapter 5, aimed at identifying how the amount of patients in need of dedicated time slots, which in this context is the demand, should be forecasted at NU-sjukvården. Using historical quantitative data from different sources, in correlation with interviews and qualitative factors, assisted the researchers in finding the appropriate data and factors to include in the forecasting process. The difference between cancer diagnoses resulted in an understanding of how to use qualitative factors together with the quantitative data in the developed forecasting process. This was done in order to fully validate the forecasting process for the studied cases.

To support the operational usage of the developed forecasting process, the methods applied in this study aimed at being as simple and understandable as possible. The result should be easy to implement, and should act as a guide for the respective process owner when they are to forecast the amount of patients in need of SCP dedicated time slots. For this reason, the data collected was displayed and analyzed to show historical variation, trends etc, to illustrate the behavior of the demand for the different cancer diagnosis.

3.4 Source Validity

To evaluate the performed study, concepts such as reliability and validity were used. Reliability represents the level to what extent the study can be repeated or not, and whether or not the measurements are stable or not. Validity concerns the integrity of the conclusions drawn from the study (Bryman and Bell, 2015). Validity is divided into three different aspects; measurement validity, internal validity and ecological validity (Bryman and Bell, 2015).

Measurement validity is related to quantitative studies and basically refers to whether or not the measures are reliable or not, and if they fit the subject being studied. Internal validity covers the issue of if a conclusion is drawn based on two or more variables is accurate or not. To evaluate the reliability of a qualitative study is more difficult to that of a quantitative study. In qualitative studies reliability and validity is divided into both internal and external factors (Bryman and Bell, 2015). External reliability means to what extent the study can be replicated, which is consistent to what was written earlier in this section. Internal reliability means that more than one member of the persons performing the study agree on what is being said and heard. External validity refers to the level of which the findings of a study can be generalized across various social settings (Bryman and Bell, 2015). Internal validity represents if there is a good match between the observations being made and the theoretical ideas that are being formed (Bryman and Bell, 2015).

In this study, to ensure consistency when interviewing involved staff, a standardized interviewing template was used, and as mentioned previously, the template was modified to fit the context of each individual interview to get as much context-based information as possible. The standardized template was used to easily imitate the study if needed. Some of the interviews were recorded so that no information was bypassed. Before each interview, the purpose of the interview and this study was explained by the researchers to make sure that the involved people were aware of what the researchers aimed to do. This consent step was performed to make sure that the participants were aware of this study’s purpose and for them to have the option whether to participate or not, which is consistent with the ethical aspects of Bryman and Bell (2015) presented in 3.5.2.

The data that was used in this study is: data from ELVIS related to the SCP initiative, data from the National Board of Health and Welfare related to the cancer situation in the region of Västra Götaland, and internal data from NU-sjukvården from the planning tool Prosit. As mentioned, data provided from large databases are often considered as high quality data. ELIVS and the National Board of Health and Welfare are both large databases approved by the Swedish government and can therefore be evaluated as being reliable. For the purpose of this study, the data provided by Prosit was relevant since it provided information about the forecasting and planning situation at NU-sjukvården’s x-ray division. The data in Prosit is entered in large excel spreadsheets and processed with the aid of mathematical forecasting models, in this case the Holt-Winter approach. This data has to be approved by the clinic management before it is officially published and used for the x-ray division's future forecasting. The data is constantly monitored and altered to fit the actual demand and the actual situation at NU-sjukvården. What the researcher kept in mind throughout the study was that the data collected and the analysis made aims at solving the problem at NU-sjukvården. By this, results and conclusions may not be applicable as an overall solution for a planning and forecasting problem within other sectors of the healthcare industry. However, for the purpose of understanding the current situation at the x-ray division at NU-sjukvården the data collected was reliable.

The data collected for the SCP initiative was at most one year old, which makes this data fairly unstable. This was considered when analyzing the data. The SCP data comes from a large database, ELVIS, which indicates that it should be reliable. However, since the SCP initiative is still in its startup phase, the data includes variation and human errors since the registration process is not yet fully standardized, which makes the quality of the data less accurate.

Regarding reliability and validity of the SCP data, the researchers used the data as an indicator of how the SCP initiative is viewed. However, no accurate conclusions were drawn from this data as it is not yet stable nor mature enough. As a result, data from the larger databases, such as the data from the Cancer Register and the National Board of Health and Welfare was used to validate the collected SCP data.

3.5 Ethical Issues

As mentioned previously there are some ethical aspects that need to be considered when conducting a study. Due to this, a section covering the ethical issues when conducting a study will be briefly covered.
The ethical issues within business design have been broken down into four different areas that need to be considered when performing a study. The four areas are (Bryman and Bell, 2015):

- Harm to participants
- Lack of informed consent
- Invasion of privacy
- Is deception involved?

3.5.1 Harm to participants

If the research is likely to harm participants it is considered to be unacceptable. However, it is crucial to discuss what harm actually is. Harm can have a variety of aspects. It can be physical or mental harm, stress, harmful to career aspects such as future employment and more. According to the Code of Ethical Conduct it is recommended to discuss issues related to confidentiality with the participants before conducting the study, and if confidentiality and anonymity is agreed upon it has to be honored (Bryman and Bell, 2015).

3.5.2 Lack of informed consent

Informed consent basically means that the participants of a study should be given as much information as possible to make an informed decision whether to participate or not. When conducting a study the participants should be aware of what they can contribute with, why their contribution is important and for what purpose, how the data will be used, and for whom results will be reported. However, it is not always possible for the researcher to get consent because it would be too time consuming to ask everyone involved for consent (Bryman and Bell, 2015).

3.5.3 Invasion of privacy

Even though a study may not be harmful to the participant, the participant may feel like the researcher is intruding on their privacy, and treating them like objects rather than individuals with value. It is recommended that the researcher treat every case with sensitivity and individually since the researcher cannot know what individual participants may consider as invasion of their privacy beforehand (Bryman and Bell, 2015).

3.5.4 Deception

Deception occurs when the researcher present their study as something other than what it is (Bryman and Bell, 2015, p.144). It is common that the researcher limit the participants understanding of what they are studying in order for the participants to answer the questions in a more natural way (Bryman and Bell, 2015).

To ensure ethics in this study, the researchers prepared the involved staff and stakeholders by presenting themselves and explaining the purpose of the study. Before an interview was conducted, the participant always had the option whether or not to participate. When recordings were used, they were used in consensus with everyone involved. When observations were made at the x-ray divisions, the examined person and the involved staff had to approve that the researchers were present. By informing the people involved and making sure that the interviews and observations were made in consensus, the study was conducted in line with the ethical aspects stated above.

4. Empirical findings from NU-sjukvården

This chapter presents background information of the Swedish healthcare system as well as an introduction to NU-sjukvården and the x-ray operations that has been studied. The chapter will also explain the demand and capacity situation that the x-ray division presently has. Both quantitative and qualitative findings from NU-sjukvården, and the four first SCP diagnoses, will be presented. Chapter 4 will then be used as important contribution to this study's purpose and will be further analyzed in chapter 5.

4.1 The Swedish Healthcare structure

The majority of the Swedish healthcare is financed by taxes and governmental support. There are private actors on the market in Sweden as well, and up to 10% of these actors are also financed by taxes and governmental support. The healthcare is based on a decentralized structure where individual regions and municipalities are making their own decisions regarding care processes and priorities (Svensk Försäkrings Rapportserie, 2013). The Swedish regions have a responsibility to offer care to patients within the healthcare guarantee's time frame (Vårdgarantin in Swedish). The health care guarantee consists of guidelines that, for example, assure that patients have the right to get access to the primary care by phone directly, and has the right to a primary care visit within seven days. Special care is treated differently and has a maximum waiting time of 90 days to first visit at a specialist, and another 90 days to treatment after such a decision is taken. Biopsy and x-ray examinations are not affected by the health care guarantee (1177.se, 2015).

The goal of the healthcare industry according to the Swedish Law (1997:142) is that everyone should have the right to equal treatment. The patients with the greatest need for medical treatment should be prioritized. Swedish healthcare should be easy to access, be of high quality, accept that the patient has their own right to decide whether or not to accept treatment, etc. (SFS 2014:822). These laws can be found at Notisum.se (2016).

4.2 NU-sjukvården's organization

NU-sjukvården is an organization consisting of two hospitals; Uddevalla Hospital and Norra Älsvsborg's Hospital (NÄL), and was founded in 1995. Connected to NU-sjukvården is also a psychiatric facility called Brinkåsen. The facilities are located in the region of Västra Götaland, in the western part of Sweden, and provide services to around 270 000 residents in the area. There are approximately 5500 people currently employed at NU-sjukvården. In November 2015 a decision was made that all emergency care was to be performed at NÄL and that Uddevalla Hospital was to be explicitly used for elective and scheduled care. The traveling distance between the two hospitals is 25 kilometers and takes 20 minutes by car. NU-sjukvården's vision is to be an organization that continuously seeks for improvements that support the patient's best interest (Nusjukvården.se, 2016a).

The organization of NU-sjukvården is divided into three areas and each area consists of several medical departments and clinics. All these divisions have managers who report to their respective Area Manager. The three Area Managers report to the Hospital Director whom overlooks the entire organization, meaning both Uddevalla Hospital and NÄL. A management office is in charge of the resources that are shared between the hospitals and this office reports directly to the Hospital Director as well. Below follows an organizational map of NU-sjukvården, which explains the areas and departments (Nusjukvården.se, 2016b):

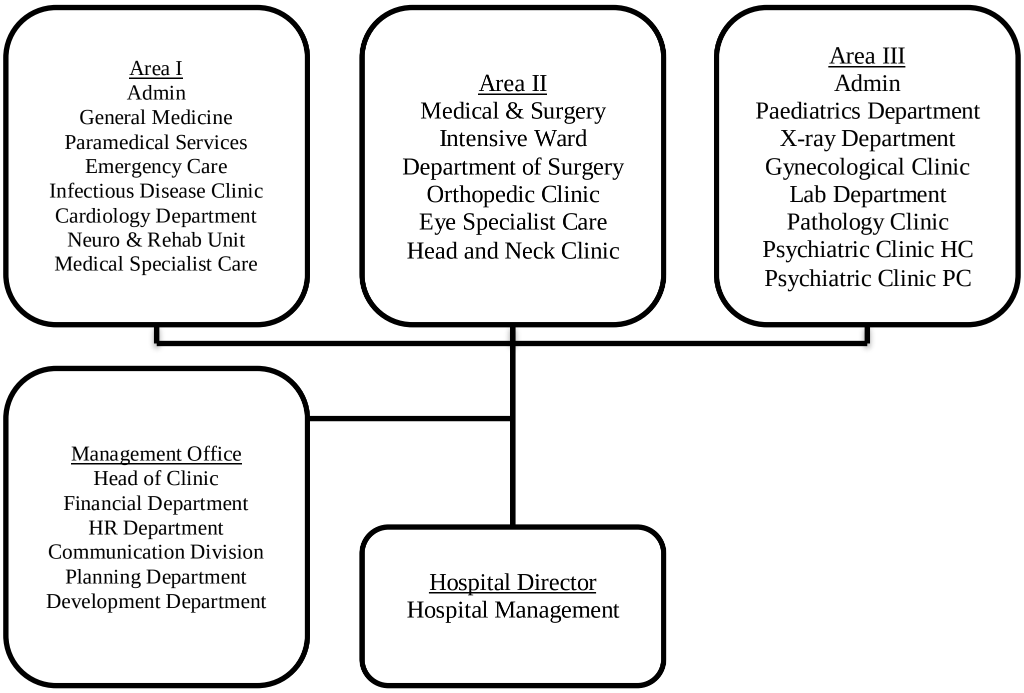

Figure 6 – Organizational map of NU-sjukvården (Adapted and translated from NU-sjukvården's webpage)

4.3 The x-ray processes studied at NU-sjukvården

There are various types of x-ray processes at the x-ray division at NU-sjukvården. To fit the scope of this study, only the Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) processes will be described as these processes are involved in the majority of the SCP cancer diagnoses and the planning of dedicated time slots. These examinations are also both time and cost consuming and to get an understanding of why, descriptions of the two different x-ray examinations are presented below.

4.3.1 Computed Tomography (CT)

Computed tomography (CT) is a special type of x-ray examination that provides detailed images of the examined body part. The procedure is performed by specialized radiology nurses and the images are then sent to a radiologist who examines and evaluates the images (Sahlgrenska.se, 2016). Each image of a CT procedure shows the examined body part as individual "slices" (three-dimensional), which means that each part of the examined body part can be thoroughly examined (National Cancer Institute, 2016a). Compared with regular two-dimensional x-ray examinations, the CT allows the images to display reconstruction of tissues, which results in better pictures.

The examination takes roughly 20 minutes to perform and the patient has to lie still on a platform while the platform is moving slowly through the CT x-ray machine (1177.se, 2016a). In Sweden, the examination is performed by two radiology nurses, sometimes one radiology nurse and one assistant nurse, who make sure that the examination is performed correctly. The nurses make sure that the CT is prepared accordingly, and monitors the examination from a control room. This means that the patient is left alone in the room, but the nurses has the opportunity to communicate with the patient during the examination (SCP Coordinator, 2016). Due to the clear images the CT produces, it is becoming more common, especially for the x-rays performed in cancer care. Compared to the regular two-dimensional x-rays, the CT needs to be operated by two (in the majority of cases) specialized radiology nurses, while the regular x-ray only requires one radiology nurse. The CT takes longer time to prepare and is more expensive than the regular two-dimensional x-ray, which makes the CT x-ray more complex to operate. However, the clear image it produces is very important in the cancer care, since it can detect cancer better (SCP Coordinator, 2016; Chief Physician and Head of the Radiology department, 2016).

Like many other x-ray examinations, the CT scan involves the use of x-rays, hence radiation. The radiation from the CT examination is higher compared to regular two-dimensional x-ray examinations, however, since the examination duration is short, the amount of radiation exposure is still fairly low (National Cancer Institute, 2016a). The amount of radiation is measured in millisieverts and is modified to be as low as possible. During one CT examination in Sweden, the amount of radiation is equal to the amount of radiation a person encounters from natural sources over one year (1177.se, 2016a).

As mentioned above, the CT examination takes roughly 20 minutes. It is not the actual imaging that takes time, these are normally done during an interval of 15-20 seconds, sometimes, using the latest technique, even less than one second. It is the preparation that takes time altering between 5-20 minutes depending on which body part is being examined and which state the patient is in (1177.se, 2016a). For this reason, NU-sjukvården has scheduled 20 minutes per CT examination for the SCP patients, except for examinations of the uterus and the urinary tract, which require an examination time of 30 minutes due to their preparation procedure, which is a bit different (SCP Coordinator, 2016). Before a patient is being examined he or she may have to prepare. In many cases, the patient has to consume contrast, either by drinking it, getting it injected or receiving it through an enema. The contrast will be given at the hospital, which means that the patients has to be at the hospital a while (normally 1-3 hours) before the actual CT examination (National Cancer Institute, 2016a; 1177.se, 2016a). The contrast highlights certain areas of the body part in order to get clearer pictures. CT examinations are used in the cancer care to detect if there is a tumor present, information of how the cancer has spread and what stage it is in, to see if the cancer is responding to the treatment, if there are abnormal growth, and more (National Cancer Institute, 2016a).

Image 1 – CT scanner at NU-sjukvården

4.3.2 Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging (MRI) is often called an x-ray, but it actually is not since it does not use radiation. As the name indicates, the MRI is performed using the magnetic field, together with radio waves. The magnetic field is surrounding the opening of the MRI machine where the patient is lying. When the patient is examined the affected tissue emits radio waves of his or her own. Depending on the chemical structure of the examined tissue, intense signals are emitted, which results in clear images. Similar to CT, the MRI produces three-dimensional images of the examined body part resulting in very clear images that are sometimes even better images than the CT x-ray (National Cancer Institute, 2016b).

An MRI examination takes roughly 20-45 minutes, sometimes up to 90 minutes, and captures about 100-500 images depending on what is being examined. The patient has to lie still on a table that is inserted into the MRI machine tube, which is consistent of a narrow magnetic tunnel (see Image 2). In Sweden the MRI is operated by two specialized radiology nurses, meaning that these nurses have to have a special competence to operate the MRI, being a regular radiology nurse is not sufficient enough. As a result, the MRI is not used as a first option since it requires a lot of resources to operate (1177.se, 2016b) and it is also more time consuming than other x-ray options. The MRI is also a lot more expensive to perform (SCP Coordinator, 2016; Chief Physician and Head of the Radiology department, 2016). Similar to the CT, the nurses prepare the MRI machine and the patient. During the examination, the nurses monitor the patient from a control room and have the opportunity to communicate directly with the patient.

Some patients may have to prepare before the examination by consuming contrast in order for the pictures to be clearer. Either the patient drinks it, gets it injected directly into the blood with a needle or receiving it through an enema. The contrast is given at the hospital, usually 1-3 hours prior of the MRI examination (1177.se, 2016b).

Image 2 – MRI scanner at NU-sjukvården

4.4 Demand and capacity situation at NU-sjukvården's x-ray division

In general, the amount of people diagnosed with cancer has been growing for the past decades. Since 1970, data for all types of cancer has been collected at The National Board of Health and Welfare's database (see Figure 7). This general growth has contributed and affected the demand and capacity situation at NU-sjukvården.

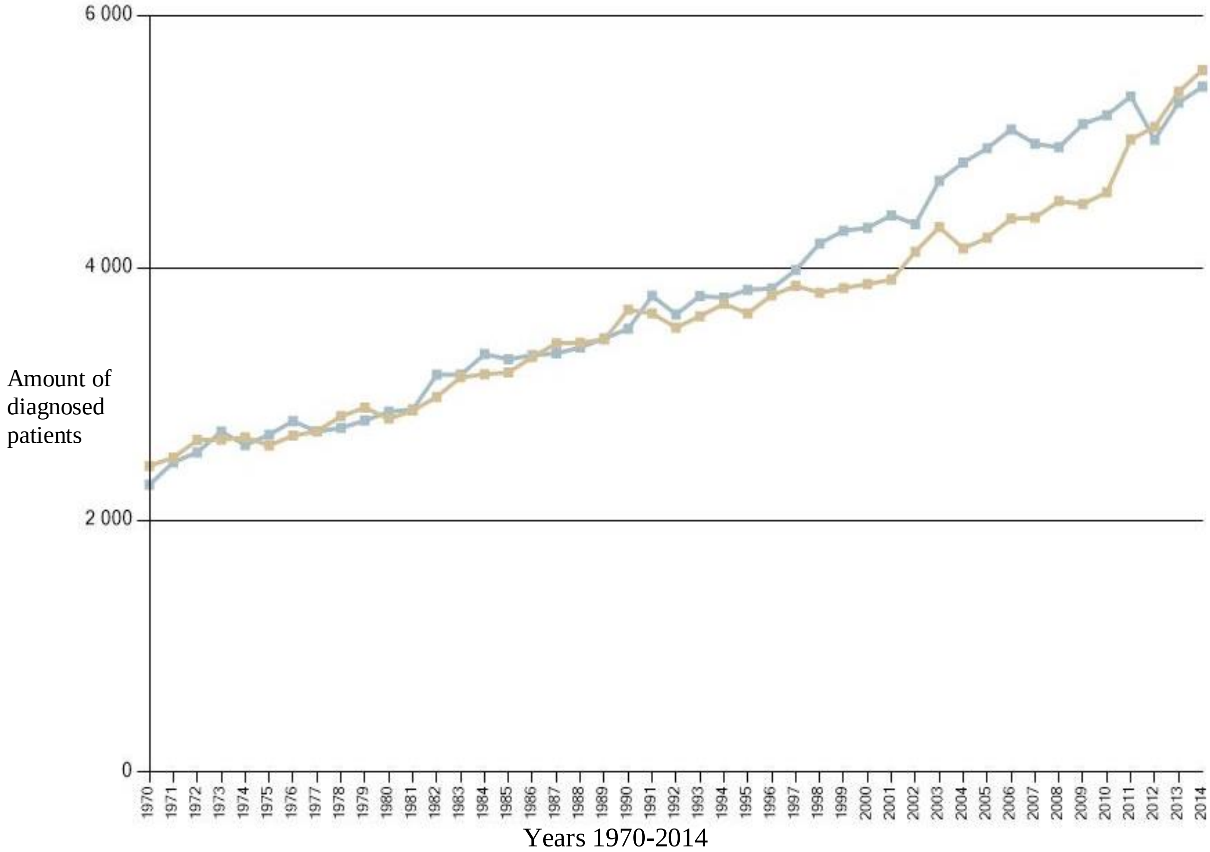

Figure 7 – Total historical amount of all cancer diagnosis in the Region of Västra Götaland between 1970 and 2014. Grey line=men, brown line=women

Besides the growth displayed in Figure 7, there has also been a shift from using general two-dimensional x-rays to using CT instead, and also a small shift from using CT to MRI, depending on what body part is being examined. This shift affects the capacity, and cost, within the healthcare industry. For all existing SCP diagnoses, the most commonly used x-ray resources are the CT scanner and the MRI scanner (SCP Coordinator, 2016). Both Uddevalla Hospital and NÄL have their own x-ray division but the planning of these is made centrally using an excel-based tool called Prosit (see section 4.4.2). Uddevalla Hospital has two CT machines and two MRI machines, and NÄL has two CT machines and one MRI machine. The divisions perform all different kinds of examinations and the only difference is that NÄL is the only one performing vessel x-ray and Uddevalla is the only one performing mammography scans. Besides that, as mentioned previously, NÄL is also the only hospital handling the emergency care in the area.

4.4.1 The SCP initiative at NU-sjukvården's x-ray division

The general process for a patient to be scheduled for an x-ray examination starts with a referral sent from the primary care, or another medical department or clinic, to the x-ray division. The SCP referrals are only one part of the total demand of referrals put on the division. For instance, referrals from other medical division, not involved with cancer care, as well as referrals directly from primary care also contribute to the total demand. Once the referral has reached the x-ray division, it is prioritized by a radiologist. The prioritization depends on the severity of the medical situation, and how urgent the examination is needed. What type of examination that is needed may also affect how it is prioritized. When the prioritization is made, the examination gets schedule by operative staff, which NU-sjukvården calls “The Booking Group”. When the examination is scheduled, an invitation including information about the examination, and how to prepare for it, is sent to the patient. The capacity of the x-ray division is depending on the number of machines and educated staff available, as well as the opening hours of the division. When the examination has been performed, a radiologist reviews the x-ray images and the results are sent back to the division that initiated the referral. That division then meets with the patient to discuss the outcome of the examination, and if any actions are necessary. Figure 8 is a visualization of the demand and capacity situation at the x-ray division of NU-sjukvården.

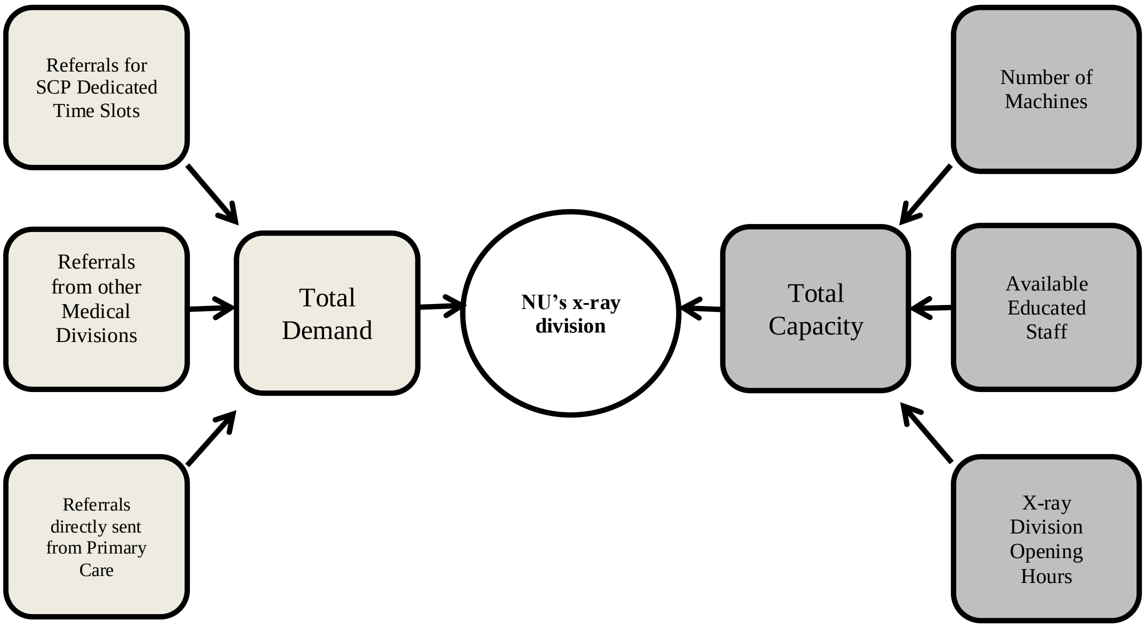

Figure 8- A map to explain the demand and capacity situation at NU-sjukvården’s x-ray division

4.4.2 The x-ray division’s planning tool Prosit

As mentioned above, the planning and forecasting of demand and capacity of the total amount of examinations is made centrally for both Uddevalla and NÄL. This is made on a monthly basis using an Excel-based planning tool called Prosit. Prosit uses the Holt-Winter model (see section 2.4) to forecast the number of examinations planned for the upcoming periods at the x-ray division.

For the overall planning at NU-sjukvården, Prosit uses a 12-month rolling forecast that is revised on a monthly basis. The Holt-Winter model was decided to be used at NU-sjukvården after a couple of trial and error runs using different forecasting models for their demand and capacity situation. The test was based on historical inflow of referrals and scheduled operations. From conducting these tests, using a 12-month forecasting horizon, based on 18- 36 months of historical data, trends became present. These trends were then smoothed out using an alpha of 0.2, meaning that 80% of the trend remained (see section 2.4).

When forecasting for specific months, the best results became present when the above-mentioned forecast was combined with seasonalized data using 36-48 months of historical data (see section 2.4). From this test forecast, the Holt-Winter model could be re-created. From monitoring the forecasts created using the Holt-Winter model, the forecasts are accurate as long as the inflow of referrals is relatively large. For the smaller flows using the previous year's inflow is sufficient enough when creating a forecast (Group staff performance control and coordination, 2016).

Today, the forecasting process for the x-ray division is done by the production planners at NU-sjukvården. They collect the historical data from ELVIS and use this as input to the tool Prosit. Prosit assists the planning of the x-ray division to respond as well as possible to the demand situation. What this means is that Prosit use the historical amount of referrals i.e the demand on the x-ray division to show what capacity level that is needed in order for NU-sjukvården to cope with all incoming referrals based from that month's historical demand. By knowing the capacity level needed, and knowing the availability of educated staff, the staff schedules can be planned. At NU-sjukvården, this planning mostly results in a higher inflow of referrals than what the existing system can deliver (see Figure 13 and 14 below). A concern that was expressed from the production planner during this study was that the operational staff at NU-sjukvården is not present when the forecasts are created. Forecasts for the x-ray division therefore has no operational knowledge and input, which means that the forecast does not cope well with fluctuating demand on a weekly or daily basis (Production planner, 2016).

The opening hours and available staff at the x-ray division vary from week to week, which imply some variation in the total number of examinations performed each week and month. When analyzing the output of Prosit it is often concluded that the capacity will not be sufficient to meet the demand. NU-sjukvården try to handle this by occasionally adding capacity by extending their opening hours and, for instance, run their machines during evenings and weekends. However, waiting times are barely affected and outsourcing of examinations to other medical facilities is still required. To get an understanding of how many CT and MRI examinations that are performed at NU-sjukvården the historical examinations data on a monthly basis is presented in Figure 9 and 10.

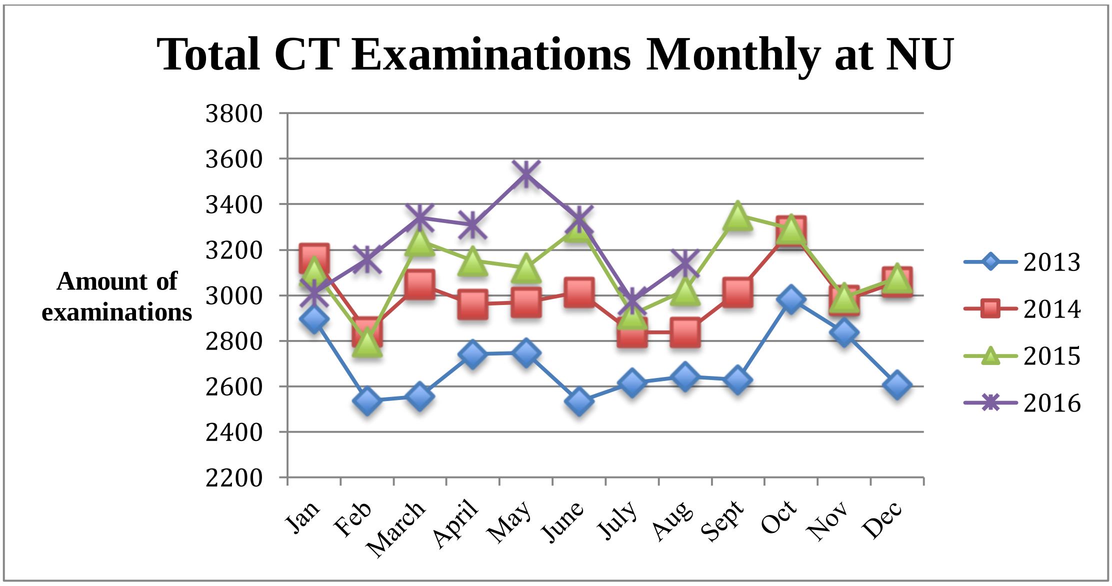

Figure 9 – Historical data for the amount of CT examinations at NU-sjukvården the years 2013-2016

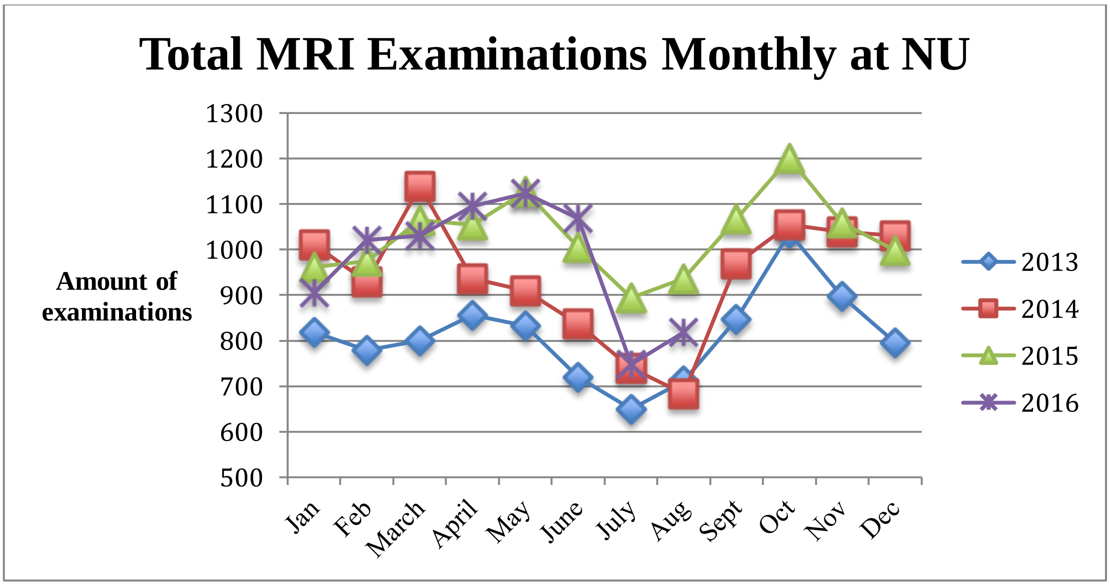

Figure 10 – Historical data for the amount of MRI examinations at NU-sjukvården the years 2013-2016

What can be seen from the figures above is that the historical amount of examinations has been stable, meaning fairly low variation, during the time period 2013-2016. It also displays the historically stable growth pattern that has affected the x-ray division.

The present forecast for the upcoming CT and MRI examinations in 2017 is presented in Figure 11 and 12 below (note that this is a forecast based on data collected today and that it may change over time).

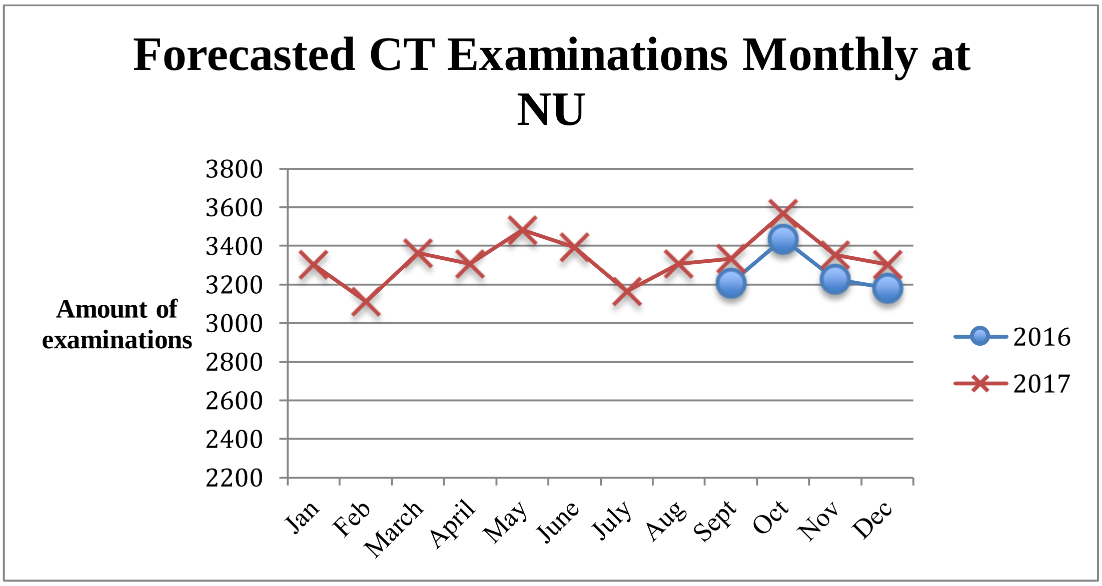

Figure 11 – Forecast from Prosit for September 2016 and all of 2017 for CT examinations at NU-sjukvården

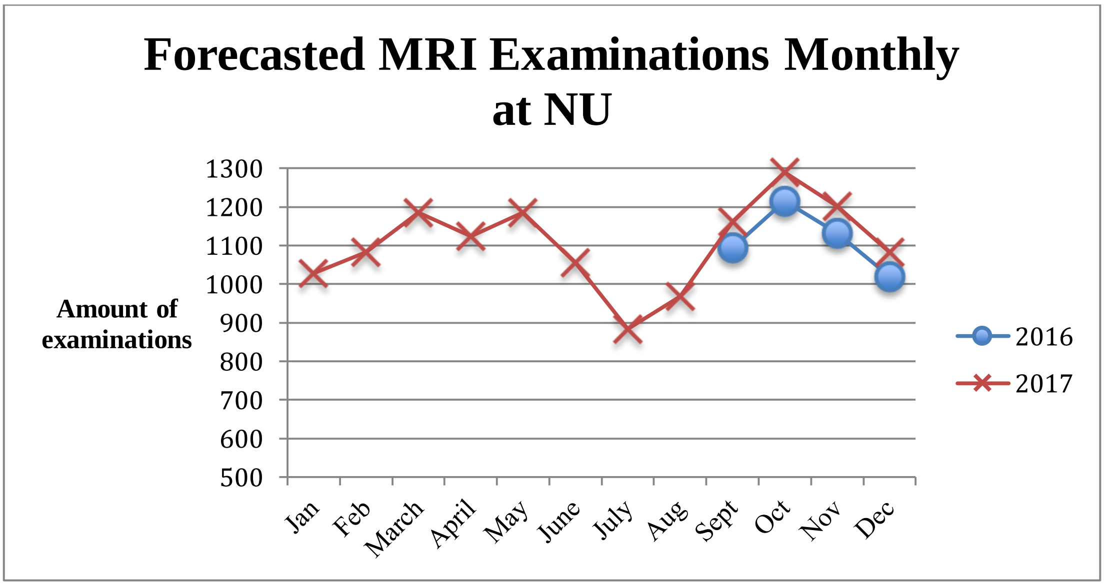

Figure 12 – Forecast from Prosit for September 2016 and all of 2017 for MRI examinations at NU-sjukvården

As can be seen above, approximately 3 000 - 3 500 CT-examinations, per month, are to be performed, and approximately 800 – 1 300 MRI-examinations, per month, are to be performed. What can also be seen from Figure 9 and 10 above is that there has been a growth in the number of CT and MRI-examinations performed over the years 2013-2016.

What complicates the planning for the x-ray division is that the amount of referrals, hence the demand, each month is higher than what can be supplied by the existing resources of the division, hence the capacity, which results in that queues are created. Below, the internal incoming referral data is presented alongside with the internal available capacity in number of referrals that NU-sjukvåren can handle each month. It can be noted that the incoming referrals are larger than the available capacity for almost every month displayed. As a result, queues are created and waiting times are long.

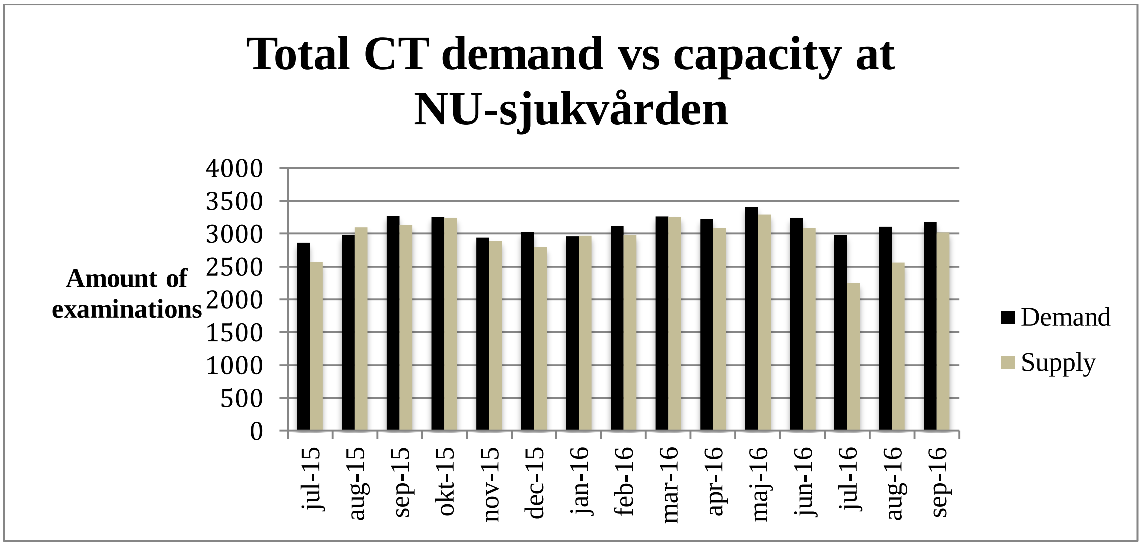

Figure 13 – Demand vs. capacity situation for CT examinations at NU-sjukvården

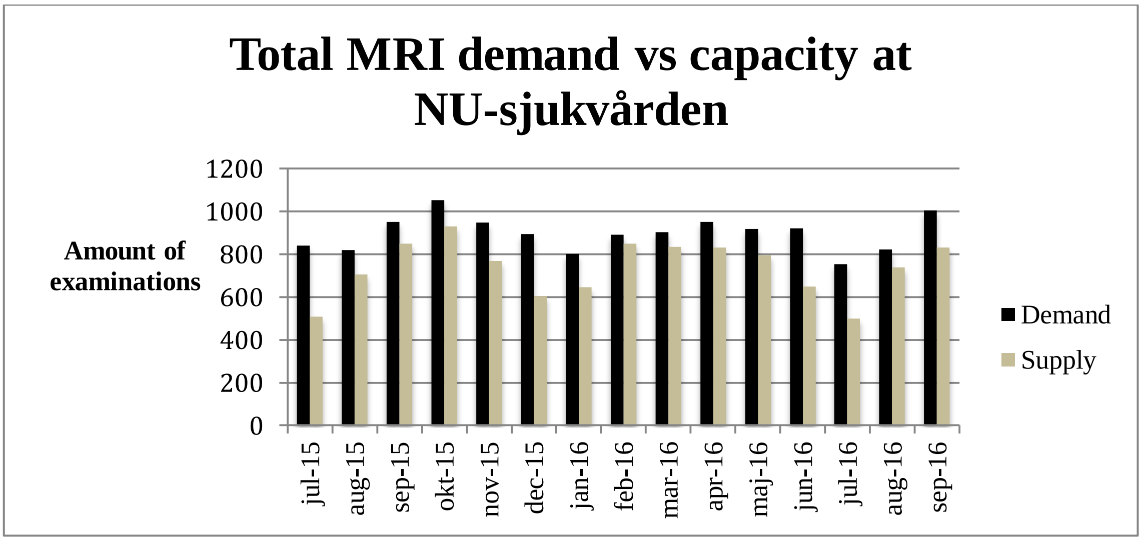

Figure 14 – Demand vs. capacity situation for MRI examinations at NU-sjukvården

For the SCP initiative's dedicated time slots, there is no pronounced forecasting process in place, meaning that there are no instructions, or standards, for how the forecasting of the amount of patients in need of dedicated time slots should be performed. The time slots have been estimated on a weekly demand by the local process owners and not with any tools like Prosit. Once the amount of dedicated time slots has been decided they are operationalized, hence planned into the system, by the x-ray coordinator, a section manager and the operative booking group.

There have been some alterations to some of the cancer diagnoses' time slots where the amount of dedicated time slots had to be changed. The changes have been made when the operative booking group notices that the time slots are often unused. NU-sjukvården also has a more formal way of revising the amount of dedicated time slots. Four times a year the steering committees have a meeting where they review the SCP initiative and the amount of dedicated time slots, and if changes are needed they will discuss it during these meetings. The steering committee consists of the local process owner, the SCP cancer diagnosis coordinator, the Chief Physician and Head of the Radiology department, the SCP coordinator, the Chief Physician for the discussed cancer diagnosis, the Chief Physician at the Pathology clinic, the Area Manager for the area in which the discussed diagnosis is belonging and additional involved staff if needed (SCP Coordinator, 2016). At NÄL the changes can be implemented within one to two weeks, while changes at Uddevalla Hospital requires at least two to three weeks. This is because the x-ray booking system at Uddevalla Hospital has a longer time span since they do not handle emergency care patients (SCP Coordinator, 2016).

The idea behind the SCP dedicated time slots is to generate faster lead times for cancer examinations, which results in a different demand situation for the x-ray division. In order to create a forecasting process for the SCP initiative that support this, it is important to map the present situation of the different cancer diagnoses, and their respective characteristics and effect on NU-sjukvården’s x-ray division. In particular it is interesting to understand the how large each of the studied cancer diagnosis is in terms of volume i.e number of patients, at the x-ray division, as well as what type of factors that are crucial in each process.

The following sections will introduce empirical findings collected, both quantitative and qualitative, that is connected to the first four SCP initiative diagnoses but also to the x-ray division. These findings will form an understanding of how large the first four SCP diagnoses’ demand is on the total x-ray division, and what quantitative and qualitative factors that are important for a forecast process.

4.5 The SCP process in the four studied cancer cases

The idea is that the SCP process should start from an SCP referral stamp at the primary care. The primary care is where the patient, in many cases, has the first contact with the medical system. Using the SCP suspicion guidelines for each individual cancer diagnosis, the primary care should be able to create a direct path, for the patient, to the x-ray division at NU-sjukvården. However, the study has shown that there are some problems related to this flow. First of all, information about the SCP initiative has not reached all primary care divisions, connected to NU-sjukvården to a satisfactory level yet, which in turn affects the speed of SCP referrals to the x-ray division. As of this, NU-sjukvården generally but also the first four SCP cancer diagnoses, use a process at the different departments that works as a filter function for the incoming referrals. This function, consisting of medical specialists, decides regardless what the referral from the primary care contains, if the patient should be treated as an SCP patient or not. For some symptoms, such as Urinary tract or bladder cancer, the symptoms indicating if a patient should be treated as an SCP patient are fairly easy to find, however, for other diagnosis the symptoms are more diffuse. As a result the SCP processes, at NU-sjukvården, always starts at the cancer specialists divisions. Today, this is true for the first four SCP cancer diagnoses.

4.5.1 The process of Urinary Tract and Bladder Cancer

When a symptom of Urinary tract or bladder cancer is found at a medical division in the Region of Västra Götaland, a referral for a CT-examination and cystoscopy is directly sent to the urology division in order to speed up the evaluation process. If a tumor is found from the CT-examination the patient gets scheduled for treatment and the cystoscopy does not need to be performed. An extra x-ray examination is usually performed if a tumor is found in the upper parts of the urinary tract. In that case a complementary kidney examination may also be needed.

It is important to evaluate which stage the cancer is in. This decides if more examinations are needed, and what type of treatment to use, to make sure that the patient care is as successful as possible. Different types of tumors can be treated in different ways. The most common treatment is cystectomy with urinary deviation. The monitoring after treatment is for this process done through cystoscopy and x-ray examinations (Cancercentrum.se, 2016b). The general SCP process for a patient being evaluated is presented below.

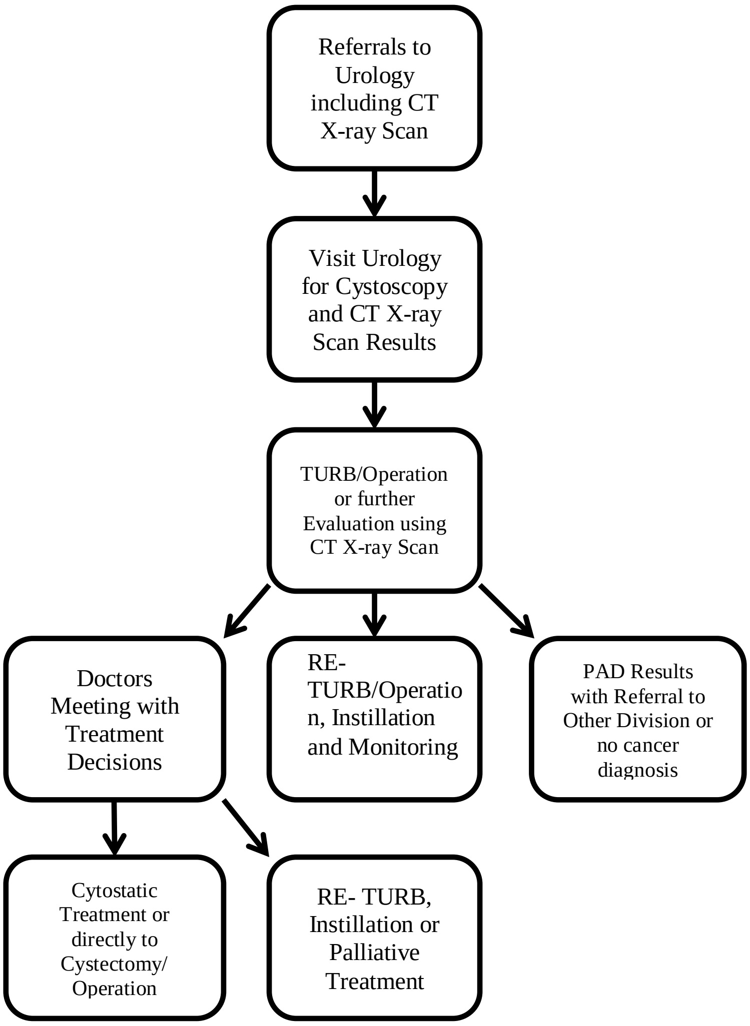

Figure 15 – The national SCP process map for Urinary tract and bladder cancer patients

At NU-sjukvården, this process is conducted differently and is instead a One Stop Clinic, which means that the patients will do all examinations and be diagnosed during one day (see the One Stop Clinic's process map in Figure 16). The one stop clinic was introduced as a facilitator for the SCP initiative and has currently been up and running for one year.

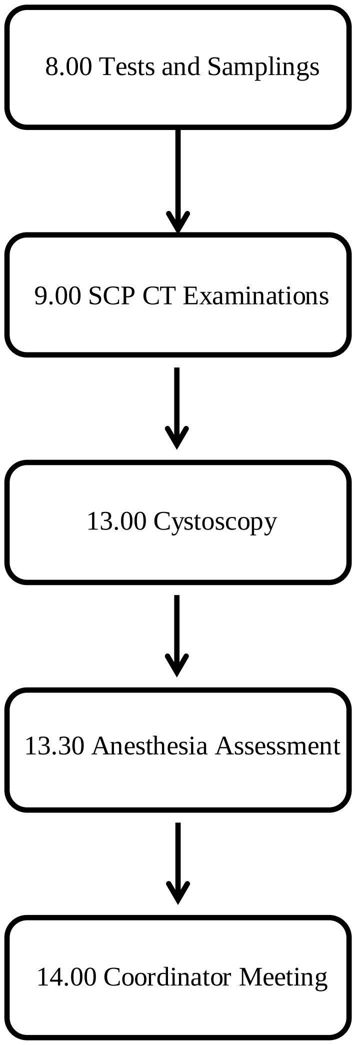

Figure 16 – Process map and time schedule for the Urinary tract and bladder cancer One Stop Clinic at NU-sjukvården

The One Stop Clinic starts from a patient being scheduled to visit the urology clinic a specific day. When the patient arrives tests and samplings are done and the patient is thereafter sent to the x-ray division where dedicated time slots are booked for this process. Depending on what the tests, samplings and x-ray results show the specialists decide whether a cystoscopy is necessary or not. The process is then finalized with an assessment and coordinator meeting where the next step for the patient is discussed. For this process to work without interruption it is necessary that coordination between different medical divisions exist. Since this process has a One Stop Clinic-concept, the x-ray results, as an example, have to be ready and analyzed before the cystoscopy is to be performed, to know whether it is necessary or not. This results in a need for careful and thorough planning of how and when the dedicated time slots at the x-ray division are to be carried out.

4.5.2 The process of Prostate Cancer

Prostate cancer only affects men, and is most common for men in their 50's or older. The constant growth of patients diagnosed with Prostate cancer has over the last couple of years decreased and has now become more stable. PSA-testing, which is a test to see the level of the PSA protein in the blood, is one factor mentioned to contribute to this decrease.

The Prostate cancer process starts when a PSA-test shows suspicious values, such as a high level of PSA in the blood. The primary care, or another equivalent division, sends a referral to the urology division, which continues with the evaluation. At the urology division, another PSA-test is performed and if the suspicious values remain, a biopsy is performed. If the results from the biopsy come back positive, the cancer stage is determined through several other examinations. At this step, a decision regarding if an x-ray examination is needed for the patient is also determined. Depending on what type of prostate cancer the patient is diagnosed with, the treatments differ (Cancercentrum.se, 2016c).

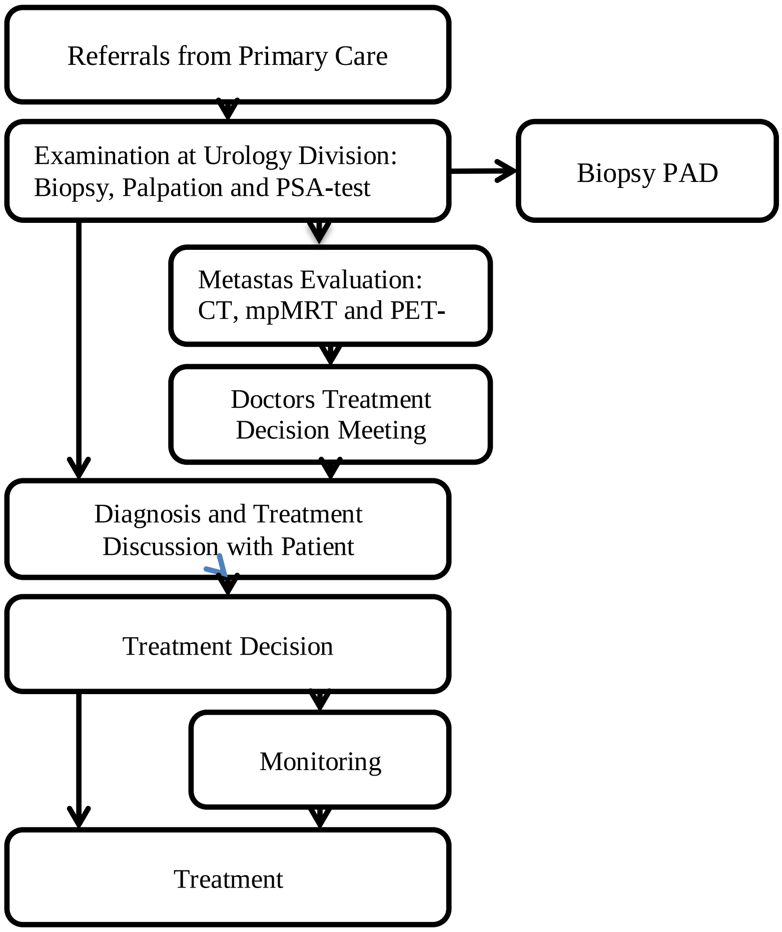

Figure 17 – The national SCP process map for Prostate Cancer patients

The coordination between medical divisions is necessary. It is of high importance that the referral information is clear and understood by all parties involved in order to minimize misinterpretations. Even though it is not obvious from the process map and description above, the demand on the x-ray division is not substantial but the x-ray evaluation is perceived as a bottleneck activity.

4.5.3 The process of Esophagus and Stomach Cancer

The treatment for Esophagus and stomach cancer is extensive and is performed during a long timeframe. The treatment process is costly and for this reason the evaluation is thoroughly performed to enable individual patient treatment. Approximately 70% of the patients diagnosed has a widespread cancer and are often not offered a curative treatment. Instead they are being offered palliative care.

The national process for Esophagus and stomach cancer starts at the primary care or equivalent medical divisions. At NU-sjukvården, however, the SCP process for this diagnosis is started at NU-sjukvården. This is the primary care is not involved in these diagnoses. This may however not be case for other hospitals in other regions in Sweden. In general, the process starts by a referral indicating a suspicion of cancer sent to a specialist division, which continues the evaluation process. The evaluation, for example, includes blood tests, gastroscopy with biopsy, and CT examinations. These tests are analyzed and a decision is made, either to perform additional tests and examinations, or if the results should be sent to the medical specialists evaluations meeting (MDK). From this meeting the type of treatment is decided (Cancercentrum.se, 2016d).

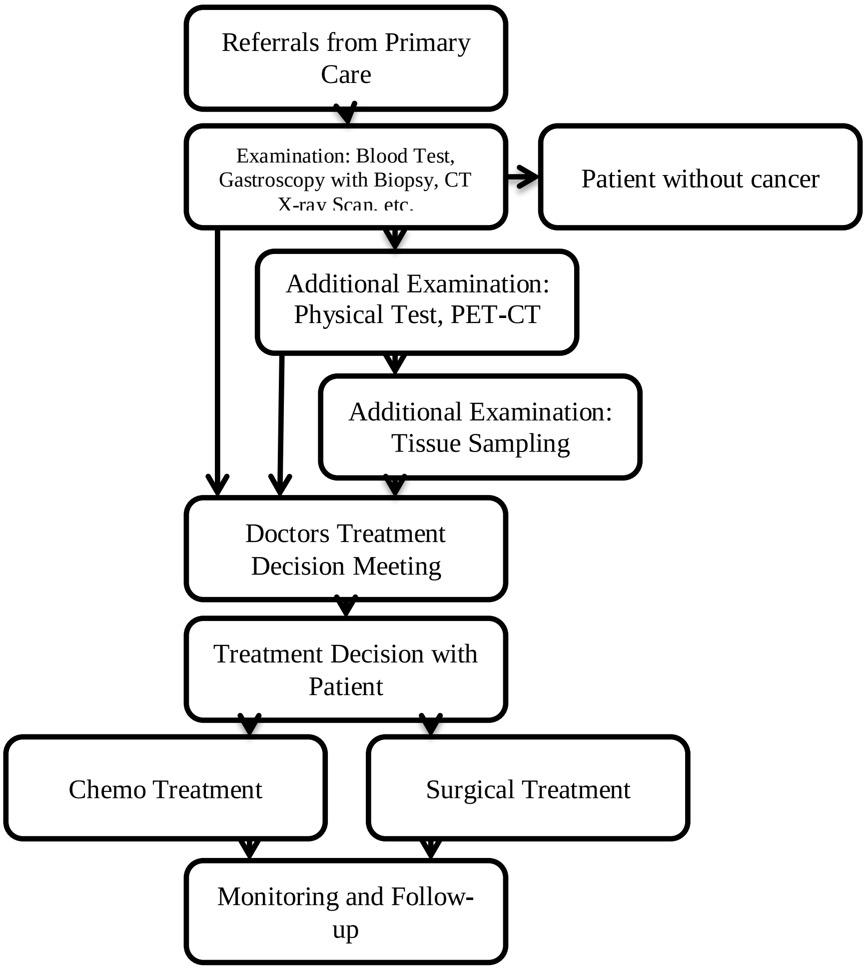

Figure 18 – The national SCP process map for Esophagus and Stomach Cancer patients

The coordination between different divisions is, as well as for the other processes, important. Dedicated time slots at the x-ray division works as a facilitator for this process.

4.5.4 The process of Head and Neck Cancer

Head and neck cancer include tumors in the lips, oral cavity, throat, larynx, nose, sinuses, salivary glands and lymph node. These tumors are divided into nine groups, which are classified in regards to growth rate, risk of spreading and treatment options.

The process for Head and neck cancer start from a referral sent to the specialist division. At NU-sjukvården, the SCP process for this diagnosis is started at NU-sjukvårdens filter function and not at the primary care. This referral is reviewed by a specialist and a decision is made whether or not to do an evaluation. If an evaluation is started, it is performed within two weeks and handed over to the MDK. At the MDK meeting the treatment type is decided. The following-up procedure is performed regularly during five years after a patient is declared cured and depending on the characteristics of the cancer this is done in different ways.

Historically, at NU-sjukvården, approximately 50 people are diagnosed with a Head and neck cancer per year and as a result approximately one patient per week should be identified. For all patients being examined, approximately 40% are diagnosed with a Head and neck cancer (Cancercentrum.se, 2016e).

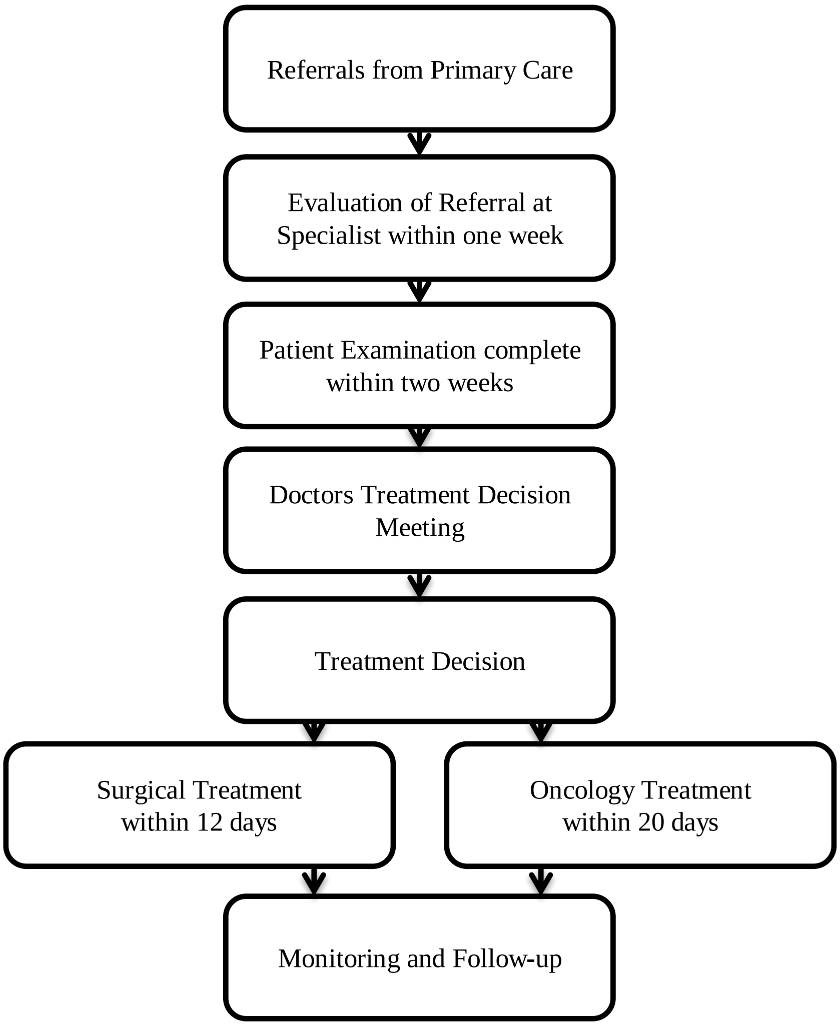

Figure 19 – The national SCP process map for Head and Neck Cancer patients

The coordination between different medical divisions is necessary to support this process and keep the targeted times for evaluation. Dedicated time slots for MRI and CT need to be easily accessed for the Head and neck cancer patients.

4.6 Quantitative findings for the first four SCP initiatives' cancer diagnoses

The way to collect the quantitative data for the four case diagnoses does not differ and comes from the number of patients being examined for, and diagnosed with a certain type of cancer, hence historical data. As the Swedish healthcare industry operates with many different information systems the amount of data is very large. To illustrate what demand the four first SCP diagnoses puts on the x-ray division in a reliable manner, the data used for this study therefore becomes important. What data to use and how to verify it in order to present the actual demand of a cancer diagnosis will be presented and analyzed below.

To understand the volumes of patients diagnosed with a certain type of cancer, and thereby understand the demand that the diagnosis place on the x-ray division at NU-sjukvården, some historical data is necessary. The number of patients that has been diagnosed historically with a certain type of cancer is needed in order to get an overview of how the situation has been looking historically in the region and this data is provided by the Cancer Register and the National Board of Health and Welfare. This data will also display if the cancer diagnosis is affected by systematic changes such as trends or seasonality. The data will be presented in Figure 20, 23, 25 and 27 for each diagnosis below. This data however not display how many patients that will require a dedicated time slot at the x-ray and for that reason complementary SCP data from ELVIS is needed.

Since the SCP initiative started in September 2015, data has been collected from ELVIS. This data is reported on:

1. The number of patients starting an SCP process, which display how many new patients that has been recorded with a suspicion of cancer. This data will capture the amount of patients in need of an x-ray examination (if the cancer process requires an x-ray examination).
2. The number of patients who started their treatment, which display the amount of patients that are diagnosed and has started their treatment.
3. The number of patients that did not have cancer displays the amount of patients that has gone through evaluation where no cancer findings have been made.
4. The SCP complete, which display the amount of patients that has gone through evaluation and had been diagnosed or dismissed.

How the data is reported for each studied diagnosis will be present in Figure 21, 24, 26 and, 28 in the next sections.

4.6.1 Quantitative Findings for Urinary tract and Bladder cancer

Presented in Figure 20 below is the historical amount of patients diagnosed with Urinary tract and bladder cancer at NU-sjukvården. The data is provided by the Cancer Register for NU-sjukvården and looks as follows:

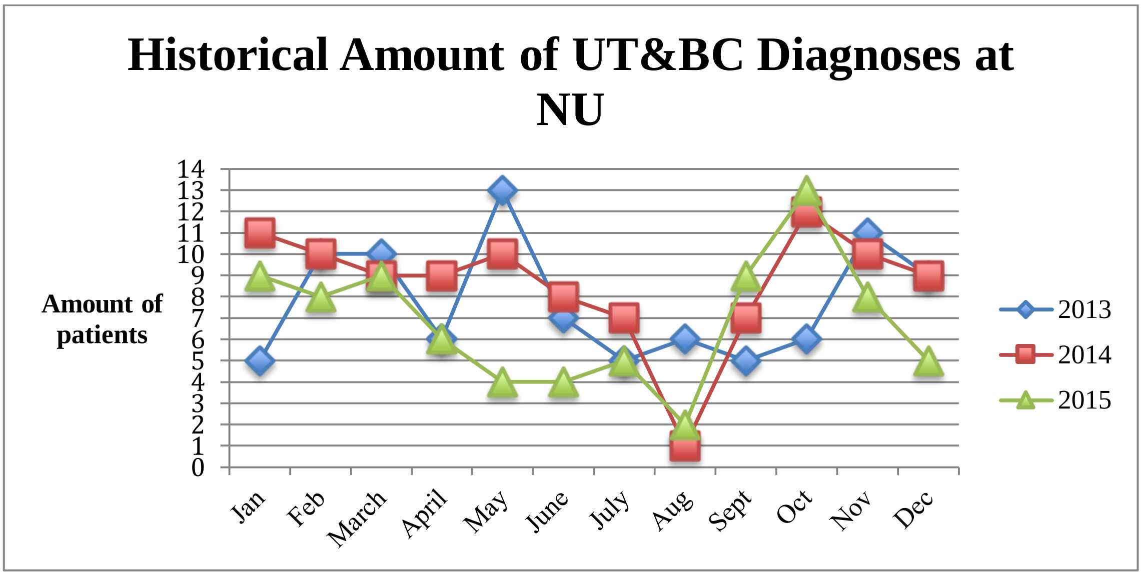

Figure 20 – Historical data from the Cancer Register for the number of patients diagnosed with Urinary Tract and Bladder Cancer for the years 2013-2015.

The number of patients diagnosed with Urinary tract and bladder cancer has over the years 2013 to 2015 been following the same pattern, with indication of seasonality during the summer, which most likely is a result of a lower production at NU-sjukvården due to summer holidays.

For the Urinary Tract and Bladder Cancer the SCP data for the first year looks as follows:

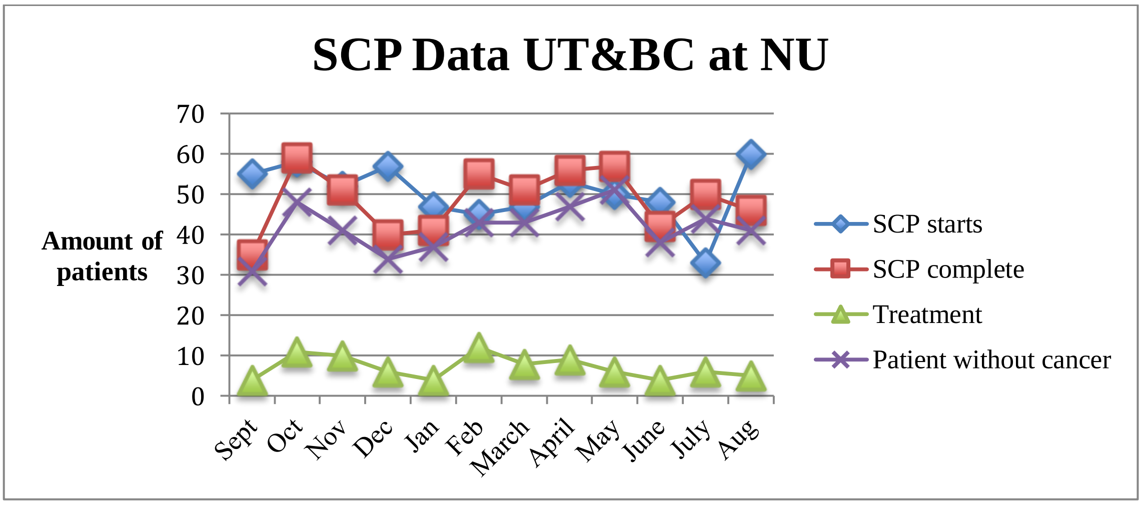

Figure 21 – SCP data for Urinary Tract and Bladder Cancer from 1st of September 2015 to 31st of August 2016.

As can be seen from Figure 21, the amount of patients starting treatment is approximately 10 % of the amount of patients who started the process (see SCP starts and compare with Treatment). From this figure it can be shown that there are a lot more patients being examined for a suspicion of cancer than what is actually diagnosed and that in turn means that a lot more patients are using the x-ray than what is being diagnosed with Urinary tract and bladder cancer.

The weekly performed examinations for Urinary tract and bladder cancer is displayed below. This data is collected using the SCP data on a local level, i.e. at NU-sjukvården. The data is provided by ELVIS and is collected by the process owner for the urinary tract and bladder cancer. The data was collected for week 1 to 19, 2016. The process Urinary tract and bladder cancer has 13 dedicated CT examinations per week and what can be seen in Figure 22 below is that during some weeks the demand is larger than the available capacity, meaning that more than 13 patients are being examined. Other weeks the demand is smaller than the available capacity, meaning that less than 13 patients are being examined. This shows that half of the time, the estimation is too high, resulting in empty slots at the x-ray if the slots cannot be filled with other patients. This might be a result of only using qualitative estimations when deciding how many slots to operationalize into the system.

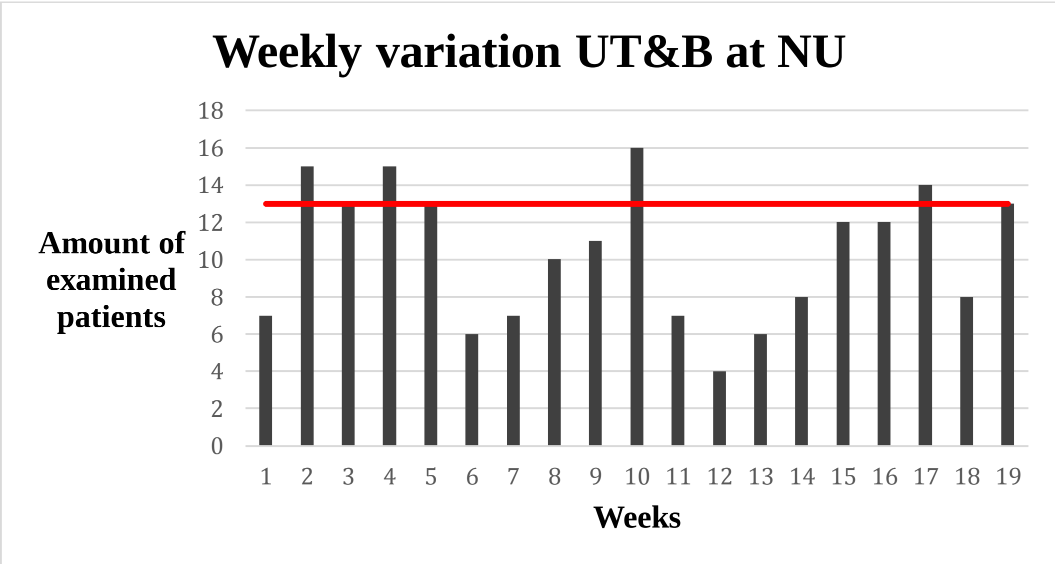

Figure 22 – Weekly number of performed examinations for Urinary tract and bladder cancer at NU-sjukvården during week 1 to 19, 2016

This weekly data was only available for the Urinary tract and bladder cancer due to the fact that only the local process owner for this diagnosis had required access to this data. For the other three cases the weekly number of examined patients cannot be displayed because of confidentiality reasons.

4.6.2 Quantitative Findings Prostate Cancer

In Figure 23 below, the historical data from the Cancer Register for prostate cancer is displayed. Accordingly, approximately between 15-30 people are diagnosed with prostate cancer per month.

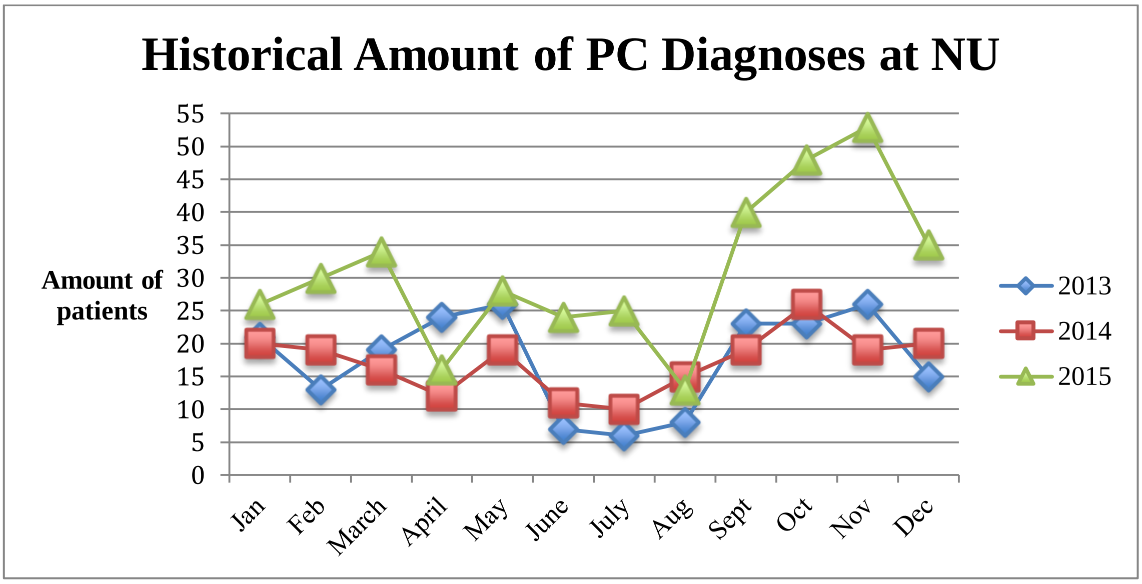

Figure 23 - Historical data from the Cancer Register for the number of patients diagnosed with Prostate Cancer for the years 2013-2015

There has been a peak in the amount of patients getting diagnosed with prostate cancer from September 2015 compared to the previous years, which also is the month when the SCP initiative started. According to involved staff it is not due to more people becoming sick. Instead, the peak is a result of NU-sjukvården's work with the SCP initiative. The simple explanation to the peak is due to a decision made at NU-sjukvården that they should evaluate the existing patients who were placed in a queue so that patients who were marked as SCP patients when the initiative was launched was not evaluated before the patients in the existing queues were evaluated. Due to this, a peak occurred during the fall of 2015 (Process owner Prostate cancer, 2016).

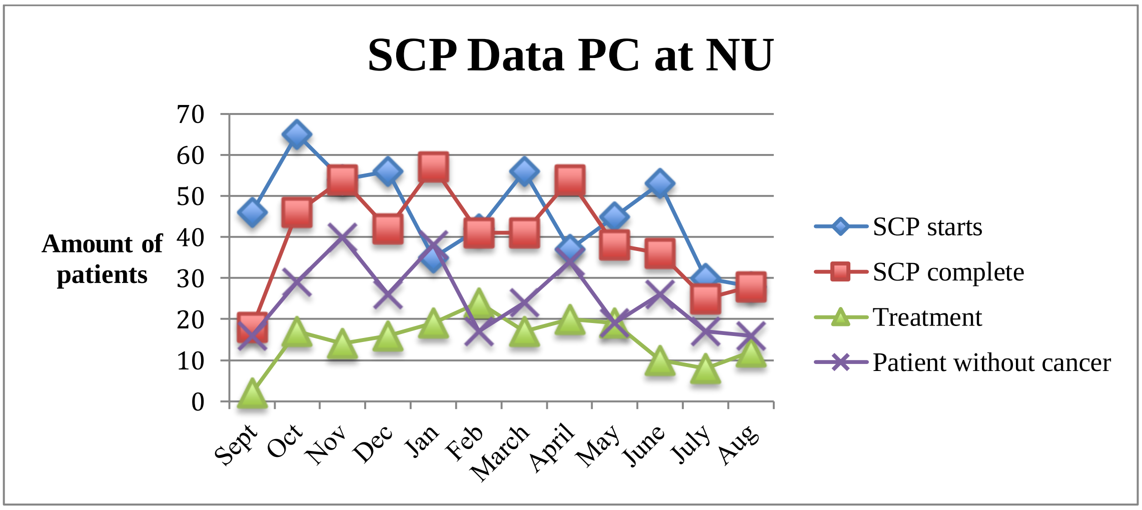

Figure 24 – SCP data for Prostate Cancer from 1st of September 2015 to 31st of August 2016.

Looking at the SCP data from Figure 24, the amount of people with a suspicion of cancer (SCP starts) is approximately 40-60 people. For this amount of people, two CT examinations per week would not be sufficient enough to examine all of the patients.

However, only 25% of the SCP starts will require a CT examination. This is because 25% of the patients are classified as “high risk patients” and only those patients are in need of a CT-examination. This means that for some months the number of CT-examinations is sufficient enough to handle the amount of people in need of CT examinations. Other months the demand is either too high or too low (Process owner Prostate Cancer, 2016).

4.6.3 Quantitative Findings Esophagus and Stomach Cancer

In the first figure below, historical data from the Cancer Register of how many patients that has been diagnosed with this type of cancer is displayed. The second figure displays the SCP data for the same diagnosis.

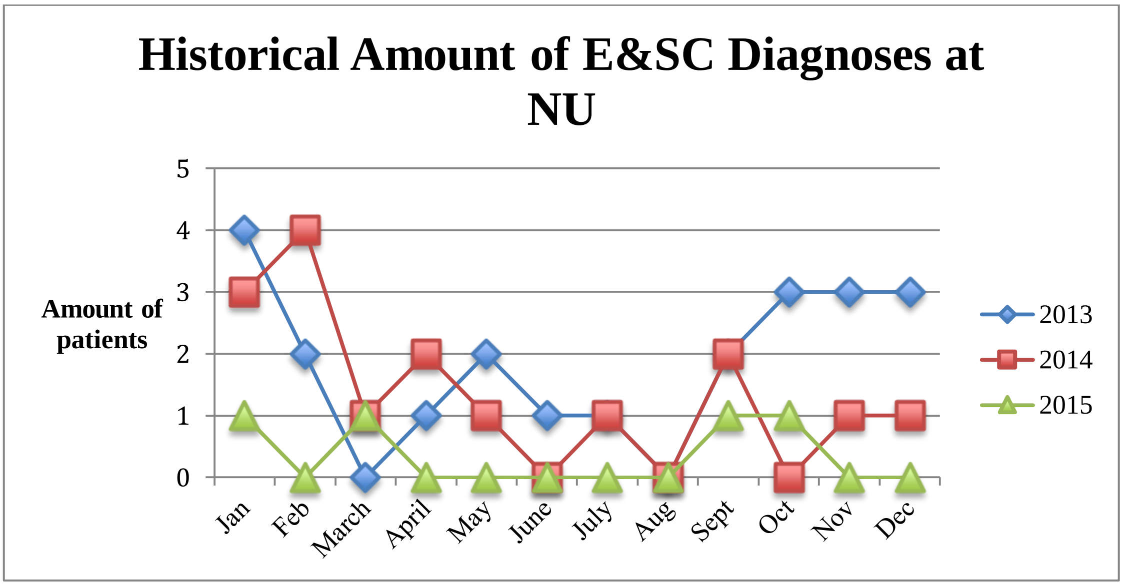

Figure 25 - Historical data from the Cancer Register for the number of patients diagnosed with Esophagus and Stomach Cancer for the years 2013-2015

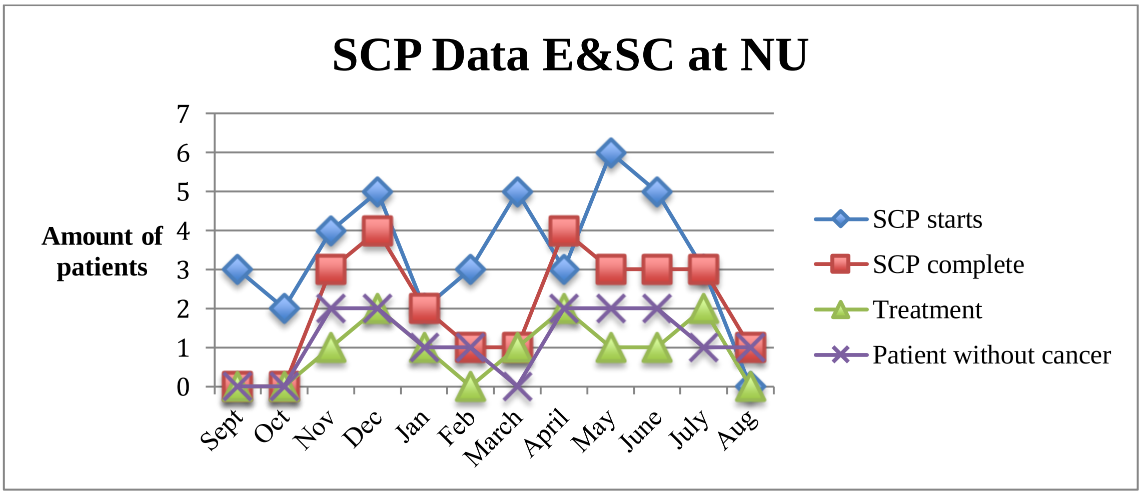

Figure 26 – SCP data for esophagus and stomach cancer from 1st of September 2015 to 31st of August 2016

What can be seen in Figures 25 and 26 is that the amount of patients being diagnosed with Esophagus and stomach cancer is very small. However, the variation is also small since the amount of patients being SCP started is small. As the evaluation process is very thorough to identify optimal treatment options the amount of patients examined stay on low levels. This makes the process easier to adapt and change as it might only mean that one extra time slot will be needed to handle all referrals if there are changes during time.

4.6.4 Quantitative Findings Head and Neck Cancer

The historical data from the Cancer Register for this diagnosis is presented in the first figure below. The second figure displays the SCP data for the same diagnosis.

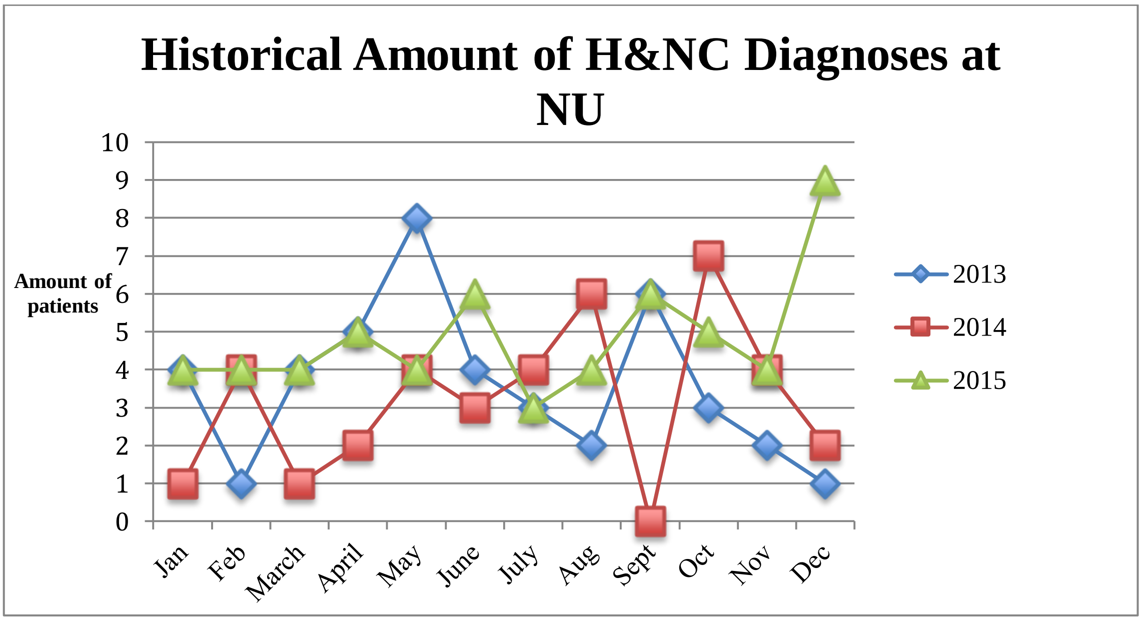

Figure 27 - Historical data from the Cancer Register for the amount of patients diagnosed with Head and Neck Cancer for the years 2013-2015

From Figure 28 below it can be observed that there has been no patients diagnosed with Head and neck cancer during the period September 2015 to September 2016 according to the SCP data. However looking at the historical data in Figure 27 there were between 6 and 9 patients diagnosed with Head and Neck cancer during September 2015 and December 2015. A reason why the SCP data and the historical data from the Cancer Register do not match will be described in section 5.1. Secondly, the SCP complete information seems to be lacking in Figure 28, this is however due to the fact that no treatments were started at NU-sjukvården, which means that the SCP complete and Patients without cancer are the same and follow the same plot.

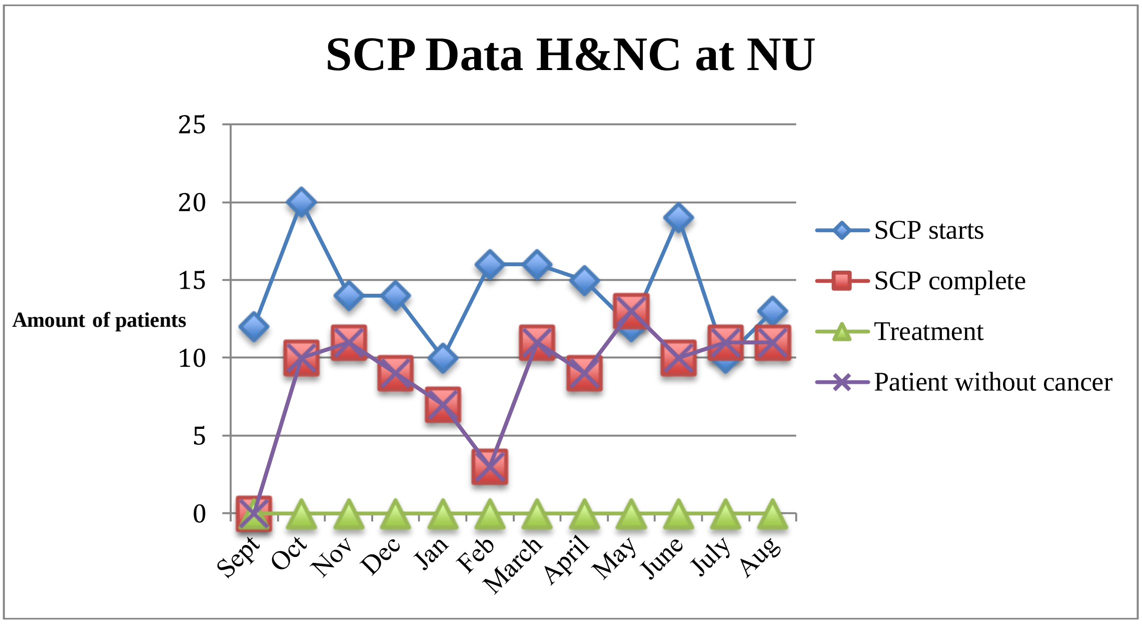

Figure 28 – SCP data for Head and Neck Cancer from 1st of September 2015 to 31st of August 2016.

4.7 Qualitative findings of the first four SCP initiatives

It is not only the quantitative findings that are important for the purpose of creating a forecasting process for the SCP initiative. From interviews with the local process owners at NU-sjukvården some qualitative factors that influence a forecasting process for the amount of patients in need of SCP dedicated time slots were identified. The qualitative data for each individual cancer diagnosis process may differ significantly due to contextual factors and needs consideration as well.

4.7.1 Qualitative Findings Urinary tract and Bladder Cancer

The amount of dedicated time slots at NU-sjukvården's x-ray division, for Urinary Tract and Bladder Cancer, to support the One Stop Clinic are set to 13 CT examinations per week. These are distributed in the mornings to support the process flow of the One Stop Clinic described above. The 13 CT dedicated time slots are estimated from the local process owner by quantifying the amount of patients that historically has had symptoms classified as suspicion of cancer from internal referral data. The process owner wanted to cover 80% of the historical annual suspicions and by that concluded that 17 CT time slots were needed weekly. However, due to the constraints related to the x-ray division's capacity situation it was decided that only 13 CT time slots could be offered as dedicated for the Urinary tract and bladder cancer (Process owner Urinary tract and bladder cancer, 2016).

According to the local process owner for Urinary tract and bladder cancer at NU-sjukvården, the evaluation process for Urinary tract and bladder cancer is most likely to look the same for many years to come. This is because, according to the local process owner, there are no known medical or technical breakthroughs that will happen during the next 5-10 years. However, there is and has been an ongoing research in developing a urine test that could detect cancer in a much easier way compared to the examinations used today. These test are although not a factor that will affect the forecast for the amount of patients in need of SCP dedicated time slots in the near future (Process owner Urinary tract and bladder cancer, 2016; Local process owner Urinary tract and bladder cancer, 2016).

4.7.2 Qualitative Findings Prostate Cancer

The amount of dedicated time slots at NU-sjukvården's x-ray division for Prostate cancer is two CT examinations per week. The estimated decision of how many dedicated time slots that was needed for this diagnosis was purely decided by a trial and error principle. The process owner required two CT time slots. After a period of time the estimation was evaluated and two examinations per week seemed to work well.

According to the local process owner at NU-sjukvården his perceived picture is that there has been a slight increase in incoming referrals marked as SCP due to less strict national guidelines compared to the guidelines that were used before the SCP inititative was launched. However, the amount of patients getting diagnosed with this type of cancer has been stable over the last couple of years, and the small increase of SCP patients is not considered as an issue today.

There has been an ongoing discussion whether or not to use screening as a way of detecting Prostate cancer. The local process owner's own opinion is that there is a high chance of PSA screening to be implemented within the next 5 -10 years. If screening is implemented, the amount of patient in need of a CT will be affected (Process owner Prostate cancer, 2016) in the sense that fewer patients are in need of a CT examination. This is because if PSA screening is offered to the population, patients who are classified as medium risk patients can be monitored using this technique. This means that they will be treated before they are classified as high-risk patients, who are the only ones who are examined using a CT examination (Regional process owner Prostate cancer, 2016).

Another qualitative factor that was mentioned was the use of MRI instead of CT. In Norway, all patients are examined by an MRI before the biopsy since the high-risk tumors are better detected using an MRI. There is a project conducted at Sahlgrenska University Hospital (SU) where the patients will be examined using MRI instead of the CT (Process owner Prostate cancer, 2016). If this is to be implemented in Sweden it will put a lot of pressure on an already scarce resource. Due to this, there is a need to monitor the SU project to see if it is successful or not, and to see if there is a possibility to implement this into the Swedish healthcare industry. The amount of SCP dedicated time slots will then definitely be affected.

4.7.3 Qualitative Findings Esophagus and Stomach Cancer

The amount of dedicated time slots at NU-sjukvården's x-ray division for Esophagus and stomach cancer are five CT and one MRI examinations per week. As this diagnosis is not very large, these slots are part of a group that the doctors also use for other gastro diagnosis' examinations. The other diagnoses involved in the "Gastro Group" as it is named are: Liver cancer, Pancreas cancer, and Gallbladder cancer. This means that the dedicated time slots mentioned above are not only available for the Esophagus and stomach cancer patients. As these cancer diagnoses are small in patient volume (see Figure 25), the decision on the amount of dedicated time slots for the Esophagus and stomach cancer was based on the Gastro Group as a whole. Similarities to the decision making process explained in the Prostate cancer section was made for this group and the estimation of time slots was based on a trial and error principle. The five CT and one MRI examinations were decided based on experience from the process owners involved in the gastro group. This trial and error process is to be evaluated and measured. The evaluation and measurement is not scheduled today, and will be performed at random occasions (Process owner Esophagus and Stomach Cancer, 2016). For NU-sjukvården, this is the only diagnosis that uses a group instead of individually determined dedicated time slots.

According to the local process owner of the Esophagus and stomach process at NU-sjukvården there are no qualitative factors that will affect the forecasting and planning in the near future. Since this diagnosis' SCP dedicated time slots are included in the "Gastro Group", factors from the other diagnoses will affect the number of slots needed. However, for the diagnosis itself, there are no potential qualitative factors that will affect the number of slots needed in the future (Process owner Esophagus and stomach cancer, 2016; Regional process owner Esophagus and stomach cancer, 2016).

4.7.4 Qualitative Findings Head and Neck Cancer

The amount of dedicated time slots at NU-sjukvården's x-ray division for Head and neck cancer are five CT and two MRI examinations per week. The estimation of the number of dedicated time slots was made by the local process owner in discussion with process owners at other hospitals in the Region of Västra Götaland.

From the discussions it was concluded that statistically one patient per week should be diagnosed with this type of cancer. According to the process owner's experience, five patients in total needs to be examined in order for the hospital to find one patient, with this type of cancer, per week. Therefore, the decision was to plan for five CT time slots.

The two MRI time slots were however added as complementary examinations since the images from a CT x-ray examination in some cases are not considered good enough. One important characteristic of the evaluation process for the Head and neck cancer diagnosis is that when patients in this process are being examined it is quite common that other incidental findings are made. Even though this cancer diagnosis in itself does not need this many dedicated time slots, the additional medical findings may motivate an overestimation of the amount of time slots needed (Process owner Head and neck cancer, 2016).

According to the local process owner for the Head and neck cancer process, there are no qualitative factors that may affect the forecast in the near future. However, there are some medical discussions that are interesting to mention that may affect the outcome in the future. There is an increase of tumors in the tonsils, which is connected to cervix cancer. Today in Sweden, younger girls are being vaccinated against the HPV virus, which is known as contributing to minimizing cervical cancer. There is a discussion regarding if the vaccine should be offered to boys as well, which, if implemented, could change the outcome of this diagnosis. However, as for the near future there are no qualitative factors affecting this diagnosis (Process owner Head and neck cancer, 2016).

4.7.5 Additional qualitative input and factors

While conducting the interviews with the local process owner at NU-sjukvården it was noted that the answers and discussions were very detailed in their specific cancer diagnosis. To get a broader perspective of qualitative factors, an additional expert was interviewed. An industrial PhD student at the Technology Management and Economics division at the University of Chalmers, who are also the Head of education at Skaraborg's hospital group and MD Consultant in Vascular surgeon, was interviewed. Factors provided by him were tightly connected to factors provided by the theory (see section 2.3) but also to what the process owners discussed for their specific cancer diagnosis. Factors provided from the PhD student were (Head of education at Skaraborg's Hospital Group, 2016).

- Strategic goals on a local, regional or national level, such as new hospitals or additional resources in the form of machines, staff, etc.
- Staff shortages: It could be natural staff turnover, such as pensions, or it could be very sudden staff turnover, such as staff ending their employment.
- Personal characteristics of the patient as well as the medical expert. This may affect how urgent the patient requires care. Since all patients are unique, the demands are different, and these factors may have to be considered from a planning and forecasting perspective.
- Media has a lot of influence on the medical system in Sweden. If the media covers important areas for certain diagnosis, there will be an increase of examinations for that diagnosis. To exemplify: The number of skin cancer examinations increases during the summer since the media covers the topic quite extensively.
- Availability: If the medical care and the examinations are free there will be an increase of people seeking medical care.

5. Analysis

This chapter connects the theory in chapter 2 with the empirical data found from the four cases at NU-sjukvården in chapter 4. The analysis will cover an example of how the data could be validated so that it can be used in the developed forecasting process. The analysis will also cover what data to include in a forecasting process for this study's context, suitable forecasting horizon and level of aggregation, as well as different forecasting models, and steps in a forecasting process. From this chapter, a resulting forecasting process for the amount of patients in need of an SCP dedicated time slot at NU-sjukvården is presented in chapter 6.

5.1 Validating the quantitative findings

For all the diagnoses, there is a mismatch between the data set named "treatment" in the SCP data figures and the historical Cancer Register data, which displays the number of patients diagnosed with cancer for each diagnoses. A reason for this is because the registration process for the SCP initiative is not standardized, hence this validation section is needed. The treatment for certain cancer diagnoses is not done at the same hospital that examines the patient and starts the SCP process. This means that the examining hospital starts the SCP process, but if the treatment is done at another hospital, that hospital is responsible for the registration of the treatment's start. If that hospital is registering into the information system less frequent, there will be a mismatch between the SCP data and the historical Cancer Register data, as was seen in the quantitative findings in chapter 4.

The two data sets, historical data from the Cancer Register and historical SCP data, complement each other as the historical data only considers the amount of patients who where diagnosed with a certain cancer diagnosis, and the SCP data capture the amount of patients with a suspicion of cancer, named SCP starts. The SCP start data reflects the actual amount of patients that will affect the x-ray division, hence will need a CT or MRI examination. SCP start-data recorded from the initiative is the data that would be most suitable to use as the quantitative part for the amount of patients in need of an SCP dedicated time slot. However, this data is still at most one year old, which makes it instable and it needs to be validated with the amount of cancer diagnosis from the Cancer Register. When the SCP data has been collected for a longer period of time than one year, the SCP start-data could be used as the quantitative input to a forcast for the amount of patients in need of an SCP dedicated time slot at the x-ray division at NU-sjuksjukvården. This is although contextual to the specific cancer diagnosis, which the different cancer case studies has shown. Today, however, this data needs to be validated with the historical data from the Cancer Register.

In Figure 29 below, the amount of SCP start for each of the studied diagnoses will be displayed together with the SCP treatment data, and the historical data from the Cancer Register for each diagnosis. Included in the figure is the difference between the SCP treatment and the historical data from the Cancer Register. When the data is marked with a minus sign it means that more patients were registered as SCP treatment compared with the historical data from the Cancer Register. See Figure 29 below.

Urinary tract and bladder cancer				
Month	**SCP start**	**SCP Treatment**	**Historical data from the Cancer Registe**	**Difference between SCP treatment and Cancer Registe**
September 2015	55	4	9	5
October 2015	58	11	13	2
November 2015	52	10	8	-2
December 2015	57	6	5	-1
September 2014			9	
October 2014			12	
November 2014			10	
December 2014	No data available		9	No data available
September 2013			5	
October 2013			6	
November 2013			11	
December 2013			9	
Prostate cancer				
Month	**SCP start**	**SCP Treatment**	**Historical data from the Cancer Registe**	**Difference between SCP treatment and Cancer Registe**
September 2015	46	2	40	38
October 2015	65	17	48	31
November 2015	54	14	53	39
December 2015	56	16	35	19
September 2014			19	
October 2014			26	
November 2014			19	
December 2014	No data available		20	No data available
September 2013			23	
October 2013			23	
November 2013			26	
December 2013			15	
Esophagus and stomach cancer				
Month	**SCP start**	**SCP Treatment**	**Historical data from the Cancer Registe**	**Difference between SCP treatment and Cancer Registe**
September 2015	3	0	1	1
October 2015	2	0	1	1
November 2015	4	2	0	-2
December 2015	5	2	0	-2
September 2014			2	
October 2014			0	
November 2014			1	
December 2014	No data available		1	No data available
September 2013			2	
October 2013			3	
November 2013			3	
December 2013			3	
Head and neck cancer				
Month	**SCP start**	**SCP Treatment**	**Historical data from the Cancer Registe**	**Difference between SCP treatment and Cancer Registe**
September 2015	12	0	6	6
October 2015	20	0	5	5
November 2015	14	0	4	4
December 2015	14	0	9	9
September 2014			0	
October 2014			7	
November 2014			4	
December 2014	No data available		2	No data available
September 2013			6	
October 2013			3	
November 2013			2	
December 2013			1	

Figure 29 – Amount of SCP start, SCP treatment and historical data from the Cancer Register for each of the individual cancer diagnoses for the fall of 2015, 2014 and 2013

As can be noted, there is no SCP data collected for the years 2013 and 2014. This is because the SCP inititative was launched in September of 2015, hence the data is only collected for the months September to December of 2015, 2014, and 2013.

Looking at the Urinary tract and bladder cancer, the difference between the SCP treatment and the historical data from the Cancer Register is quite small. During November and December 2015, more patients were registered as SCP patients than in the Cancer Register, hence the minus sign. This may be due to the SCP registration process that was mentioned above. Looking at the historical data for Urinary tract and bladder cancer, the amount of patients that have been diagnosed with cancer historically is also fairly stable, with the smallest amount of 5 patients in December 2015 and

September 2013, and the largest amount of 13 patients in October 2015. This indicates that this cancer diagnosis is stable, and once the SCP treatment data has been collected for a longer period of time it should match the historical data from the Cancer Register.

Another way of validating the data is to calculate how many of the SCP start patients that actually get diagnosed with Urinary tract and bladder cancer according to the percentage adjustment mentioned by Cote and Tucker (2001) in chapter 2. A mean for the SCP data during the fall can be calculated for both the SCP start and the SCP treatment. For the Urinary tract and bladder cancer, the mean of both can be calculated as follows:

$$\bar{X} SCP\ start = \frac{55 + 58 + 52 + 57}{4} = 55{,}5$$

$$\bar{X} SCP\ treatment = \frac{4 + 11 + 10 + 6}{4} = 7{,}75$$

$$Percentage\ of\ SCP\ start\ patients\ that\ get\ diagnosed\ and\ treated = \frac{7{,}75}{55{,}5} \approx 0{,}1396 \approx 0{,}14$$

For the fall of 2015, roughly 14% of all patients entering the SCP intitative with a suspicion of Urinary tract and bladder cancer get diagnosed with that certain type cancer. This can be compared with the data from the Cancer Register for the same time interval. Below the SCP start-data will be compared to the historical data from the Cancer Register:

$$\bar{X} Historical\ data\ for\ the\ fall\ of\ 2015 = \frac{9 + 13 + 8 + 5}{4} = 8{,}75$$

$$Comparative\ percentage\ for\ the\ historical\ data\ \frac{8{,}75}{55{,}5} \approx 0{,}1576 \approx 0{,}16$$

Comparing the mean of the historical Cancer Register data with the SCP start-data, approximately 16% of all SCP start patients get diagnosed with Urinary tract and bladder cancer.

Now, the average percentage between the SCP start and treatment, and the SCP start and historical data from the Cancer Register is 15% (14+16/2). Using this logic the mean of patients in need of a dedicated time slot for the same time period of 2014 would then be:

$$\bar{X} Historical\ data\ for\ the\ fall\ of\ 2014 = \frac{9 + 12 + 10 + 9}{4} = 10$$

Once the mean is calculated, the mean number of the patients that are in need of an SCP dedicated time slot for 2015, using the mean percentage of 15% would be:

$$\frac{\bar{X} Historical\ data\ for\ the\ fall\ of\ 2014}{Mean\ percentage\ of\ 15\%} \Rightarrow$$

$$\frac{10}{0{,}15} = 66{,}667 \approx 67\ patients$$

As can be noted, 67 patients are more than the mean of 55,5 patients, however, more patients were diagnosed during the same time period of 2014 than in 2015.

The same calculation can be done for the same period of time for 2013.

$$\bar{X} Historical\ data\ for\ the\ fall\ of\ 2013 = \frac{5 + 6 + 11 + 9}{4} = 7{,}75$$

$$\frac{\bar{X} Historical\ data\ for\ the\ fall\ of\ 2013}{Mean\ percentage\ of\ 15\%} \Rightarrow$$

$$\frac{7{,}75}{0{,}15} = 51{,}667 \approx 52\ patients$$

As can be noted using the data for the fall of 2013, the mean for this period is closer to the mean of the SCP start data of 2015. The calculated means are very rough and will most likely never be exact since they are merely an assessments of the future, and therefore monitoring the forecasts and aiming to reduce the forecasting error is of interest so that the forecast becomes as accurate as possible.

The above validation can be done for the remaining three cancer diagnoses as well. Looking at the data for the Head and Neck it may be more difficult since no patients were diagnosed accordning to the SCP data. However, this is probably because the treatments for the Head and Neck diagnosis are done at another hospital, and that the registration process at that hospital is not done frequently.

This could also be done for the Prostate cancer diagnosis, but the data for the fall of 2015 is very unstable with large variation, which if looking at the historical data from the Cancer Register for Prostate cancer is unusual. The reason for the peak, hence the large variation for this diagnosis, is as mentioned in section 4.6.2 due to an incentive that NU-sjukvården should examine all existing patients in their Prostate cancer queue before the SCP initiative was launched. When more data is available for this cancer type, the data can be validated using the same logic as described above.

5.2 Data and factors to include in the developed forecasting process

The following sections will cover an analysis of what factors and data that should be included in a forecasting process, how the data and factors should be collected, from where, and what planning horizons that are suitable for a forecasting process for the amount of patients in need of SCP dedicated time slots.

5.2.1 Quantitative data collected at NU-sjukvården

Quantitative data is data that can be collected using numbers. In the theory, Fildes et al. (2006) presents different quantitative data that needs to be collected depending on the context and the aim of the forecast. Fildes et al. (2006) states that such data may be time series data, previous forecast, forecasts made from other departments, etc. For the purpose of this study, and for the forecasting process that is to be developed, time series data is of interest since it is related to historical data that has been collected over time and could be used as historical quantitative data for the forecasting process of the SCP cancer diagnoses.

There are different types of quantitative data that needs to be considered when developing a forecasting process. Quantitative data can be collected on different levels, such as at organizational level, in this study this would be equal to the hospital level, and on a regional level.

In this study, the regional data was provided by The National Board of Health and Welfare and has been collected since 1970, which means that there is a lot of data related to cancer available. The data was used to provide the researchers with an understanding of how the overall cancer situation has looked like since 1970. It allowed the researchers to see if there were any abnormally large trends, or if the cancer situation in Sweden has been slowly growing since 1970. The latter statements is true when looking at Figure 7. The local quantitative data that would be suitable to use for NU-sjukvården's x-ray division cannot be provided by the National Board of Health and Welfare since this data is only available on a regional or national level. In the study this data is only presented to display the total amount of people being diagnosed with cancer and the growth, which is why additional data was needed.

In order to access information about the cancer statistics at a local level additional data is needed, which was provided by the Cancer Register. This data displayed how the historical situation of cancer diagnosis at NU-sjukvården has looked like. As mentioned before, only the data for the years 2013-2015, for NU-sjukvården as a whole, was used in this study. This data is important since it is the historical quantitative time series data on a local, more detailed level, compared to the data provided by the National Board of Health and Welfare. The cancer statistics from the Cancer Register contains very little variation, and the cancer situation in Sweden is likely to maintain stable in the future as well. Due to this, the historical data from the Cancer Register is suitable data to collect and include in the forecasting process for the dedicated time slots, since the historical amount of patients diagnosed with one of the four cancer diagnoses in this study will most likely stay the same. This means that this data provides the users of the forecasting process with a good indication of how many patients that will get diagnosed with a certain type of cancer in the future. To make the forecast for the amount of patients in need of SCP dedicated time slots at the x-ray division will however not be answered using only the National Board of Health and Welfare and historical data from the Cancer Register, which means that additional data should be included in the forecasting process at NU-sjukvården..

As mentioned in section 1.1.1 the SCP initiative was launched in September 2015, and with this initiative came a new way of collecting data, namely the SCP data that is presented in chapter 4. This data is collected on the amount of patients that have, or are being examined, with a suspicion of cancer, how many patients that has gone through the process and either been diagnosed with cancer, or dismissed without cancer.

The four diagnoses involved in this study all use an x-ray examination as an evaluation step. This means that all of these four diagnoses consume capacity at the x-ray division. Therefore it should be of interest to access information about the amount of patients that actually consumed capacity at the x-ray division. For this reason, the SCP data for each diagnosis is needed as an input to the forecasting process in order to make the forecast for the amount of patients in need of an SCP dedicated time slots more accurate. Since the x-ray evaluation for the four diagnoses involved in this study takes place early in the evaluation process, the only SCP data that needs to be considered is the parameter called SCP starts. This data provides the amount of patients with a suspicion of cancer that should be offered a SCP dedicated time slot at the x-ray division. With this data, the amount of SCP patients in need of a dedicated time slot at the x-ray division can be captured and collected.

Today the data is at most one year old, which means that it is still quite unstable to use alone as input to a forecasting process. However, as more SCP cancer diagnoses are started and as time passes, the data will become more stable and eventually become very important data to include in the forecasting process for the amount of patients in need of an SCP dedicated time slot at NU-sjukvården's x-ray division. If using the SCP starts data in the developed forecasting process in present time it should be validated with the historical data from the Cancer Register for the local level at NU-sjukvården. Today, until the SCP start data has become more stable, the data can be validated using the percentage adjustment presented in section 2.4 and used in section 5.1.

5.2.2 Qualitative data collected at NU-sjukvården

Theory states that in order to produce an accurate forecast, qualitative data is also needed since contextual factors can affect the outcome substantially. Monitoring these factors can lead to better forecasts and reduced costs (Soyiri and Reidpath, 2013). Contextual factors are in many cases difficult to detect since they cannot be measured using numbers, and they may not follow certain patterns. However, not including certain qualitative contextual factors can lead to an inaccurate forecast and increased costs may occur (Soyiri and Reidpath, 2013).

From a more general perspective, qualitative data, hence qualitative factors are highly dependent upon the healthcare environment where the studies have been made (Soyiri and Reidpath, 2013; Grossman, 1972; Pierskalla and Brailer, 1994). Grossman (1972) and Pierskalla and Brailer (1994) talked about socio-economical factors, payment factors, availability, and demographical characteristics as important to investigate. These are all factors that will affect the need for medical care, and could be used as input to a forecast. From a healthcare perspective, these factors are relevant, but there are also other qualitative factors that can have affect. For instance, medical or technical breakthroughs, and regulations can affect the forecast (Daim and Hernandez, 2008).

To gain information about contextual factors for this study interviews were made. Qualitative data and factors were provided by the local process owners at NU-sjukvården, as well as by a PhD student at Chalmers who are also a Chief Physician. Since the qualitative data is highly contextual, experience and knowledge from involved staff will be needed as qualitative input to a forecasting process for NU-sjukvården's x-ray division. In this study, all SCP process owners were asked specifically about qualitative factors related to medical and technical breakthroughs, as well as regulations in their specific diagnosis. This was to make sure that the qualitative data was collected in the same way to assure consistency. However, additional qualitative factors were provided by the PhD student at Chalmers to make sure that the researchers thought of supplementary factors that could affect the outcome of a forecasting process. These factors were although more general and not directly linked to the SCP initiative for the four initial cancer diagnoses at NU-sjukvården.

Daim and Hernandez (2008) talked about medical and technical breakthroughs, and regulations, which were factors discussed with the process owners at NU-sjukvården during the interviews. These factors will most definitely affect a hospital's forecast, and can be considered as factors that are qualitative and cannot be captured in the historical data, compared to the factors discussed above. Regarding medical and technical breakthroughs, all process owners agreed that there is no likeliness that this will occur in a near future, such as 5-10 years. This is however only their personal, and medical opinion which means that no conclusion can be drawn from this as it can be seen as bias. To minimize the risk of the results becoming too bias, both local and regional process owners were asked the same questions. Including factors such as medical and technical breakthroughs, and regulations to a forecasting process are important because if a breakthrough occurs, or regulations are implemented, it will have an impact on the forecast.

For instance, when the SCP initiative was decided it took six months before the initiative was launched. This initiative placed a strict requirement on the x-ray division, namely to have dedicated time slots for the patients, which affected the demand at the x-ray division. If this qualitative factor had been excluded in a forecasting process, the forecast accuracy would have been affected and additional cost could have incurred (Soyiri and Reidpath, 2013) and the waiting times for x-ray examinations could become longer. This shows why qualitative factors, as the once mentioned above, are important to consider in a forecasting process, especially a forecasting process within the cancer care and for an x-ray division.

Three out of the four cancer diagnoses in this study also stated that they did not think that any regulatory changes for their cancer diagnosis would occur in a near future. Only one of the cancer diagnoses, namely prostate cancer, thought that a regulation may occur within the next 5-10 years. The local process owner for prostate cancer stated that PSA screening most likely could be present within the next 5 to 10 years. If PSA screening is implemented for prostate cancer it will change the amount of patients in need of SCP dedicated time slots at the x-ray division at NU-sjukvården. This is because by monitoring the patients who were identified as medium-risk patient, and start their treatment early, they will not risk becoming a high-risk patient. As mentioned in section 4.6.2, only high-risk patients are in need of a CT examination. By mimimizing the amount of high-risk patients, the amount of patients in need of an SCP dedicated time slot should also be minimized.

Additional qualitative factors outside of NU-sjukvården's context were also provided to gain broader information about qualitative factors that could affect a forecasting process for a hospital in general. Such a factor that was mentioned was strategic decisions. A strategic decision, such as if a new hospital were to be opened in the same area as NU-sjukvården, would have a huge impact on the inflow of patients at NU-sjukvården. Strategic decisions regarding capacity would also affect the outcome of a forecast significantly. For example, adding capacity, both short term by having longer opening hours at the labs, or long term by adding additional staff or new machines, would affect the outcome of the forecast since more patients could be examined. Strategic factors, such as these, are important to include in a forecasting process even though they are highly contextual. For that matter, including qualitative data related to strategic decisions at NU-sjukvården is highly relevant for the forecasting process that is to be developed in this study.

Lastly, other qualitative factor mentioned by Grossman (1972) and Pierskalla and Brailer (1994) are always important to consider when creating a forecast. However for the purpose of this study, they are not as relevant due to the nature of the data. For instance, if an organization has been present in a certain geographical area for a longer period of time, certain contextual factors, such as demographical characteristics and socio-economical factors are most likely already included into the quantitative data that can be withdrawn from the various information systems. NU-sjukvården, as an example, was founded in 1995, but the two individual hospitals have existed for much longer than that. This means that demographical characteristics, such as age and gender in the geographical area where NU-sjukvården operate in, will affect the need for healthcare and it will be reflected in the historical quantitative data provided.

For instance, if a hospital is located within an area where a lot of older men are living, there will most likely be a higher rate of prostate cancer diagnosis compared to an area where the majority of men are younger. This means that the quantitative data will reflect this in the total amount of people getting diagnosed with prostate cancer. The same argument can be discussed for a hospital that is located in an area where the average income is considered to be low. In these areas there might be a higher percentage of the population that will be diagnosed with, for example, lung cancer or cervical cancer (Clegg et al., 2009). This fact will most likely be displayed in the quantitative data as well. This means that environmental and contextual factors that authors in the theory chapter called qualitative, would in this case be seen as quantitative. This means that these factors are included in the developed forecasting process as quantitative data, not qualitative.

5.2.3 Combining quantitative and qualitative factors

From the article written by Sanders and Ritzman (2004) it is stated that a combination of qualitative and quantitative data yielded in the most accurate forecasts. Since the forecasting process that is to be developed should reflect the reality better, the forecasting process should include a combination of qualitative and quantitative factors.

There are different ways of combining data as was described in section 2.5. Qualitative input can be used to correct a quantitative forecast, which is the case in the tool Prosit. Or it can be used in the opposite way meaning that quantitative data can be used to correct a qualitative forecast. Two forecast can be created separately and then be combined, meaning one quantitative and one qualitative forecast that are created separately are combined together. The last way of combining qualitative and quantitative data is to allow qualitative input in the design of a forecast, for instance, when parameters for the forecast are selected (Sanders and Ritzman, 2004).

Since the purpose of this study is to create a forecasting process for the cancer diagnoses included in the SCP initiative and specifically for the four first cancer diagnoses, the first method (Method 1 – Judgmental adjustment of quantitative forecasts) has been evaluated to be most suitable (see section 2.5). The reason why this method is the most suitable is because it allows qualitative factors as input when a quantitative forecast has been generated (Sanders and Ritzman, 2004). As NU-sjukvården has a working quantitative forecast, Method 1 adapts well and is simple to include in the process. For instance, if a forecast is produced using a rolling forecast, and the forecast is revised frequently, the experienced and knowledgeable people will reflect upon their situation regularly. They then have the opportunity to add qualitative factors that can affect the outcome of the forecast when a certain factor is identified. The qualitative factors and the historical quantitative data will then combined be the data the forecast will be based upon. Figure 30 below visualizes Method 1 provided by the article written by Sanders and Ritzman (2004).

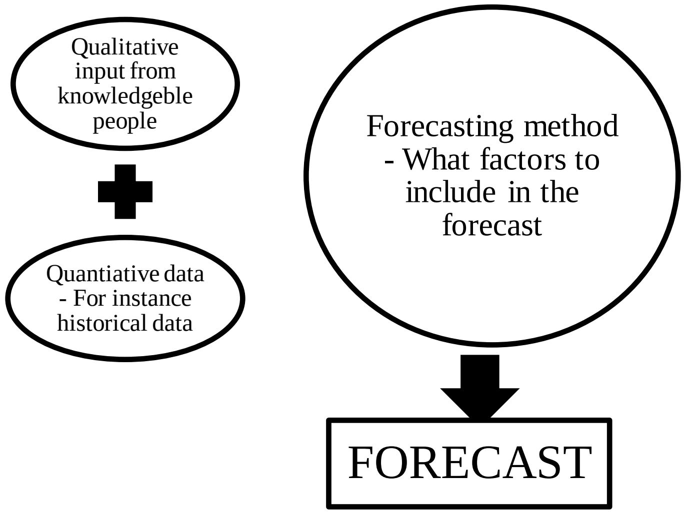

Figure 30 – Combining quantitative and qualitative data. Method 1 adopted from Sanders and Ritzman 2004

The majority of the SCP cancer processes are already initiated, but the collected data is less than one year old making it less reliable, which means that the forecast process for these diagnoses can be initiated and changed with time. As no pronounced forecasting processes are in place for the dedicated time slots it is possible to do as Method 1 suggests and adjust the quantitative forecast with qualitative input. Using expertise, together with historical data, can result in higher forecast accuracy compared to using quantitative or qualitative input separately. The combination of quantitative and qualitative data in the context of the cancer care is important as there might be situations where historical data does not reflect the reality in a good way. Having an amount of total examinations performed does not by itself create an understanding of how many dedicated times slots to plan for. Using qualitative input in such a situation is a way to find a more accurate forecast that reflects reality better.

5.2.4 Aggregation level and forecasting horizon

As mentioned in section 1.2, the estimations of the dedicated time slots are done individually with no level of aggregation. From the theory it became clear that the aggregation level and planning horizon depends on what objective the forecast is suppose to support (Jonsson and Mattsson, 2009, p.37; Jacobs et al, 2011, p.55). This means that organizations can have several planning horizons and aggregation levels. For instance, the S&OP's planning horizon is normally one year or longer, and the aggregation level is normally done based on product groups. Jonsson and Mattsson

(2009, p.112-114) state that forecasting on product group is sufficient enough when the planning horizon is fairly long. For a forecasting process, aggregation is of interest because it describes on what level the objective that is being forecasted should be planned, and also how detailed the forecast should be. This indicates that aggregation levels and planning horizons are correlated. It is important that the aggregation level and planning horizon supports the forecasts intended aim.

It is quite difficult to say on what level the data should be aggregated and planned for since it depends on what objective the aggregation and planning horizons should support, and is therefore highly contextual and cannot be treated using standardized methods. Today, NU-sjukvården does not use a pronounced forecasting process for the SCP initiative, and the amount of patients in need of an SCP dedicated time slot is done on an individual level for each of the involved cancer diagnoses. The dedicated time slots are planned weekly meaning that the x-ray division at NU-sjukvården should have a certain amount (slots) of CT and MRI examinations available for each diagnosis each week.

When it comes to forecasting for the amount of patients in need of an SCP dedicated time slot it would be good if the forecast were done on a weekly level so that it matched the planning of the SCP dedicated time slots. However, the historical data from the Cancer Register for each diagnosis is only collected on a monthly level. The SCP data is also comonly available on a montly level. There is an alternative to get the SCP data on a weekly level, but it requires a lot more processing time to get access. Since both the SCP data and the historical data from the cancer register is collected on a montly basis, the aggregation level and forecasting horizon for the quantitative data could be argued to be one month, meaning that the forecast for the amount of patients in need of a dedicated time slot is done on a montly level.

The amount of patients in need of an SCP dedicated time slot consume capacity at the x-ray division. Since the overall planning for the x-ray examinations performed at NU-sjukvården is done on a monthly basis in Prosit, it would be of interest to forecast the SCP patients on the same time horizon to see how much of the total capacity they consume. By knowning the amount of capacity the individual cancer SCP diagnoses consume at the x-ray division, there is an opportunity for the planning department at the x-ray division to see if there is a possibility to aggregate the planning of the different cancer diagnoses in terms of, for example, volume. Theory has mentioned, on numerous occasions, that aggregation can lead to a more accurate forecast. This will be further discussed in chapter 7. Lastly, by using Prosit's rolling forecast of 12 months for the forecasting process means that the developed forecasting process for the amount of patients in need of an SCP dedicated time slot can easier be plugged into Prosit, if needed.

In Figure 3 and 4 in chapter 2, which displayed variables to include in a forecasting process based on the information from the theory chapter, one of the last variables was to monitor and evaluate the produced forecast. Monitoring and revising the forecast often makes it reliable since the latest information is included in the forecast (Huang et al., 2010). For the quantitative data, arguments were made to have a forecasting horizon of one month. This means that the data for the quantitative part of the forecast is updated every month.

For the qualitative part of the forecasting process it may not be as important to update it on a montly basis. This is because the qualitative factors that were examined in this study are more long term, such as medical and technical breakthroughs. Once a breakthrough has occurred it will take a while before it may be applied to any medical diagnosis, which gives the healthcare time to consider the breakthrough and include it in a forecast process. For instance, as mentioned before, a factor that affected the forecasting at NU-sjukvården's x-ray division was the SCP initiative. The initiative was decided on a national level in March 2015, and was started in September 2015. The SCP initiative was implemented in only six months (see section 1.1.1), which shows the importance of updating the forecast information frequently. It has been mentioned that changes to the SCP diagnoses (if any are detected) are discussed during the steering committiees that take place four times per year. This would be a suitable time horizon to discuss the qualitative factors that may affect the outcome of a forecast.

With the arguments presented above, the quantitative data from the SCP data and the Cancer Register will be updated monthly to ensure that the latest data is available, and the qualitative data will be included in the forecasting process every quarter to make sure that important knowledge will be included in the forecast. Updating the forecast frequently also means that the risk of missing important information is mitigated.

5.2.5 Different forecasting models

The theory chapter presented different forecasting models that are commonly used in the industry today, depending on the validity and availability of the data (Levary and Dongchui, 1995). The theory chapter covered the regression analysis, exponential smoothing, moving average, Holt-Winter, Delphi method and the GNP. The first four models are quantitative forecasting models, and the two latter are qualitative forecasting models.

The SCP data is, as mentioned many times before, at most one year old. The historical data from the cancer register has, however, been collected since 1970 and contains a lot of information about the different cancer diagnoses involved in the SCP initiative. If using the arguments from Levary and Dongchui (1995) the validity and availability of the SCP data is quite low. The validity and availability of the historical data would, however, be considered as quite high. From Figure 3 the most suitable model for the SCP data would be the Delphi method or the GNP, and for the historical data from the Cancer Register the most suitable model would be the regression analysis. This argument is to show that validity and availability are not the only factors that affect what forecasting model to use.

As mentioned in the empirical findings chapter 4, NU-sjukvården uses an excel-based forecasting method called Holt-Winter approach for the master planning at the x-ray division. The Holt-Winter approach is a type of exponential smoothing (see section 2.4). The data for the planning department at NU-sjukvården would be of fairly high availability since the data has been collected internally for many years, and the validity is also fairly high since the clinic management needs to approve the data before it is used. As mentioned previously in section 4.4.2, Holt-Winter was chosen on trial and error, where it provided the lowest forecast error.

According to Levary and Dongchui (1995) exponential smoothing was suitable to use when the availability and validity of the data was moderate, which does not seem to be the case for the data that NU-sjukvården's planning department uses. The difference between the Holt-Winter approach and a regular exponential smoothing approach is that it considers three components simultaneously, which are: level, trend and seasonality. Since NU-sjukvården uses the Holt-Winter approach, and does not add any qualitative input, their forecast for the entire x-ray division is solely based on quantitative measures. The planning staff does have the opportunity to adjust the forecast on a monthly basis, which is a qualitative input. In order for adjustments to actually be implemented into the forecast and further into the production plan, the adjusted forecast needs to be approved by clinic management, which consists of the Chief Physician and Head of the Radiology department, Head of the x-ray division at Uddevalla Hospital and the Head of the x-ray division at NÄL (Production Planner, 2016).

For a forecast process of the amount of patients in need of a dedicated time slots, the Holt-Winter approach may not be the most suitable model to use since the approach is most suitable when the demand is affected by volatility. The historical data for the cancer diagnoses involved in the SCP initiative has, during the years 2013-2015, been stable with low variation. The demand is affected by a small increasing trend, and some seasonality due to constraints in the capacity during, for instance, the summer, but neither the trend nor the seasonality is substantially large. According to Goodwin (2010) the Holt-Winter approach is a popular choice since it can react quickly to changes on the market and suitable to use when the market is affected by volatility. For the cancer situation in Sweden, the demand is stable and the market is not volatile, and for this reason it might not be the most optimal forecasting approach for the SCP cancer diagnoses. Also, the theory would rather point towards using the regression analysis for the historical data at NU-sjukvården if the factors "validity and availability" were to be used as the decision variables that decided the forecasting model. However, NU-sjukvården is using Holt-Winter for their overall production, which suits the situation well due to the seasonality and trends for both CT and MRI examinations, and to question whether or not NU-sjukvåden should use Holt-Winter for the forecast of the amount of patients in need of an SCP dedicated time slot lies outside the scope of this report. It may, however, not be the most suitable forecasting model for this study's purpose due to the arguments stated above.

5.2.6 Steps in the detailed forecasting process

Sanders and Reid (2011, p.266-267) presented five steps that were included in a forecasting process. The first step according to Sanders and Reid (2011, p. 266-267) is to decide the forecast objective. From Figure 3 in section 2.9, this had already been done, which means that for this study's forecasting process, the steps in the detailed forecasting process (see Figure 4) is to analyze and evaluate the available data that has been collected in previous steps (see Figure 3).

In this study, the quantitative data that would be collected for the purpose would be the SCP data and the historical data from the Cancer Register. This data would then be analyzed and validated using the percentage adjustment mentioned previously. This is becase the SCP data is currently not accurate and informative enough to draw any conclusions from, and the historical data only presents the amount of patients that have been diagnosed with a certain type of cancer historically. The Cancer Register data does not present the number of patients in need of an examination at the x-ray, which is why the data needs to be combined and validated using the percentage adjustment, see section 2.4.

The third step according to Sanders and Reid (2011, p.266-267) was to decide the model to use. In Figure 3, the decision was also done in the overall forecasting process, which means that the model to use has, in this step, already been decided. The third step in this study would instead be to plug the data into the chosen model, and the following step is to add the qualitative knowledge/information into the forecast. This is to make sure that the latest qualitative information is included in the forecast, so that important qualitative information that will affect the outcome of the forecast is not missed. Once the forecast is produced, it needs to be monitored by calculating and monitoring the forecasting error. Commonly used methods for calculating the forecast is to calculate the Mean Error, Mean Square Error, Mean Absolute Deviation, Mean Percentage Absolute Deviation, etc. Since the forecasting horizon has already been chosen in the overall forecasting process, the forecast is updated based on the decided forecast horizon, which in this case could be one month if following the arguments presented in section 5.2.4.

The idea behind the developed forecasting process is that the process owner for each individual cancer diagnosis can make more fact-based decisions regarding the amount of patients in need of an SCP dedicated time slot. Chambers et al. (1971) stated that the manager and the forecaster should collaborate. In this context, the process owner would be the manager and the forecaster would be the production planner, which means that they should collaborate. The production planner can aid the process owner with quantitative aspects, and together they can produce a forecast, and discuss the outcome of the forecast to see if the forecast is reasonable or not.

6. Results

This section will present the developed forecasting process for the amount of patients in need of an SCP dedicated time slot at NU-sjukvården’s x-ray division. The forecasting process will be presented together with some brief information about the process itself, and with a checklist that supports the process’ data collection step.

6.1 Information about the developed forecasting process

In section 2.9 inputs to the design of a general forecasting process was presented based on the information provided by the theory. This general forecasting process displayed the importance to decide what the forecast objective was, and who the user of the forecast should be. Theory also covered the different ways of choosing necessary data, and how the data should be collected. It was found that the data can be collected either quantitatively or qualitatively, or that it can be a combination of both. Once the input data for a specific context has been decided it is important to reflect upon the level of aggregation that the data should have, and also what planning horizon that is suitable to use. Depending on the availability and validity of the data, some suitable forecasting models were presented. The processes displayed in Figure 3 and 4 will be the foundation to the developed forecasting process presented further down in this chapter.

This SCP forecasting design and process is presented in Figure 31 and 32 further down in this chapter. The checklist that ends this chapter will support the qualitative and quantitative data collection that is needed for the developed forecasting process at NU-sjukvården.

6.2 The developed forecasting process for the SCP initiative at NU-sjukvården

The developed forecasting process presented below is a guideline for each process owner of the SCP cancer diagnoses at NU-sjukvården. Based on the theory, findings and analysis there should be an owner of the data, and for the forecasting process in this study, the owner of the data is each of the cancer diagnosis' process owner. The process owner will be responsible for the collected data since he/she is responsible for his/her individual cancer diagnosis. It is important that the process owners understand their cancer diagnosis and understand what type of data that is needed to display how many patients that are in need of SCP dedicated time slots at the x-ray division. The process owners also possess specific qualitative information regarding their process, which is important information to include in the forecasting process. The process owner and the production planner should collaborate to determine if the forecasted amount of patients is reliable, hence if the amount of dedicated time slots would be sufficient enough.

The data collection step for the forecasting process consists of a quantitative and a qualitative data collection part. Since the owner of the developed forecasting process is the respective process owner, he or she needs to understand what data to collect and why this data is important. The quantitative data can be collected in a similar way regardless of which cancer diagnosis that is to be forecasted. This is because the data reflects the demand and volume for each different cancer diagnosis in a similar way.

The quantitative data that will best reflect the amount of patients in need of an SCP dedicated time slot is the SCP start data as it displays the amount of patients that has been identified with a suspicion of cancer. This means that for the SCP cancer diagnoses that have an x-ray examination as a step in their evaluation process, the data from the SCP start reflects the amount of patients that is affecting the x-ray division. This data will be validated using the percentage adjustment (see section 5.1) on the historical data from the Cancer Register. The data is collected from ELVIS and the forecast, which is based on this data, is produced using the tool Prosit. This task is done by the Production planner.

Not all cancer diagnoses, or all patients involved in a certain process, are in need of an x-ray examination, which is an important factor for the process owner to consider. For example, the Prostate cancer that has been studied showed that only the “high risk patients” (approximately 25% of the total amount of patients) where in need of a CT-examination. Understanding these volumes is important, and something that the respective process owner needs to consider in their forecasting process. Other qualitative data and factors that have been introduced in chapter 2 and 4 should be collected through the respective process owner. This is because of the differences among the specific cancer diagnosis’ characteristics.

In order for the developed forecasting process to support NU-sjukvårdens x-ray divisions general planning the amount of patients should be forecasted on a monthly basis and using the same rolling forecasting horizon as the one used in Holt-Winter (12 months). This means that the forecasting will be produced to cover a period of 12 months, but will be updated monthly so that the latest data always is included. Since the studied cancer diagnoses will not be affected by any qualitative factors within the near future, the qualitative input will only be added quarterly, as a result from discussions from the steering committee’s meetings. If new information is provided from the meeting, the forecast will be updated accordingly. The quantitative and qualitative data that needs to be included in the forecasting process is presented in a checklist in 6.2 below.

The design and forecasting process for the amount of patients in need of an SCP dedicated time slot at NU-sjukvården’s x-ray division is displayed in Figure 31 and 32 below. Figure 31, on the next page, displays the design of a forecasting process based on NU-sjukvården’s context, and Figure 32 is a more detailed forecasting process once the overall parameters and inputs are decided. The forecasting process presented can be used by any of the four studied SCP diagnoses.

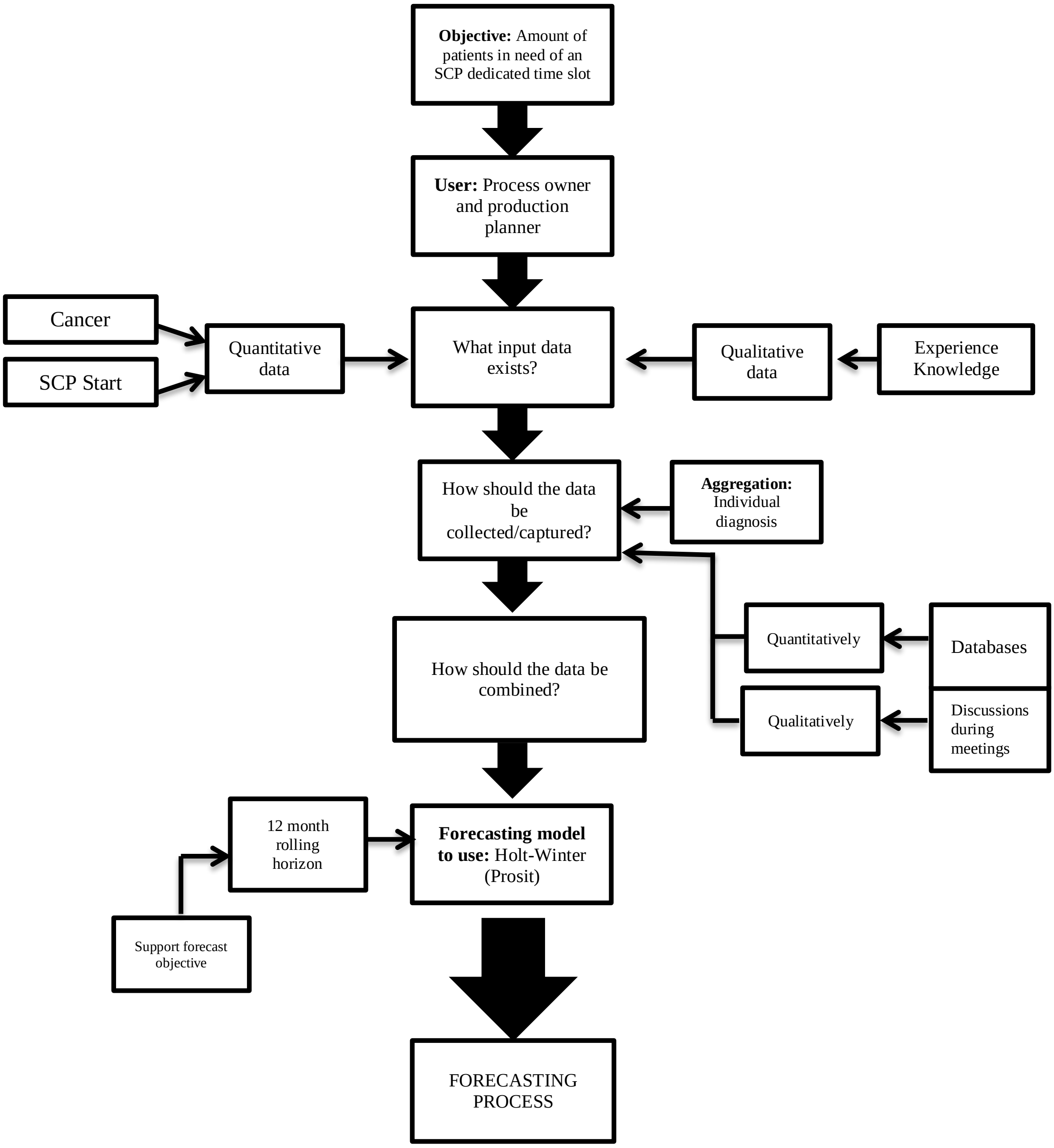

Figure 31 – The developed overall forecasting process for this study

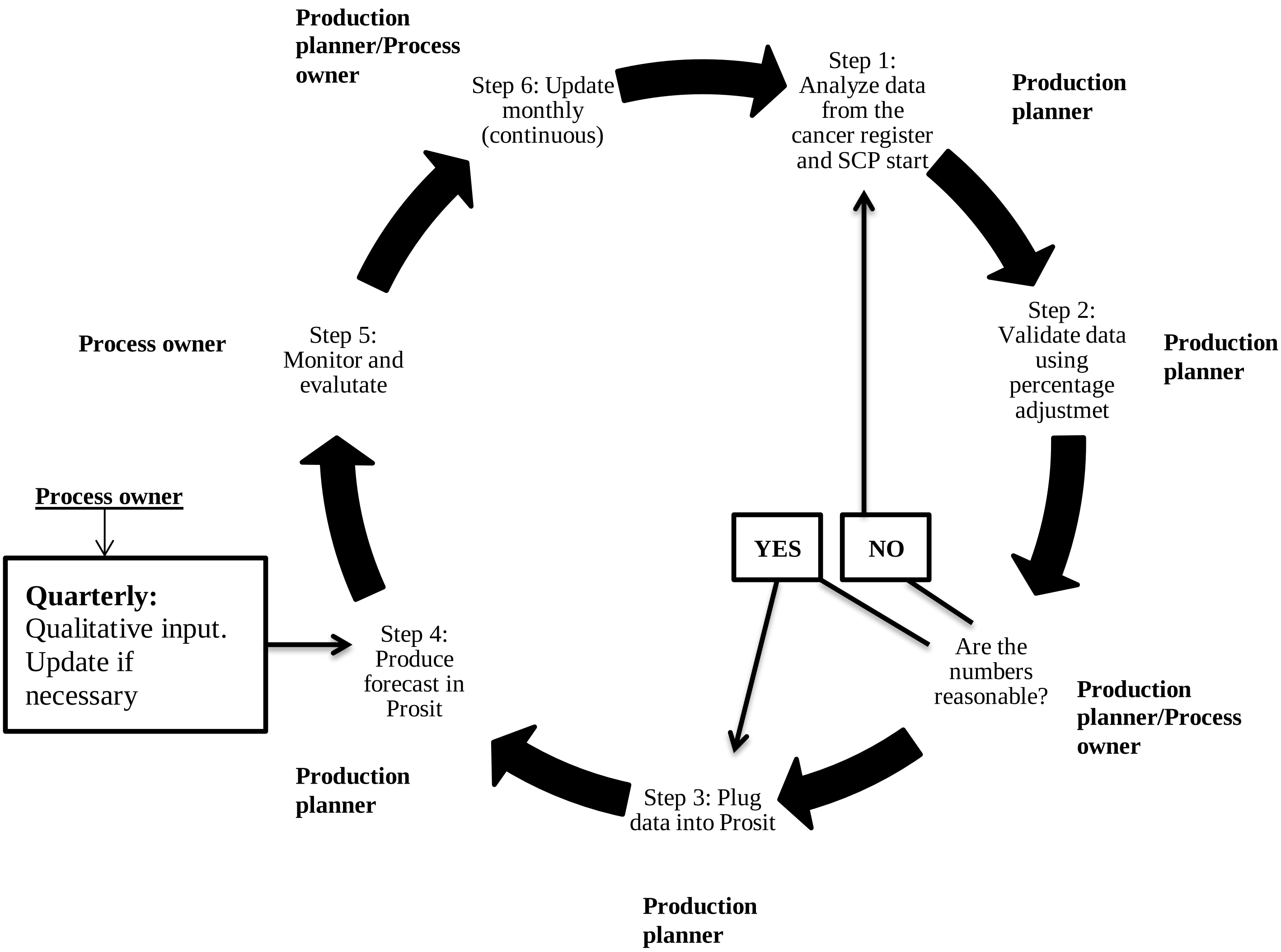

Figure 32 - The detailed developed forecasting process of activities to be done and the person responsible for performing the activity

6.2 Checklist

Dedicated time slots for________________________SCP process

Factors to include on a **monthly** basis:

Quantitative data

- ☐ Local historical cancer data from the Cancer Register
  - ☐ Uddevalla Hospital
  - ☐ Norra Älvsborg's Hospital

- ☐ SCP start from historical data*

Factors to include on the Steering committees (**quarterly**):

Qualitative data

- ☐ Medical breakthroughs/changes
  - ☐ ______________________________
  - ☐ ______________________________
- ☐ Technical breakthroughs/changes
  - ☐ ______________________________
  - ☐ ______________________________
- ☐ Regulations /legislations
  - ☐ ______________________________
  - ☐ ______________________________
- ☐ Strategic changes/decisions
  - ☐ ______________________________
  - ☐ ______________________________
- ☐ Other additional input
  - ☐ ______________________________
  - ☐ ______________________________

** Only include the data called "SCP start" from ELVIS*

As the SCP start data is not presently fully reliable to forecast the amount of patients, the historical data from the Cancer Register is included in the checklist. With time, the SCP start data will include the necessary information so that the historical data from the Cancer Register can be excluded from the process. It is however important to keep them until the SCP data is more stable and reliable to use. From the developed forecasting process, together with the checklist, a realistic and facts-driven forecast can be finalized for the amount of patients in need of a SCP dedicated time slot for a specific cancer diagnosis at the x-ray division at NU-sjukvården. Having this information from several different cancer diagnoses will then work as an input for the forecasting and planning of the SCP dedicated time slots at the entire x-ray division at NU-sjukvården.

7. Discussion

This section will discuss the analyzed problem and the results found in this study. Factors that may mean additional research in regards to the purpose of this study will be noted and discussed.

A common problem related to all information systems, registers and databases is the frequency of registrations. Since the data is registered manually by people, there is a risk that the data contains error. Even though the data is collected from a large, regional and national database, which according to Bryman and Bell (2015) indicates high quality data the issue remains. This becomes evident when looking at the recorded SCP data so far. The SCP initiative is supposed to become the standardized way of working within Swedish cancer care in 2018. As of today the data registrations for the SCP initiative are lacking, which indicates that the data is not yet mature and not reliable to solely make decision upon.

Another issue related to the SCP data is where the patients' examinations and doctors appointments are performed, and in particular who is responsible for which registration in the SCP process. The SCP initiative data is only to register a patient's start and end dates but these dates do not necessarily have to be registered at the same facility. The end date is either when the patient starts their first treatment, or when the patient is dismissed with no sign of the evaluated cancer diagnosis. For instance, an SCP patient might be examined at NU-sjukvården, which indicates that the SCP process starts there and that the start-date is registered at that hospital. What complicates the registrations further is that some of the cancer diagnoses that started at NU-sjukvården are not treated there, and are instead transferred to another hospital for treatment. This means that the hospital treating the patients has to register the status of the patient. If this hospital has a less frequent registration process, the data for the different cancer diagnoses are not reflecting reality, meaning that the lead times and information flow for diagnoses that switch facilities are not as accurate as they could be. According to some of the local process owners at NU-sjukvården this was an issue for certain cancer diagnosis and is something that is in need of consideration if using the SCP data for analysis and forecast processes.

The forecasting process that has been developed in this study is develop for NU-sjukvården's work with the SCP initiative and is not general for other medical facilities in Sweden. However, this forecasting process' mindset could be implemented for other diagnoses as well, meaning including both qualitative and quantitative factors. By including both qualitative and quantitative factors in the forecast, the forecast error may be reduced, which will make it more accurate. What was displayed when only qualitative factors were used for the estimation of the dedicated time slots for Urinary tract and bladder cancer was that the amount of patients in need of a dedicated time slot differed significantly during the different weeks (see Figure 23). By considering the developed forecasting process in this study, the forecast for the amount of patients in need of an SCP dedicated time slots can become more accurate and the variation can be reduced.

As was stated in previously, the SCP initiative is still in its start-up phase, it is too early to say if the dedicated time slots should be aggregated or be planned on an individual level. However, there are some general aggregation thoughts about what NU-sjukvården could consider in the future, if the context would allow it. For instance, the overall planning at the x-ray division, the forecast is made for each x-ray resource, i.e. one forecast for the MRI and one forecast for the CT, etc. There is also a possibility for NU-sjukvården to aggregate the planning for the SCP dedicated time slots by using the same logic as the Esophagus and stomach cancer process, namely to group examinations of different parts of the body that falls into the same category, or maybe aggregate based on diagnoses that have the same volume or similarities in their processes. Aggregation is beneficial since it allows the planning to become flexible (Diam and Hernandez, 2008), which is something that NU-sjukvården should look into. However, aggregate the different diagnoses for the forecasting process may not be as favorable. Instead, each individual cancer diagnosis can be forecasted separately, and once the amount of patients in need of an SCP dedicated time slot, for each cancer diagnosis, is known, NU-sjukvården can analyze if there is a possibility to aggregate or not.

8. Conclusions

Long waiting times are an issue in Swedish healthcare. The objective of the SCP initiative is to shorten the waiting times and minimize the regional variation, which will lead to improved patient satisfaction. This study had its focus on one of the bottlenecks contributing to long waiting times, namely the x-ray examinations. To enable faster access to x-ray examinations, the SCP initiative has introduced dedicated time slots as a way to improve the speed in cancer care. The problem with these time slots is that there has been no pronounced forecasting process in place to decide the amount of patients in need of an SCP dedicated time slot for a specific diagnosis. This has either contributed to unfilled time slots, and by that missed usage of the available capacity, or lack of time slots, which means that cancer patients does not get access to the x-ray division at a satisfactory level.

The current process of deciding the amount of dedicated time slots is only performed by local process owners for their respective cancer diagnosis. Some has partly used quantitative data in their estimations, but for the majority of the diagnoses, the decisions have been made on experience and trial and error methods. As a result, mismatches between the estimated dedicated time slots and the actual demand occurred. Literature consequently emphasize on the combination of quantitative and qualitative data and factors in order to make the forecast as accurate as possible. This study was conducted in order to develop a forecasting process for the amount of patients in need of an SCP dedicated time slot by identifying what input data and factors that need to be included in such a forecasting process.

An improved forecasting process suggests what data and factors that are needed, how the data and factors should be collected, who the user of the forecasting process is, and how often the data and factors should be revised. Quantitative data should be collected using the SCP start data and validate it using the percentage adjustment for the historical data from the Cancer Register. Qualitative data is more contextual and should be collected depending on what type of cancer diagnosis processes it is to support. Some processes are similar to each other, which concludes that they can more or less be treated with similarity, while other diagnosis are more different, which means that the qualitative data for those processes are highly contextual. The qualitative areas to include in a forecasting process are for each diagnosis different and depending on the characteristics of the disease and some factors are more important for one diagnosis than it is for another.

The intention of the study was to create a forecasting process, within the cancer care, that could be conducted in order to decide an appropriate amount of patients in need of dedicated time slots at NU-sjukvården’s x-ray division. Since there are contextual factors for every cancer diagnosis, the study was not to generate an exact version of how to find the optimal amount of time slots for each diagnosis. The forecast process is instead created to support the process owners, x-ray planning staff and others in their forecasting and planning work. The generality of the proposed forecast process could be used as a general comparison process for the implementation of future SCP cancer diagnosis, and possibly also for other medical diagnoses, which are in the need of dedicated time slots in their evaluation processes.

9. Recommendations to NU-sjukvården

In a forecasting process it is recommended to use both quantitative and a qualitative data and factors combined. From NU-sjukvården it was understood that the dedicated time slots has been decided mostly upon qualitative information, which has proven not to reflect reality in a sustainable manner. Even though the statement that a forecast is almost always incorrect, the developed forecasting process from this study can aid the forecasting and planning process towards a more accurate way of working with dedicated time slots for a cancer diagnosis, which supports the general problem at the x-ray division. Therefore, NU-sjukvården is recommended to implement a forecasting process for each of the SCP diagnoses, and to use both quantitative and qualitative data and factors in order to make the forecasts as accurate as possible. NU-sjukvården is recommended to use quantitative input data from the SCP start and validate it using historical data from the Cancer Register for each of the diagnoses. The qualitative inputs come from the local process owners, coordinators and other involved staff. The quantitative data and input should use Holt-Winter's rolling forecast of 12 months and be revised on a monthly basis so that it is consistent with the overall planning of the x-ray division at NU-sjukvården. The qualitative factors needs to be revised more seldom. Since NU-sjukvården's steering committee meet four times a year, this would be a suitable revision time horizon for the qualitative factors that may affect the outcome of a forecast.

The idea behind the developed forecasting process is that it may also, in the future, be used for various medical diagnoses and divisions, which enable a more comprehensive process to support different divisions' master planning initiatives. There has been resistance within the healthcare industry, compared to the industrial industry, to use planning and logistical approaches. This is because the healthcare industry handles people, who are considered as being unique, hence standardization is more difficult within this field. However, data collection within the healthcare industry, still proves that the total demand situation, for many diagnosis, is stable with low variation which, should lead to a rather pleasant forecasting and planning situation. By properly introducing the conclusions drawn from this study, and many other studies within the same field, the perceived forecast and planning problem can be manageable in different, but rather simple ways. By sharing information among the different departments, and also among different hospitals, opportunities to learn from each other can be realized.

Suggestions for further studies are as follows:

- Can this forecasting process using dedicated time slots be used for all different demands put on the x-ray division?
- Can the forecasting process be used for other medical diagnosis outside the cancer care?
- To what extent can the SCP initiative ideas be implemented as a means of standardizing other departments besides the cancer care at NU-sjukvården?

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Appendix A – Initial interview sheet

Interviewers: Filip Lagerstedt and Isabelle Sahlén

- Are you familiar with the SCP initiative?
- What are your feeling towards/perception of the SCP initiative?
- How does the hospital work with the SCP initiative?
- Do you have a close communication with the primary case?
  - How does the flow of referrals look like from the primary care now that the initiative is up and running?
  - Have you experienced an increase or decrease in the number of patients being examined for cancer?
- Has the SCP initiative affected the planning at the x-ray division? If yes, how?
- What type of x-ray examinations does the hospital offer?
- How many of each x-ray machine does the hospital have?
- How many x-ray examinations do you perform per day/month/year/time period?
- Are you working with dedicated time slots? If yes, how did you forecast/estimate the number of slots needed?
- Of the existing SCP diagnoses, which one is the biggest one? How does this diagnosis affect the x-ray division?
- What do you consider to be your bottlenecks?
- What are your goals?
  - Are your goals connected to the goals set on a national level?

Appendix B – Planning at NU-sjukvården's x-ray division

Interviewers: Filip Lagerstedt and Isabelle Sahlén

- What type of tool is used for the planning at NU-sjukvården?
- What type of data does it consider?
- How is the forecast for the x-ray division conducted?
- What planning period are you planning according to?
- For the SCP diagnoses, are they aggregated in any way?
- Do you collect data so that the number of patients examined for a suspicion of cancer is registered?
- How does the capacity at NU-sjukvården look like? Do you have sufficient capacity?
- Are there any types of requirement that have to be considered for certain x-ray examination? Such as additional time per patient, additional education for the staff, etc.?
- How has the situation looked like historically?

Appendix C – Prosit

Interviewers: Filip Lagerstedt and Isabelle Sahlén

- How does Prosit work?
- Why was Holt-Winter chosen as a suitable choice for NU-sjukvården?
- What planning horizon does it consider?

Appendix D – Qualitative factors for the process owners

Interviewers: Filip Lagerstedt and Isabelle Sahlén

- Do you have a local process map for your process? If yes, is it different from the one available on a national level?
- From where do you get your demand? Primary care, specialist care, additional departments, etc.?
- What factors affect your capacity?
- Are all patients in this SCP processes examined using either CT or MRI?
- Do you have to re-do the x-ray examination of a patient often?
- How did you forecast the number of dedicated time slots being used today?
- How does the historical data look like?
- What factors affects the forecast?
- Are there any qualitative factors that might affect the forecast today and in the future?
    - Medical qualitative factors?
    - Technical factors?
    - Regulations and legislations?
    - Strategic factors?