Comparing resource use and outcomes for hip, heart and stroke treatments

A case study to figure out how much health improvements Norwegians are gaining for additional health spending

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Master Thesis
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UNIVERSITETET I OSLO

15.06.2016
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http://www.duo.uio.no/

Print: Reprosentralen, Universitetet i Oslo

IV
Abstract

**Topic:** Compute the return of spending from additional money spent, in defined diagnostic categories and state how much Norwegians are paying for an extra quality adjusted life year (QALY). Decide in which diagnostic category the use of additional resource is a valuable intervention and define the group that benefits most.

**Research Question:** How much do Norwegians have to pay for an additional QALY in the different diagnostic categories including hip, heart, and stroke, related issues and what is the benefit of using more resources in terms of health outcomes?

**Methods:** The primary task of the thesis consists of the calculation of the marginal cost per QALY for the different diagnostic groups whereby the incremental costs were compared to the incremental gain from an intervention. The incremental gain consists of the expected length of life and the expected quality of life after a medical event, after receiving treatment, times a value called p. P is standing for the 30-day survival probability gained after incrementing the length of stay (LOS) in all hospitals by 1 day in the three diagnosis groups. This value is estimated by performing linear regressions in SPSS from ”Norwegian patient registry” data. The other values inserted in the calculation (Excel) are based on assumptions from the literature. In order to show the results with the means of a cost-effectiveness plane and the cost-acceptability curve 1000 random calculations were performed in Excel for generating the needed cost-effectiveness pairs. Additionally it was tested whether the different interventions are likely to be found cost-effective under different WTP thresholds.

**Results:** The results are diverse for the diagnosis groups. The only group showing marginal costs per QALY under a specified threshold of 700 000 NOK is the diagnosis related group (DRG) heart with a value of less than one third of the threshold. For the other diagnosis groups the intervention of increasing the hospital stay by one day was not regarded to be cost-effective showing values for a costs per extra QALY which are far beyond the set thresholds.

**Conclusion:** In the DRG heart, an increase of the LOS by one day is a valuable option in order to increase average survival rates of Norwegian hospitals although not cost-effective for all years, whereas for the other DRGs the intervention was mostly not regarded to be cost-effective. It is recommended that research should include more years and a greater number of DRGs to find correlations which can be generalized.
Preface

I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources and that I have explicitly marked all material that has been quoted either literally or by content from the used sources.

I would like to take this opportunity to express my gratitude to my two university supervisors Hans Olav Melberg and Nils Mevenkamp for their time, valuable input and constructive feedback throughout the master period.

I would also like to thank Marc Fiedler for his constructive comments on the thesis and Georg Wimmer for establishing this contact.

Finally I would like to thank my friends and family for being helpful and supportive during my studies.
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List of Abbreviations

ABF  activity based financing
AMI  acute myocardial infarction
C    cost of an additional hospital day
CEAC cost-effectiveness-acceptability curve
CEP  cost-effectiveness plane
DRG  diagnosis related group
ICU  intensive care unit
l    expected length of life after a medical event with received treatment
LOS  length of stay (in a hospital)
NICE the National Institute for Health and Care Excellence (UK)
p    30-day survival probability gained after incrementing the length of stay by 1 day
q    expected quality of life after a medical event with received treatment
QALY quality adjusted life year
Qol  quality of life
WTP  willingness to pay
YLL  Years of life lost
1 Introduction

The main objective of this thesis is to compute the return of spending from additional money spent in health, for some diagnostic categories in Norway. In other terms, the question is how much health one gets as an outcome of the money spent in different sectors in health care. Those topics are important, as they enable informed policy decisions especially in terms of priority setting, which is gaining importance because of scarce resources and unlimited wants.

The question of principle is how much money has to be spent, in order to gain higher survival rates. Additionally there should be carved out differences between diagnostic categories if it is shown that variation exists. In this work, three fields of diagnostic categories are used DRG 121 E/F & 122, DRG 210/211 and DRG 14A/B, which are referred to, as heart, hip and stroke respectively in order to facilitate general understanding.

Combining heart, hip and stroke related issues, seems to be particularly attractive as there are studies available comparing exactly these three fields. Additionally there is much evidence in the literature that different types of diagnosis are handled differently in the calculation of the QALY values. Big differences can be observed in the estimation for a value of the quality of life (Qol), which is particularly important because this influences the results of the values for a QALY. Furthermore, large variation can be found in the willingness to pay for different diagnostic categories (Bobinac et al., 2012; Busse et al., 2011; Claxton et al., 2013; Neuman et al., 2014; Paulden et al., 2014).

Norway seems particularly interesting and appropriate for conducting a study examining these issues, because it is somewhat special in many different approaches. First point to mention is Norway’s unique position in terms of data density. In Norway, hospitalizations in all Norwegian hospitals, private and public and for all diagnosis groups are registered by the Norwegian patient registry. This makes it possible to state prevailing facts about the entire population in terms of health related issues concerning hospitalizations (NPR, 2014-2015; ssb, 2016). An additional benefit of this enormous amount of data available is that this facilitates evidence-based policymaking. Second, Norway is special in terms of geographical issues and concerns about the population density, which complicates the medical supply, especially for specialized care. A third point to mention is that the country is facing a similar problem as nearly all industrialized countries, namely an aging population and therewith the need in improving the sustainability and efficiency of the social- and the healthcare systems (ssb,
As a last topic, the special history of the Norwegian healthcare system must be mentioned, the development of the DRGs, and the changing payment and responsibility structure of the last decades. Especially because it is known that the way hospitals are paid highly influences the hospital activity and quality. Additionally each payment structure has its drawbacks one has to be aware of (Busse et al., 2011; Hagen & Kaarbøe, 2006; Hofsteindottir & Siciliani, 2010; Leemore, 2005; NPR, 2014-15; ssb, 2016).

To compare the Norwegian diagnosis groups, in order to decide where one gets the biggest benefit for an additional investment, it is necessary to figure out the differences between the investigated diagnosis groups in the marginal cost for a QALY. Following information is needed. i) Cost information, more precisely the costs per hospital day in the different diagnostic categories. ii) Information about the quality of life before the medical incident happened and after the patients received treatment, provided that they survived. iii) Information about the expected gain in the length of life after an event with received treatment, compared with not receiving any treatment or an alternative treatment option. As a last parameter it is important to know how much the probability of survival is increased, by setting an intervention, in order to calculate applicable values for the marginal cost per QALY. This work examines, how much the probability of survival changes, by increasing the average length of stay, for all patients in the diagnosis groups heart, hip and stroke, in the single hospitals, by one day. To sum up, variations between a) the resource-use - in terms of costs, more precisely in terms of the costs caused by one additional hospital day and b) patient outcomes on hospital level-in terms of the quality of life, c) the expected additional length of life and d) the increased probability of survival are examined. In short terms it is examined how much it costs to increase the length of stay in all hospitals, for a special diagnosis group by one day and how big the gain of that arrangement is, in terms of 30-day survival rates.

The essential result of this work therefore should be based on the variation in resource use - in terms of length of stay, and hospital outcomes - in terms of survival rates, in a solely Norwegian setting and should present the medical field - diagnosis related group -, where additional spending is regarded to be most beneficial.

All issues related to health appear to be more frequently discussed in the last decades because of increased demand for ever expanding health and health care services but facing limited resources. In the literature, different approaches exist how resource use and outcomes in the health sector are compared.
Or (2001), published a study in which the effects of health care on mortality rates were examined, showing that there is a significant influence between resource use and health outcomes, measured by the amount of doctors per capita and mortality rates. Furthermore, his results indicate that an increased share of public financing is associated with lower mortality rates.

Not only does the number of physicians seem to be important but also the fact whether they tend to keep their patients in hospital only for a short period of time or longer. According to the results of Southern & Arnsten (2015), patients who were treated by doctors who are known for longer “in hospital times” show lower mortality rates. A Swedish study from Nordström et al. (2015), validated these results among patients with hip fractures. Martin et al. (2008) suggest regarding to circulatory diseases of the British population, that an increase in health expenditure of one percent would lead to a 1.4% reduction in years of life lost (YLL), which can be seen as a recommendation for investment in this field as it can be regarded to be highly cost-effective. West et al. published an article in 2006 with the central message that human resource management, independent of the medical field or profession, should be focused, in order to decrease mortality rates by increasing the quality of health services.

The fact that a higher resource use is associated with better patient outcomes does not hold for doctors only but also for nurses. Needleman et al. (2011) showed for example that low levels of nurse staffing, lead to higher mortality rates. Which is confirmed by Penoyer (2010), where it is emphasized, that this tendency is even stronger for intensive care patients. Additionally, Dall et al. (2009) stated that an adequate amount of staffing leadsto a higher quality and therefore influences the patient outcomes in a positive way. Aiken et al. (2011) added that not only the staffing levels are important but also the average level of training of the staff.

Aside of the big influence of resource use in terms of staffing issues, one can consider resource use in a broader approach like Romley et al. (2011). They searched for a correlation between hospital spending and inpatient mortality and discovered that hospitals with higher spending, not only regarding to staffing issues but in a more general way, had lower mortality rates.

Additionally, there is some discussion about the timing when money should be spent. Whereas for example Goetzl (2009), state that prevention can be highly effective in saving money if there are programs concerning the right issues at the right time. Others like Cohen et
al. (2008) argue that in terms of cost-effectiveness preventive and curative interventions are on the same level.

Staying in the line of argumentation, concerning economical aspects, an article of Filmer and Pritchett published in 1999 has to be mentioned. They argue that public spending has to follow a special chain; otherwise, money spent in the health sector is likely to have too little impact to be regarded cost-effective. This article emphasizes, how difficult decisions in the health sector can be and indicates that every topic has to be viewed from different angles namely the cost-effectiveness, the net impact of the public sector supply and the efficacy.

An article by Garthwaite (2012) also focused on economic aspects, but is elaborating about the consequences medical treatments can have on the labor force, especially in terms of innovations made in the medical sector. This article shows that considerations about cost-effectiveness should not only include the money used for the treatment per se but should be widened. This is mainly because the patient’s life is not ending after being released from the hospital or in a period of 30 days, like measured with the 30-day-survival rate. People who recover can and should be again part of the labor force. From an economical perspective the time frame in which the patients recover is important, the earlier they are fit, the lower the economic burden. A quick recovery is even more important from an ethical perspective, because a better health state is connected to a higher quality of life.

All this considerations about in which field resources are most beneficial to use and are leading to the best possible health outcomes and are therefore most beneficial for the society, are important for answering the research question as follows:

*How much do Norwegians have to pay for an additional QALY in the different diagnostic categories including heart, hip and stroke related issues and what is the benefit of using more resources in terms of health outcomes?*

This question should be answered by conducting research on variations in resource use and outcomes in all Norwegian hospitals. Additionally different ways of using more resources are considered, as well as how these strategies influence the outcomes. Together with information about the gain in quality of life, the gain in life length and the costs, there should be a clear result in which diagnostic category additional spending is regarded to be most beneficial as well as how high the cost for an additional QALY is in the different diagnosis groups.
2 Setting: Information about Norway

This chapter is including a description of all Norwegian specific features, in order to contextualize the results of this work and to gain a broader understanding about the country and the countries special characteristics. It starts with some general facts of the Norwegian population, which are interesting in the context of the used DRGs, in order to visualize issues concerning resource use. Therewith questions like “how many resources should be used for what” are increasing in importance. Additionally included are a short description of the most important facts about the actual health situation of the Norwegian population, the geographical specialties and the organization of health care under these geographical circumstances. This is followed by a description of the Norwegian patient registry, the Norwegian history of DRGs and the DRGs used in the thesis, as well as important developments in the health sector.

2.1 General information about the Norwegian population

Norway’s population is 5 213 985 people (1st January 2016) with a population growth of about 50 000 people in 2015. In 2012 the population exceeded 5 million for the first time which is an increase of over 1.7 million people since 1950 (ssb, 2016). The actual Norwegian life expectancy at birth is 80.4 years for men and 84.1 years for women. The actual population distribution in terms of age groups shows, that 24.1% of the population are in the age group from zero to 19 and 14.3% are older than 67 years.

Figure 1: Key facts about the Norwegian population. Source: Statistics Norway
Actually 11% of the population are 70 years or older and it is expected that the age group of people who are reaching the age of 70 or more, will double in the next 30 years as a consequence of the baby boomers after the Second World War. It is estimated that in 2060 every fifth person living in Norway, will be at least 70 years or older. The same growth is expected for the 80-89 year olds, as their share is expected to rise from the current 3.4% of the population to approximately 7%. For people older than 90 the number is expected to rise from 0.8% to 2.5% in 2060. An interesting development from the last decades is that 41% of all households are single households; this amounts to almost one fifth of the population (NPR, 2014-2015; ssb, 2016). The aging population, as well as the amount of people living in single households, indicates that the state is gaining an ever higher responsibility, in terms of the treatment and the rehabilitation of hip, heart and stroke related issues in the next decades. The importance of the best possible treatment, in terms of patients’ health outcomes while having a decreased resource use due to the higher amount of patients who need treatment, will increase.

2.2 Health matters of the Norwegian population

Over the last century the life expectancy in the Norwegian population increased by about 25 years, up to the current values of about 80 for men and 84 for women. In addition to the increase of life expectancy, also the number of healthy life years increased. According to lifestyle habits, the health related development in Norway is pulled into different directions.

Figure 2: Health and Health Services in Norway. Source: Statistics Norway
While the smoking rate fell from more than 50% for man and more than 30% for woman in 1970 to 13% in 2015, the Norwegian population is considerably gaining weight. About 10% of the population is obese and 30% overweight compared to 5% of obese people in 1995. This is especially important because overweight people have a higher risk of cardiovascular diseases like acute myocardial infarctions and strokes. Additionally it is general knowledge that being obese is obstructive in the rehabilitation after fractures because of a complicated healing process like for example due to a limited mobility.

In Norway about 85% of all health spending is publicly financed. Most of this money is used for medical treatments which include all hospital services, doctor visits, dental care and physiotherapy. The health care services paid by the state, account for about 10% of the GDP, whereas the health expenditure is steadily increasing. In 2015 the per capita expenditure for health was totaling up to 60 000 NOK per year. Within the specialist care sector most of the money (about 60%) is spent on physical illness and injuries. Although the majority of patients are treated out of hospital, three in ten needed treatment at a general hospital. In 2014, 3.5 million over-night stays were recorded in general hospitals (NPR, 2014-2015; ssb, 2016).

### 2.3 Geography and organization of the health care

Norway is a big country in geographical terms with 361 191 square kilometers - Svalbard and Jan Mayen included. The county shows huge differences in terms of population density, whereby about half of the population is living in Helse Sør-Øst and about one fifth in Helse Vest. The rest of the population - which is slightly more than 1.3 million people, is spread over Helse Midt-Norge and Helse Nord, which is therefore a huge sparsely populated area. Resulting from the size of the Norwegian health districts and the hospitals located in them, it is logical that there is a strong variation in the number of patients treated.

![Figure 3: Norway in terms of population density & the structure of the health sector. Source: Rasmussen, 2012](image)
The four big sectors can be seen as the regional health authorities (RHF), who are then split into 29 health enterprises (HF) included in the dataset and to these health enterprises, the single hospitals can be assigned. As already mentioned above most of the health care system is publicly financed so it is funded mainly over taxes, and the state is the owner of all public hospitals. In the dataset from the patient registry, there are 57 hospitals included in the thesis and data for the years 2010, 2011 and 2012 and the amount of private ones is varying between 20 and 30 in the different datasets. The overall supervisory responsibility of the health authorities and further downstream of the hospitals, is in the hands of the Ministry of Health and Care Services. The Health Regions (RHF) are responsible for an effective operating of the hospitals and have to make sure that there is an adequate supply of specialist health care in the whole region. The general practitioners, care for elderly, dental care, public psychotherapy and other issues related to mental health, are it the responsibility of the 430 Norwegian municipalities (NPR, 2014-2015; Rasmussen, 2012; ssb, 2016).

2.4 The Norwegian patient registry

The Norwegian patient registry was started on the 01.01.2002 and is directly subordinated to the Norwegian Directorate of Health as a central unit. Direct authority from the Health Directorate is the Ministry of Health and Care services. All patient data is gathered in order to be able to conduct sound scientific investigations with the main goal of being able to base future political decisions on evidence and to be able to estimate future medical and care needs as well as facilitating decisions for which sector higher spending is appropriate (NPR, 2014-2015). All patient data, the diagnosis group, the length of stay, the survival rates and a few more aspects is gathered automatically.

2.5 Norwegian history of DRGs and important developments in the health system

DRGs - diagnosis related groups - were first used in the Medicare Program in 1983, as a parameter to measure hospital production. Reasons of different countries for introducing
DRGs, varied from budgetary allocation issues, to receiving an easier patient classification, over a precise description of hospital activity, to reasons considering payment structures and hospital output measurement. In the last decades, a fundamental issue was transparency. The payment via DRG points is now widespread because it incentivizes the providers in a way which reduces the cost per patient and increases the number of patients treated in a way, that payers and providers can collaborate on a fair level (Busse et al., 2011).

In Norway and other Nordic countries, namely Finland, Sweden, Iceland and Estonia the NordDRGs are used. This corporate project started in the 1990s and until 2002 Denmark was also included in those group and is still connected although having its own system the DkDRGs; Estonia was included in 2003. One diagnosis related group includes: “(the) main diagnosis, secondary diagnoses (a list of diagnoses), procedures (a list of procedures), age, gender, mode of discharge and length of stay” (Busse et al., 2011; 298).

In Norway the financing structure of hospitals can be divided according to different time frames into three big groups. To start with the time of the Per Diem Reimbursement, which was used from about 1970 to 1980, whereby hospitals increased activity and were incentivized to high investments in buildings and equipment. This payment structure lead to a overly high level of activity and big differences in issues related to equity and access to specialized care as it could be expected in a retrospective system where all costs are covered. From 1980 to 1997, the payment model of Block grant financing was used whereby the provider´s main issue shifted to cost containment, which lead to long waiting times and the hospitals were not able to treat all patients (Hagen & Kaarbøe, 2006). In July 1997, therefore the concept of activity-based financing was introduced. Activity based financing increased the number of patients treated and reduced the long waiting times but lead to an unplanned activity increase (Hagen et al., 2000; Hagen & Kaarbøe, 2006; Kjerstad, 2003). In the Norwegian Hospital reform in 2002 specialized care and other sectors became state owned, which lead to a change in the reimbursement system, more precisely to a mix of pro- and retrospective payment, financed partly by a block grant and partly by activity based financing measured by DRG points (Hagen & Kaarbøe, 2006).

From this time, the share of ABF and Block Grant payment varied between 40 (2002-2003 and 2006-2007) and 60 percent (2005 and from 2008) which lead to an increase of produced DRG points when the value was high and to a decrease if the share of ABF based financing was lower (Januleviciute et al., 2011). Norway recentralized parts of their medical system, especially the specialized care sector. Magnussen et al. (2007) are showing the positive and
negative effects of this process. Although “recentralization” obviously has not lead to a reduction in the overall costs at least not in the desired magnitude, it leads to improvements in cost efficiency and technical efficiency.

Paying according to DRG points has got two sided effects whereas on the one hand it can increase quality and effectiveness, on the other hand it can lead to a shift in treating only relatively healthy patients from one DRG group in order to have low production costs and great gains, like stated by Danove (1987). Martinussen & Hagen supported these results for Norway in 2009 but realized that cream skimming was a more important issue in the first years of activity-based financing. After that is was stable or even reduced for some diagnosis groups, especially since the hospital reform in 2002. Another widely used practice in order to increase the revenue was examined by Leemore in 2005 where the results suggested that hospitals upgraded the patients which means they shifted the patients into a DRG group which is better reimbursed.

Hafsteinsdottir & Siciliani (2010) showed that the way DRG groups are set, influences the way patients are treated. If for example within one diagnosis related group the treatment can be a medical one or a surgical one, the way the tariffs are set is very important. If the tariff is set only according to the diagnosis, although the treatment can be medical or surgical, the provider is attempted to under provide the surgical treatment as it is the more costly option. If the DRG is split into a medical and a surgical group, it leads to a disproportionate increase in surgical treatments.

2.6 NordDRGs heart, hip and stroke

As the DRGs are set differently in the various countries and across different health systems, the DRGs used in this thesis are described below. The information how these DRGs are defined within the context of NordDRGs was taken from the homepage of the Nordic casemix centre called “NordCase”. In the table below, one could find the Norwegian definition to the left and in the right column the English description.
<table>
<thead>
<tr>
<th>DRG</th>
<th>Norwegian Definition</th>
<th>English Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>210</td>
<td>Op på bekken/hofte/femur ekskl proteseop &gt; 17år m/bk</td>
<td>Operation on pelvic /hip /femur prosthetic surgery excluded for patients over 17 years with and without complications</td>
</tr>
<tr>
<td>211</td>
<td>Op på bekken/hofte/femur ekskl proteseop &gt; 17år u/bk</td>
<td></td>
</tr>
<tr>
<td>112E</td>
<td>PCI med AMI u/bk</td>
<td>PCI (percutaneous coronary intervention) with AMI (acute myocardial infarction) with and without complications</td>
</tr>
<tr>
<td>112F</td>
<td>PCI med AMI m/bk</td>
<td></td>
</tr>
<tr>
<td>122</td>
<td>Sirk.sykdom m/ AMI u/kardiov komplik i live etter 4 dager</td>
<td>Circulatory system diseases with cardiovascular complications including only patients who are alive after 4 days</td>
</tr>
<tr>
<td>14A</td>
<td>Spesifikke karsykdommer i hjernen ekskl TIA m/bk</td>
<td>Specific diseases of the brain without TIA (transient ischemic attack) with and without complications</td>
</tr>
<tr>
<td>14B</td>
<td>Spesifikke karsykdommer i hjernen ekskl TIA u/bk</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Definition of the different DRGs used. Source: “NordCase”

The DRGs 210 and 211 are within one description field as they are summed up in one group for the calculation later on and sum up to DRG hip. The same applies for DRG 112 E/F together with 122, and 14A/B, which are referred to as DRG heart as DRG stroke.
3 Literature Discussion

3.1 Possibilities of changing patients outcomes due to different interventions in terms of resource use

As the objective of this study is to assess how much health benefits one gets if additional money is spent in a diagnostic category, it is important for a general understanding to state different ways money can be spent in terms of resources used and to define what kind of outcome is therefore expected.

Naturally, resource use and therefore the overall patient’s outcomes of hospitals vary tremendously, between different countries and within a country, especially if a country is as various in geographical circumstances and its population density like Norway. Resource use is a broad term which sums up the length of stay (LOS) of the patients in a hospital, staffing issues, technical innovations, economical considerations, buildings and equipment and many other issues (all investments). Also hospital outcomes can be measured in several ways but very often the patient outcomes are measured due to the mortality rates or vice versa the survival rate, like for example a thirty-day survival rate.

A very important point regarding resource use and hospitals patients’ outcomes is that these measures are additionally a political issue and used for discussions and decisions concerning equity and equality, about the distribution of responsibilities and for considerations concerning budget allocations. Issues discussed, include questions about the distribution of responsibilities and who is liable for health, what influences people’s health status, how and when can, or should, the government intervene, who is accountable to pay for health interventions, the government, the society as a whole or the person him/herself and many other fundamental questions and topics (GRADE, 2008).

3.1.1 Resource use and outcomes with regard to staffing decisions

As a remarkable share of the money in hospitals is used to cover the expenses for personnel, resource use in terms of staffing decisions seems to be a highly relevant topic. It is trivial that hospitals with higher staffing levels have a higher use of resources in terms of costs. The more interesting question is whether this has an influence on the patient’s outcomes or not. Otherwise, higher personnel costs could be seen as a waste of valuable resources.
A highly discussed issue is, whether and how much staffing decisions and other decisions concerning the use of resources influence patients’ mortality or survival rates. Needleman et al. (2011) concluded that nurse staffing below the target level leads to a significantly higher mortality rate. This is exacerbated by a high patient turnover in one shift or/and if the working time is longer than eight hours, which is general practice. Similar results were described by Penoyer (2010) in a meta-analysis including 26 studies. There is a strong association between nurse staffing and patient outcomes especially at the intensive care unit. Furthermore, sufficient staff is leading to a higher quality of care, which is again leading to better outcomes. This statement agrees with the results obtained by Dall et al. (2009).

Aiken et al. (2011) showed that not only an adequate number of staff, but also the level of training can have a major influence on the patient’s survival rates, especially by reducing the number of “failures of rescue”. All the issues above with the same fundamental results are covered and thereby summed up by a cross sectional study in 12 European countries and the US by Aiken et al. (2012). West et al. (2006) showed that better treatment quality is not only connected to nurse staffing but is transferable to physicians. As a practical implication of their study they state that human resource management is not yet focused enough but has the potential to “encourage high performance and commitment amongst employees” (West et al., 2006; 998) which again leads to a better quality and therefore to a reduction in terms of lower mortality rates.

Southern & Arnsten (2015) covered the question whether there is an increased risk of mortality for patients who are treated by physicians which are known for their tendency for a shorter length of stay. They concluded that: “Policies that incentivize short length of stay may lead to worse patient outcomes. The financial benefits of shortening inpatient length of stay should be weighed against the potential harm to patients” (Southern & Arnsten, 2015; 712). In terms of mortality rates, patients who had a shorter length of stay showed 30-day mortality rates of 5.5% compared to 4.3% of those who stayed longer.

The results of a study by Or (2001) confirmed the previous results by stating that a ten percent increase in doctors leads to a decrease in the values of premature mortality by 3% for men and 4% for women. Therefore it can be stated, that a higher resource use, displayed by a higher number of physicians, leads to better health outcomes, whereby the study focused on a reduced mortality rate. Moreover this study suggests that a high share of public financing is associated with lower mortality rates. This is especially interesting in the Norwegian context.
as the Norwegian health systems is in an internationally prominent position according their huge share of public financing.

3.1.2 Best ways of resource use and the connection between economics and health

Whereby some authors like Goetzel (2009) state that “(h) ealth improvements and cost savings are achievable by providing targeted, evidence-based, and cost-effective health promotion and disease prevention programs that reduce modifiable risk factors” (Goetzel, 2009: 37) other publications show a more critical opinion towards prevention. This is not stating that the publication by Goetzel (2009) is an uncritical one, clearly differentiating between preventive services, which are saving costs like for example colonoscopies for high-risk groups and different vaccinations and others which are too expensive considering the gain. To a certain degree these results are supported by Cohen et al. (2008) especially for colorectal cancer and some vaccinations. On the contrary they claim “statements about the cost-saving potential of prevention, are overreaching. Studies have concluded that preventing illness can in some cases save money but in other cases can add to health care costs” (Cohen et al., 2008; 661). Furthermore, they show that the cost effectiveness ratios are very similar for preventive actions and different treatment options.

In an article by Filmer & Pritchett (1999) the overall impact of public spending on health outcomes was questioned. In their study, they examined the impact of public spending on child and infant mortality in developing countries by analyzing factors regarding health and other factors, such as education, culture and economics. They discovered that “(d)oubling the share of GDP devoted to public spending on health from the mean of 2.96 to 5.92% is associated with an improvement in mortality of only between 9 and 13%” (Filmer & Pritchett, 1999; 1317). They argue that there is a public health chain, which explains why a reduction of the mortality rate for a low price is, although easy to reach in theory, difficult to achieve in a practical setting. The basic thoughts behind the “chain concept” are not only relevant in developing countries and in research regarding to children and infants but also for this thesis. As a first issue, they state that health is a “production functions” which means that a change in health can be achieved by consuming more or less health services. The patient outcomes due to an intervention of increasing health services are highly dependent on the effectiveness of these services and the facts, whether they are used or not. As a second point in the research by Filmer & Pritchett, they mention the “net public sector impact”. They raise questions as to
what extent a public intervention is crowding out services, which are widely accepted and therefore used also without being incentivized by the state. As a last point they mention the “public sector efficacy”, referring to the question to what extent public spending is transformed into effective health services. They highlight that all these points must be seen as a chain. “(F)irst, public spending must create effective health services, second the existence of those new public services has to change the total amount of effective health services consumed by the population, and third, the additional services consumed have to be cost-effective in improving health” (Filmer & Pritchett, 1999; 1320). This framework emphasizes that a claim for more public health spending is a critical issue although these interventions can show great outputs if all points are fulfilled. This paper also shows that interventions in the health sector always have to be viewed from different angles which include the cost-effectiveness of public spending, the net impact of the public sector supply - supplement not replace services - and the public sector efficacy.

Garthwaite (2012) showed that innovations in the health care and medical sector could lead to big changes in terms of economic outcomes. The paper further states that there is too little attention on this issue. In this research, Garthwaite estimates the effect of taking the most wide spread drug of a special drug group (namely Cox-2 Inhibitors) is taken from the market. Although the removal was no surprise, because there were several warnings of unintended side effects and secondary health damages, the withdrawal of the product from the market was rapid. Mostly older employees with joint conditions used this drug; therefore, in the study a population between 55 and 75 years was analyzed. This group made up 14% of the US labor force. From this group about one quarter reported joint conditions of which about 20% took this drug. Because of this withdrawal, a huge amount of employees stopped working which lead to approximately $19 billion in terms of lost wages for this age group, with joint conditions in the first year after the removal of this drug. This case is only an example standing for many different treatments, which are important for patients due to the pain relief, as well due to economical reasons. For example, hip and knee replacements and a highly effective treatment for patients with an acute myocardial infarction can be seen under a similar aspect because most of these patients are nearly recovering to the initial degree of quality of life and are hence able to rejoin the labor force.

Results of this study are widening the claims towards drugs, medical treatment and care. Treatments should not only have a positive effect on the length and the quality of life but also in terms of economic effects. These expands the discussion about the question where one gets
most health for the additional money invested, to a discussion about the issue, where and how
do one get the highest level of health in a long run. This is next to ethical considerations
useful in order to reintegrate the former patients into the labor force.

3.2 Literature comparing hip, heart & stroke issues

Häkkinen et al. (2015) published a paper in the journal “Health Economics” covering the
outcome, the use of resources and the relationship of resource use and patient outcomes in the
treatment of acute myocardial infarction (AMI), stroke and hip fractures in Finland, Hungary,
Italy, Norway and Sweden. In terms of survival rates Finnish and Hungarian hospitals showed
low rates for AMI, whereby the survival rates varied about 30 percent between the hospitals,
ranging from 67.5% to 97.5% with an average value for all hospitals of 88%. The best
performing hospitals in Hungary and Finland had survival rates on the same level as the worst
performing ones in Sweden, Norway and Italy. If the hospital had a catheterization laboratory
the survival rates were mostly positively correlated but also the costs had been higher
(Häkkinen et al., 2015). Norwegian survival rates according to AMI were quite stable over the
years 2010/2011 and 2012 with a 30-day-survival rate of slightly over 87% (NPR, 2014-
2015).

Regarding to the diagnosis group covering strokes there were no results for Norway in the
study of Häkkinen et al. but for Sweden, Hungary, Finland and Italy. In comparison to
Sweden, Italy had higher survival rates, Finnish hospitals were almost on the same level as
Swedish ones which was surprising in this field because they use 30 percent less resources in
terms of the LOS; Hungary showed lower survival rates. The average 30-day survival rate for
stroke patients was 89%. In terms of survival there is not such a huge difference between the
survival rates mainly because the best Hungarian hospitals perform on the same level as the
hospitals in the other countries (Häkkinen et al., 2015). Looking at the 30-day-survival rates
from the (NPR, 2014-2015) one can see that the Norwegian rates are slightly lower at least for
the years 2010, 2011 and 2012 with a value of about 86%.

Within the diagnosis covering hip fractures, the overall 30-day survival rate showed 92% with
a variation between 80.8% and 97.2% between all hospitals included. In this diagnosis group,
the performance of all Hungarian hospitals was worse than the average level. In terms of
costs, Hungary used 18% less than Sweden whereas Finland and Norway had cost savings
compared to Sweden ranging from 29% to 37%. Only Italian hospitals used 14% more resources (Häkkinen et al., 2015).

An Italian study published in 2012 by Piscitelli et al. shows the costs and incidence of hip fractures, strokes and AMIs in the years between 2001 and 2005 in Italy. Costs for hip fractures rose from 373 million Euros in 2001 to 467 million Euros in 2005 in terms of hospital costs. This result is similar to the hospital costs for AMI with an increase from 305 million Euros in 2001 to 370 million Euros in 2005. The hospital treatment of strokes seems to be more expensive rising from 486 million Euros in 2001 to 492 million in 2005. Not only the costs but also the number of hospitalizations increased for the main diagnosis.

Claxton et al. published the Final Report of the “Methods for the Estimation of the NICE Cost Effectiveness Threshold” in 2013, where they planned to find implications for an evidence based cost per QALY threshold. Therefore, they tried to figure out the link between mortality rates, the actual cost of a life year and health spending. After that, they transformed the mortality rates into life years and QALYs. In their paper the cost per life year gained is £13830 calculated for a big group of diagnosis including cancer, circulatory problems, respiratory problems and gastrointestinal issues.

### 3.3 Resource use in broad terms and by increasing the length of stay (LOS)

As resource use does not only cover staffing issues and economic considerations, other research is available covering issues about the relationship between resource use and outcomes in a broader way. Romley et al. (2011) showed the relationship between hospital spending and the inpatient mortality rate. The study included a population of more than 2.5 million patients from Medicare within six different diagnoses, which included amongst others, acute myocardial infarctions, acute stroke and hip fractures. The results showed significantly lower values for the inpatient mortality if the hospitals were assigned to the higher spending sector.

With regards to higher resource use by increasing the length of stay Nordström et al. (2015) show that there is a strong association between the days people spend in hospitals and the risk of dying within the following 30 days after being discharged in Sweden among patients with hip fractures. Their results show that there is a critical value involved, which can be seen as the minimum length of stay. For patients who had a length of stay, which was exceeding
eleven days, a reduction of one hospital day could not be associated with a higher risk of dying in the following 30 days. Contrary results could be observed, if the length of stay for patients with ten or less than ten “inpatient” days were reduced by one day. Then the reduction of hospital time lead to an 8% increase in the risk of dying for the year 2006 and even increased to the value of 16% for 2012. It can be stated that decreasing the length of stay is associated with higher mortality rates within the following 30 days if the length of stay is decreased too much, more concisely if the LOS falls under a minimum amount of days, which can be referred to as the critical minimum value.

Martin et al. (2008) answered the question whether health care spending is improving health outcomes. They calculated for cardiovascular diseases that a 1% increase of health expenditure, which is an amount of £1.22 per person is associated with a 1.4% reduction of life years lost and therefore the value of a life year would amount to £7979 in terms of an unadjusted life year. Transforming this value into a QALY increases the cost of a life year saved to £11960 which makes circulatory diseases an interesting field for action as the NICE willingness to pay threshold is approximately £30 000. Another interesting aspect shows that the money needed for circulatory diseases increases if people live in single households. This seems to be relevant, regarding the values from the general data part for the Norwegian population, where at the beginning of the year 2016, 41% of all households were single households.

### 3.4 Variation in resource use and outcomes used in the thesis

In the thesis, resource use is represented due to the length of stay (LOS) out of three reasons. First it was available in the dataset and therefore there was the need to work with this variable, additionally “(t)here are advantages to analysing LoS, notably because information is more readily available and less subject to discretionary measurement than costs. Analysis based on LoS rather than cost may also prove more powerful at fostering behaviour change if it prompts clinicians to ask why their patients are staying longer in hospitals than are those treated elsewhere” (Street et al. 2012). Another argument for using the LOS is that it is a comparable unit and not restricted to match interventions in one country but also between countries. To sum up the LOS is a good indicator out of three reasons. i) LOS is a practical indicator people easily do comprehend. ii) LOS is often available because it is measured automatically due to the ABF payment according to DRG points – whereby hospitals are
incentivized to stay within a prescribed time interval within every DRG. iii) As a last reason the length of stay is a comparable indicator.

An interesting question arising in connection with the length of stay is why there is some variation in the LOS between hospitals. There are three main explanations to this issue.

The first possible and most common explanation is that there are different kinds of patients within the hospitals. Some hospitals, which have their main focus for example on the treatment of hip fractures are more likely to get more difficult cases for these kinds of operations, which very likely includes patients with a worse general state of health. Therefore the average length of stay in these hospitals can be influenced by the use of a longer LOS and worse patient outcomes. On the other hand, as this institute is specialized on hip fractures they also get more of the “normal” patients falling into this DRG. Regarding to the treatment of those, they may be so much better in terms of the operating procedure or from a technical standard, and/or have less postoperative complications, which decreases the LOS and increases the 30-day survival rate. Another argument that is found in the literature is that university hospitals often have worse patient outcomes because of the cases that are treated there are more likely to be complicated ones.

Another reason why there is some variation in the length of stay is agreeing with the results of different authors. i) Romley et al. (2011) state that hospitals which can be assigned to the higher spending sector show better patient outcomes. ii) Or et al. (2001), showed a connection between the number of physicians and the mortality rates. iii) As a last publication to mention is Southern and Arnsten (2010), who figured out that patients who are assigned to physicians with a tendency for a longer hospital stay have better survival rates. Therefore, it can be stated that, next to the different patient mix, there are different cultures within hospitals with regard to the average length of stay in hospitals, which influence the patient outcomes.

A third reason explaining the variation in the LOS is that hospitals have different capacities. This influences the number of patients treated but also the average length of stay, in that case due to patient turnover. If hospitals are highly frequented the length of stay is shortened, because the hospital-beds are needed again. Next to a shorter stay because of a higher patient turnover, a high patient frequency can be problematic per se, as Penoyer (2010) showed a high patient turnover leads to a worse patient outcome in terms of survival rates. On the other hand, in highly frequented hospitals, the physicians are more likely to have more experience and it is more likely to get a specialist for every kind of medical condition or operation, which
increases the probability of good patient outcomes, although the LOS might be shorter. Other reasons for the variation in the LOS could be different levels of resource use in terms of money, staffing issues, technical innovations and much more.

As an outcome variable the 30-day-survival rate was used, which also was prescribed by the dataset, as it was for this type of analysis the best one included. Next to that the 30-day survival rate is a spread indicator and similar to the LOS often available, highly practical, easy to measure and to compare.
4 Methodology

In this chapter there is given the coarse structure of the methodology in order to simplify the understanding and for getting an overview. More information about the methods and details about the variables used are in the following sections. In order to detect the marginal cost of an additional QALY in different diagnostic categories, the incremental costs of an intervention are compared to the incremental gain through that intervention. For making this possible, information is needed about the costs and about the benefits. The gain is a combination out of the 30-day survival probability gained by increasing the LOS, the expected length of life after the treatment and the expected Qol due to the received treatment. The incremental gain in the quality of life, together with the gain in life length, sum up to a QALY. The QALYs are than multiplied by the increased survival probability gained after incrementing the length of stay by one day; this sum is standing in the denominator. The numerator consists of the cost for an additional day spent in the hospital for the different diagnostic categories.

A QALY consists of the component of the increase in the quality of life due to an intervention, multiplied by the time gained through that intervention. A QALY is than calculated by multiplying the gain in terms of the life length (time gain) by the gain in the quality of life (quality gain). The calculation of QALYs, is a very spread technique in health economics because it includes the measurement aspect of time and quality which are both possible to measure. Next to that, QALYs make it possible to compare interventions from different fields and thus enable an informed decision-making. The time gain through an intervention is straightforward to measure. More difficult to obtain is the quality of life element. The health related quality of life is a value between zero and one. There are different possibilities to measure the quality gain but widely spread are the time-trade-off method, the visual analogue scale and the standard gamble. Out of different
reasons, also generic preference based measures are used, like for example the EQ-5D and the SF-6D. Referring to the time-trade-off and the standard gamble method different problems arise. First, a lot of time is needed for explaining the techniques for the people who should rate the quality aspect. It is important to be certain that people understand how to set the values according to the techniques. Additionally generic based measures can be preferred out of ethical reasons (Drummond et al., 2005; Park et al., 1990; Whitehead & Shezard, 2010; Wisløff et al., 2014). An interesting fact is that the quality aspect from the calculation is rarely touching the upper and lower bound of zero or one. “However, unsurprisingly, there is good evidence that, on average, the general population is not in this state of full health. Therefore, the quality of life score associated with the health states experienced by the general population are less than 1, decline with age and differ by gender”(Claxton et al., 2013; 56).

4.1 The way of calculating marginal costs per QALY

The calculation for the marginal costs per QALY and the means for the presentation of the results, the cost effectiveness plane and the cost-effectiveness acceptability curve were conducted in Excel. Values were available for every DRG group, for the combination of the years 2010, 2011 and 2012 and for all years separate.

1000 random numbers between the lower and the upper values found in the literature (C, l, q) and due to the calculation of the linear regressions (p) had been produced by excel for the variables C, l, q and p - in order to get approximately correct values due to a bigger volume of data. The interval for the costs variable was specified by inserting the smallest and the biggest credible value found in the literature, which was used as a cost per additional hospital day. The same structure of thinking applied for the variables l and q. It has to be noticed that the values for the upper and lower bound show a wide range, as patient’s outcomes after medical events differ tremendously. For the increased probability of survival, the intervals were set according to the values gained from the linear regressions, whereas the lower bound was set on the value of the year reporting the lowest value and the upper bound according to the highest value gained.

The actual calculation takes place upon a straightforward scheme. From all random 1000 values for all variables, and for those stated explicitly – the assumed values and the lower and upper bound - the marginal costs per QALY were calculated. First, the gain out of the combination of p, l and q was calculated and then the costs were divided by those values.
All combinations of values, which include the variables p, q and l, were transmitted into a cost-effectiveness plane and the cost-effectiveness-acceptability curve.

Taking a closer look at different interventions in the health sector one can recognize that costs and benefits are calculated in order to be sure a new intervention is regarded to be cost-effective, before introducing this project. Therefore the costs and the effectiveness are studied and these cost-effectiveness pairs are than presented as points in a cost-effectiveness plane.

It is possible to assign new interventions to one sector of the plane depending on the level of the costs and the effectiveness. On the horizontal axis, the difference in the effectiveness from point zero is presented, whereas the vertical axis represents the distance in the costs from point zero. Zero is the representative point for the actual treatment or any other option the new intervention is compared with. If there are new interventions, it is important to examine into which quadrant A, B, C or D the cost-effectiveness pairs fall. In quadrant B, the intervention is regarded to be more effective and less costly. Most likely interventions of this kind will be regarded to beneficial and will be introduced or at least preferred over the option represented in point zero. All points falling into quadrant D indicate that the intervention is more expensive and less effective and therefore it is most likely that the intervention is not a preferred option. More difficult it is to decide about the cost-effectiveness for sector A and C, as in sector A an intervention is more expensive but also more effective than in point zero and in sector C it is the opposite by being less expensive and less effective. So in A and C the choice to introduce a new intervention or not, depends on the highest acceptable cost-effectiveness ratio, which is represented by the diagonal line in the graph. In sector A all interventions which are to the right and lower than the slope are more likely to be considered than points which are over the slope; this is the same in sector C (Black, 1990; Drummond et al., 2005). To state it clearly, one would risk recommending a less effective treatment option.
only if the effectiveness is not reduced drastically while simultaneously the price is radically reduced. This also works for sector A whereby all cost-effect pairs under the highest acceptable cost-effectiveness ratio are regarded to be worthy options because the gain in terms of efficiency is higher than the cost increase.

For the acceptability-curve, the Excel-function “countif” was used. The acceptability-curve shows the probability that an intervention is regarded to be cost effective, compared with an alternative option, for different willingness to pay thresholds. The alternative option is often represented through the values which can be observed (Fenwick et al., 2006). In this thesis the observed data, and therefore the alternative option, is the number of hospital days (LOS) in the different diagnosis groups that was actually used and the intervention is represented by an increased number of hospital days by one. “The curve is constructed by plotting the proportion of the incremental cost-effect pairs that are cost-effective” in a special range. The shape of the acceptability curve is “depending solely upon the location of the incremental cost-effect pairs” (Fenwick et al., 2006; 5). If there are specified values on the x-axis, like there are in the thesis, with defined thresholds for the willingness to pay, the data on the y-axis shows the probability that the true ratio of the cost-effectiveness is below that values. If the willingness to pay threshold increases - going to the right on the x-axis -, also the probability that an intervention is regarded to be cost-effective usually increases (Drummond et al., 2005; Fenwick et al., 2006). The blue line in this graph represents the cost-effectiveness-acceptability-curve. The curve is depending on the cost effectiveness values based on the different values for the willingness to pay, represented on the x-axis, and the probability that an intervention is regarded to be cost effective under the different values assumed for the WTP (between 0 and 1) on the y-axis. The values on the y-axis cannot be solely seen as values between zero and one but can also be interpreted as percentage values. If the values on the x-axis are set – according to different WTPs - Excel counts how many percent of the, in this thesis 1000, calculated values of the marginal cost per QALY are under that threshold.
As not all health care needs can be afforded because of “unlimited wants and limited resources” it is common to have an upper limit stating how much money per QALY is likely to be paid for a special intervention. This limit is called the willingness to pay threshold short WTP. This cost-effectiveness threshold varies from £20 000 to £30 000 in the UK to about 50 000$ to 100 000$ in the US, but can take any other value according to the state´s preference. NICE “The National Institute for Health and Care Excellence” in the UK, is using a threshold interval from £20 000 to £30 000 but is focusing on the higher sector of this range. Although using a threshold, there are doubts whether there is enough empirical foundation to use the WTP threshold and it is asked for further research (Claxton et al. 2013). Neumann & Cohen (2014) and other teams of researchers, tried for example to update the 50 000 Dollar threshold which was, although it was outdated and not directly based on evidence, widespread. They calculated a new threshold, which additionally counts for our “modern-technical standards” and the change in the general condition of “nowadays patients” with for example for higher co-morbidity rates. As a consequence the threshold calculated by them was much higher, in an interval from 100 000$ to 150 000$ (Baker et al., 2010; Bobinac et al. 2012; Donaldson et al., 2011; Neumann et al., 2014; Nord, 2001; Paulden et al., 2014; Shiroiwa et al., 2010). In this thesis the threshold of 700 000 NOK is interpreted because it is assumed to be the approximate value the Norwegian government uses.

Values which were inserted in this thesis on the x-axis of the CEAC are zero NOK, 100 000 NOK and 700 000 NOK. In addition, one million and two million NOK were looked at, although these values indicate a use of resources, which is not regarded to be cost-effective, but it is interesting to know whether an intervention is changing into the direction of being cost-effective if the budget is not subject to a strict constraint.

The same procedure was followed for all diagnosis groups, all years in combination, and the years 2010, 2011 and 2012 separately and again with changed main values and adapted lower and upper values for the sensitivity analysis. The sensitivity analyses for 2012 as it is the most current year can be found in the results part, the others are in the appendix table 6 and 7.
4.2 Calculation basis - formula

For the calculation used in the thesis, in the denominator first the QALYs were calculated and then multiplied by p – the increased probability of survival. In the numerator, the costs of an additional hospital day were inserted. The complete notation is therefore described as follows:

\[ \text{Marginal cost of a QALY} = \frac{\text{incremental costs}}{\text{incremental gain}} = \frac{C}{p \cdot l \cdot q} = C/(p \cdot \text{QALY}) \]

\( C \rightarrow \text{cost for one additional hospital day (NOK)} \)
\( p \rightarrow 30 \text{ – day survival probability gained after incrementing the length of stay by 1 day} \)
\( l \rightarrow \text{expected length of life after the event with received treatment (YEARS)} \)
\( q \rightarrow \text{expected quality of life after the event with treatment [0,1]} \)

As the values for the variables inserted in the model were found due to different means, in the following chapter, the different ways the values were generated are described.

4.3 Origin of the data & description of the variables

\( p \rightarrow 30 \text{ – day survival probability gained after incrementing the length of stay by 1 day} \)

The values for p were calculated from three datasets of the Norwegian Patient Registry, which include data from all 87 Norwegian hospitals. The data was divided into the four big health districts Helse Midt-Norge RHF, Helse Nord RHF, Helse Vest RHF, Helse Sør-Øst and an additional section with the private hospitals of all 4 districts. For all three different diagnostic categories DRG 112 E/F and 122, DRG 210/211 and DRG 14 A/B and all years included, datasets from the Norwegian patient registry were used. All data used was on hospital level and not including data for individual patients.

Next to other variables, the datasets include variables of the length of stay (LOS) and the 30-day survival rate. These values were already weighted according the number of the treatments within the different hospitals. Full data was available for the years 2010, 2011 and 2012 whereas for 2013, there was a dataset available but the values of the 30-day survival were missing and therefore the year 2013 was excluded.
Within the three big diagnostic categories heart, hip and stroke there were different subgroups in the dataset. Although the diagnosis were slightly different which was observed due to the differences of the LOS they got pooled because the 30-day survival data is only available for the grouped data. Therefore, DRG112 E/F and 122 can be seen as a single diagnosis related group. The same applies for DRG 210/211 and for DRG 14A/B.

In addition, it must be mentioned that the variable p is not a probability per se but is assumed to be a probability for the short interval which is of interest for this research. This is possible because in the short section of interest, p acts like being a probability. This changes if one looks at the bigger picture. If p would be a real probability, hospitals could get a 100% survival rate by a disproportionate increase of the LOS, which is not possible in daily life.

In order to get values for p (increased probability of survival if the LOS is increased by 1) the datasets were viewed, translated to English and transformed in a way that they could be transferred to, and used in, SPSS. In a next step, considerations to detect variations in resource use, and the effects from the variations in resource use on the output were made. As the data is on hospital level, effort was made into the direction to find concrete input and output variables. Thereby the LOS in the different hospitals was seen as the input of resources and the 30-day survival rate as the output variable. One could expect that the higher the LOS the lower is the survival rate because patients who stay longer are assumed to be more sick e.g. have co-morbidities and/or a lower general health condition. In order to investigate on that, linear regressions were conducted for each year (2010, 2011 and 2012) and all the years together, whereby for the combination of the years the arithmetic mean was calculated. All hospitals with the LOS = 0 were excluded in the analysis because that would indicate that the patient died or was transferred into another hospital. This is important because if the patients with zero hospital days would not be excluded one could assume that sicker patients have a shorter length of stay because of increased mortality rates. Contrary to that expectation, a higher length of stay is linked to a higher 30-day survival rate in all three diagnosis groups, for almost all years. It can be concluded that a higher use of resources in terms of the LOS is leading to higher survival rates. As the assumption - the longer they stay in hospital the sicker the patients are and the lower the 30-day survival is - would point into the opposite direction, the direction of the results can be seen as correct furthermore the bias is helping to underpin this results and makes them more conservative ones.
As these values cannot be generated from the datasets of the Norwegian patient registry, they need to be based on assumptions. In order to estimate proper values for the costs per hospital day (C) in the different diagnostic categories, the expected length of life (l) after the event and the expected quality of life (q), an extensive literature research was conducted.

The main part of the articles used, had been extracted from the Databases Cinahl, Pubmed and Medline, some were detected with the searching-engine Google-scholar. In order to gain additional articles, a snowball search on Google-scholar was performed. For all DRGs used, meta-analysis and systematic reviews are included. Overall, for the DRG hip 70 abstracts were viewed whereby data out of 24 articles was included, for the diagnosis referring to heart issues 39 abstracts were viewed and 13 articles were taken and for strokes 48 abstracts came into consideration and 22 articles got chosen.

It was attempted to include only articles published after 2005, because the medical field is changing rapidly and as new technologies or a new operation/treatment procedure are introduced, values for the costs, quality of life and gain in life length change a lot. Articles older than 2005 were only used if they gave some insight how the different values are connected and/or showed an explicitly good methodology. Most of the older articles included were found due to the snowball sampling method. In the literature research, articles had also been included, which show similar diagnosis or types of treatments to those included in the thesis. Although these articles had not been used to calculate the values used in the analysis, they helped to gather an extended knowledge. The focus was on studies from Europe; non-European ones were included if they seemed particularly relevant. Like regarding to older articles, values from non-European studies were not used explicitly but were viewed to check whether the values are approximately correct. In order to reduce bias, all recommended values from the literature were first transformed into Euros to be easier manageable because of the clearer presentation and afterwards for the calculation, transformed into Norwegian Kroner (NOK). The values inserted into the model are stated at the end of each page of appendix 2, 3 and 4. It can be observed that relevant figures are often not given directly but within the context, this information can be found in the column additional.

For the calculation, a few components were given special considerations, namely the number of samples in the articles, the type of publication and the publication years.
As the data for the calculation was based on assumptions, some technical issues have to be considered especially for the QOL and the length of life. It was assumed that the QOL is the same with a hypothesized old, and a new treatment so there is no gain between two treatment options but it was assumed that patients would die without treatment, so the gain in the QOL is as big as the expected quality of life after the treatment. The same reasoning applied for the increased length of life as AMI and stroke are acute diagnosis and an untreated hip fracture can lead to death in form of internal bleedings or to a shortened life expectancy because patients are confined to bed. In all the different DRGs, a non-treatment is not an option. The variable “l”, the gain in life length, is as the QOL not compared to another treatment option but displays the expected average gain in life years for those who survive.

As in most studies only the cost for the total procedure was given, the number and the costs of days at ICU and the ward days were figured out than the overall value was separated accordingly. Therefore, it should be marked that it is possible that the costs used are more likely to display the average hospital day cost for the specified diagnosis groups, than to express the costs of an additional hospital day.

In order to be sure about the basic statements in the result part, an exact sensitivity analysis was conducted. Whereby the sensitivity analysis for the cost part is the same for all DRGs from the qualitative aspect - the lowest and highest values stated in the literature for an additional hospital day with especially this diagnosis were used. For the other variables and as there is not that much scattering in the literature, the values had been tested with upper and lower values of +/-25% and are therefore conducted in the same way additionally from a quantitative approach.

### 4.4 Values inserted into the formula

The values inserted in the model, demonstrate many differences between the diagnostic categories but also similarities. For the costs per hospital day, the values based on the assumptions from the literature, vary between 4000 NOK per day for hip related issues, over 5500 NOK per day for heart related ones, up to 6800 NOK per day for the diagnosis group, which refers to strokes. Whereby there cannot be made a reliable statement whether this values are expressing average or marginal costs for a hospital day. Additionally it is not clear whether in this case average and marginal costs substantially differ.
The different values for the costs per an additional hospital day can be explained by the differences between the diagnosis groups. As hip patients normally have a relatively short time spent on ICU, this time is prolonged for the DRG heart and is once again longer for stroke related diseases. Taking the average cost for a hospital day is a mixture between ward days and days spent at intensive care unit, so the more days spent on ICU the higher the cost per hospital day. Evident from the literature research was that especially stroke patients are more care-intense patients. The same is true for heart patient but out of a different reason. As heart patients often stay a short time, the maintenance effort in this time is very high.

The average LOS in the data from the Norwegian patient registry for heart patients was less than three days for all three years with a variation between 1.5 and six days with a 30-day-survival rate of about 87%. For hip related issues, the length of stay was decreasing from more than nine days in 2010, to less than seven in 2012, with a stable 30-day survival rate slightly over 91%. The LOS varied between a fixed lower bound of 5 days for all three years whereby some hospitals show up to 15 days LOS in 2010, two hospitals still over 12.5 days average LOS in 2011 and values up to 8.5 days in 2012. For the stroke related diagnosis group the 30-day survival was stable with values for the different years between 86 and 87% whereas the average LOS was decreased from nearly 9.6 days in 2010 to a slightly lower value of 9.47 in 2011 an further decreased to 8.3 days in 2012. The range of the average length of stay varied between a lower bound of about six days in all three years and showed the highest value of about 15 days in 2010, one outlier hospital with 20 days and two hospitals with about 15 days in 2011 and the highest value with less than 14 days in 2012.

Additionally the average expected gain in life years after an incident with received treatment varied between the diagnoses. For hip related issues a shorter lifetime after an event was expected out of several reasons. An obvious reason is that patients are on average 75 years or older when the event is occurring compared to less than 70 for heart related issues and only slightly over 70 for stroke related ones. The values used for heart and stroke related issues are the same but there is a bigger variation for strokes as the outcomes in terms of life length are more diverse following the assumptions from the literature. Regarding to the expected average QOL the values were defined according the literature with 0.8 for heart issues with a range between 0.6 and nearly perfect health. For hip related issues 0.7 ranging from 0.5 to 0.9 and for strokes the lowest average value of 0.6 with a big range between 0.3 and 0.9 because the outcomes for stroke related issues seem to be various.
4.5 Assumptions according to the variables and the economical concepts used

The values for the length of life and the quality of life after an event, as well as the costs per hospital day are solely based on assumptions. To control for possible bias these assumptions were based on literature. Thereby the numbers gained from the different publications first were listed and the most important values stated in the table. Next to that, the type of publication was specified, whether it is a meta-analysis or not. Than the values, which were most often used in the literature, were taken with special consideration of aspects related to the publication year, to the sample size used in that study and the study type. Meta-analysis for example was given higher weight than other publications, studies with a higher sample size were more important than smaller ones and the focus was on more actual publications. More information about the articles used and the information gained out of them can be found in chapter 4.1 and in the appendix table 1, 2 and 3.

One important point, which is assumed not to be that relevant for the results of this thesis, is the discussion about the reliability of the QALYs per se. The concept of QALYs has some critical aspects for example changing values of the quality of life component, depending on the people who rate the quality of life. There is a huge variation whether people who are actually in the state of having this condition, potentially sick people or healthy ones set the values. Also the fact if the condition is seen as a life threatening condition or not, is influencing the rate, whereby life threatening conditions are likely to be overrated in terms of low quality values assigned (Drummond et al. 2005; Paulden, et al. 2014; Weinstein et al. 2009).

An additional assumption behind the QALY concept is that the main goal of the decision makers is to maximize health by being constrained by a fixed budget at the same time. “The use of QALYs further assumes that health or health improvement can be measured or valued based on amounts of time spent in various health states. The conventional QALY is therefore a valuation of health benefit” (Weinstein et al., 2009; 5). All this assumptions do not hold if decision makers have other goals, for example political ones, next to the maximization of the population´s health (Weinstein et al., 2009). Nevertheless, QALYs are used because they are a common instrument in Cost-Utility-Analyses, especially in the healthcare sector and are meant to be comparable units. In this thesis, it is assumed that the values for the quality aspect of life included in a QALY are set with awareness of this discussion.
Assumptions according to “p” - 30-day survival probability gained after incrementing the length of stay by 1 day:

It was assumed that the relationship is linear at least within the small sector where p is looked at in order to get a value for is this calculation. Looking at the bigger picture, p is not a probability and the relationship is not linear. Would it be a linear relationship, hospitals could achieve survival rates of 100 percent by increasing the LOS to an unrealistically long time period.

Another issue connected to the values for p is that it was assumed that there are no confounding factors involved -which means no external matters-, which influence the LOS and the survival rate. This is not true, but the confounding factor “patient case-mix” is influencing the results in a direction, which makes it likely that the results are underestimating the positive effects, so the results in the thesis are conservative ones. Therefore, the bias is going into the opposite direction. More about that is stated in figure 9 and the adjoining description.

Next to that, the dataset from the Norwegian patient registry can be biased which is unlikely because it is no sample data but data from the overall population and assumed to be reliable.
5 Results

5.1 Results from the linear regressions

In order to get values for p, the increased probability of survival, linear regressions were conducted for all three diagnoses groups and all three years. As stated in the chapter assumptions the relationship between LOS and survival rate is not linear per se but is treated, as it would be linear, for the short interval of interest. In order to get a clear picture about the meaning of p a graphical presentation from the DRG heart in the year 2011 and a table with the values from the regression for each year are presented. In figure 8 the points represent the single hospitals included in the dataset. These points consist of the average length of stay for a special diagnosis in one hospital for this defined year on the x-axis and the average 30-day survival rate for the single hospitals on the y-axis.

Figure 8: Graphical presentation of the relationship between LOS and 30-day survival rates/DRG heart/2012. Source: SPSS output / own presentation

<table>
<thead>
<tr>
<th>Values for p as results from the regression</th>
<th>All Years Heart</th>
<th>All Years Hip</th>
<th>All Years Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Years Heart</td>
<td>0,453</td>
<td>0,1</td>
<td>0,087</td>
</tr>
<tr>
<td>Heart 2010</td>
<td>0,055</td>
<td>0,099</td>
<td>0,122</td>
</tr>
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<td>Heart 2011</td>
<td>0,799</td>
<td>0,102</td>
<td>0,17</td>
</tr>
<tr>
<td>Heart 2012</td>
<td>0,552</td>
<td>0,137</td>
<td>-0,059</td>
</tr>
<tr>
<td>Table 2: Values from the linear regressions/ p for all DRGs and all Years. Source: own presentation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 5.2 Results from the main calculation

The results of the marginal costs per QALY and the percentage values of the more than 1000 calculations lying under the 700 000 NOK threshold, are listed in the table below together with the values used in the calculation. The table contains information for all years together (arithmetic mean) and all years separate. The upper area shows the results for the heart DRG, the area in the middle for the DRG hip and the lower one for the stroke related DRG. It is important to note that the values stated under the category cost/QALY are not average costs per QALY but marginal costs per QALY because this thesis is examining the additional costs, which are arising through an intervention.

Table 3: Results for all DRGs, for all years and each year separate. Presentation of the values inserted in the model and the most important results in terms of marginal costs per QALY and the WTP thresholds. Source: own presentation
As 2012 is the most current year in this analysis, the focus will be on the year 2012. The other years are important in order to see how the costs per additional QALY and the percentage of the calculations lying under the 700 000 NOK threshold, change, if the probability of survival is varied. The results of the arithmetic mean of all three years are presented because the increased probability of survival \((p)\) varies a lot between the years. If only one year is presented it would give a misleading picture of the overall situation. The values for \(p\) in table 3, are divided by 100 as they represent percentage values.

An important point to add is that all results of the thesis are rather conservative ones which means that it is not likely that they show exaggerated values and more likely that the positive effects are presented too small. That is mainly because of one of the confounding factors stated in the assumptions, the “patient case-mix”.

The blue line in the graph is representing how the relationship between the length of stay and the 30-day survival rate would be, if hospitals with a higher LOS would have a higher length of stay because they treat patients with worse general conditions and therefore have lower 30-day survival rates. That of course will be true for in cases and therefore influences the “real” values (green line) in a way that the results are less positive (red line).

According to that, it can be stated that the results are most likely to show lower values as there could be observed in reality and therefore the true effects of the intervention are probably stronger. As most of the values for \(p\), which can be seen in table 2 and 3 are positive, and it is likely that they are biased in a negative direction, it can be stated that the true values may lead to better results. This includes lower marginal costs per QALY and therewith a higher probability that the intervention is cost-effective under the WTP threshold of 700 000 NOK. The value from the diagnosis group stroke for 2012 is a negative one and therefore the intervention is not regarded to be cost-effective. Considering this confounding factor, it can be possible that \(p\) is “really negative” or has a negative value through that mechanism.

Figure 9: Why the following results are conservative ones.
Source: own presentation
5.2.1 Results for DRG 112 E/F & 122 (heart)

The value presenting the increased probability of surviving is noticeably varying between the years. Whereas in the year 2010 an increase of the LOS by one day had hardly any influence on the probability of survival with a value of 0.055 and therefore a marginal cost per QALY higher than 1.5 million NOK, in the year 2011 a big influence of the increase in the LOS on the probability of survival can be observed with a value of 0.799. Inserting i) 5500 NOK as a value representing the costs of a hospital day, with a range between 4000 and 18 000 NOK, ii) assuming the average length of life after treatment to be 8 years with an interval from 6 to 10 years and iii) the average quality of life to be 0.8, varying between 0.6 and almost perfect quality of life 0.98, is leading to the following results.

In 2011 the marginal cost per additional QALY was very low with a value of 107 556 NOK which is definitely beyond the threshold of 700 000 NOK per QALY. In the year 2012 the increased probability of survival due to the rise in the LOS reduced to 0.552 and the cost per additional QALY rose up to 155 684 NOK which is still far beyond the Norwegian threshold and thus a favorable result. Looking at the average values for all three years it can be observed that the average costs of an additional QALY summed up to 190 972 NOK which is about 500 000 NOK under the threshold. This result is largely in line with the expectations due to the numbers from the literature.

Figure 11: Cost-Effectiveness plane for DRG heart. Source: own presentation

Figure 10: Acceptability Curve for DRG heart. Source: own presentation
Taking a look at the cost effectiveness plane from 2012 it can be stated that a large share of the cost-effectiveness combinations are in the upper right sector which indicates a more costly but also more effective option. Additionally a considerable proportion of the calculated combinations, is located in the lower right sector which indicates that the intervention is less costly and more effective. The intervention of increasing the average LOS in the hospitals of one day can therefore be seen as cost effective. Additionally the acceptability curve shows that more than 80% are beyond the threshold of 700 000 NOK. With the actual WTP for nearly 85% of the more than 1000 random modulations of different hospitals, an increase in the LOS, is thought to be cost-effective.

Taking a look at the results from 2012, for 87.4% of all combinations, the average increase in the LOS in the hospitals of one day, is regarded to be a good option in terms of cost-effectiveness. This value is even higher for the year 2011 where it would be useful for 91.7%. Like mentioned above for the year 2010 an increase in the LOS is not regarded cost-effective.

### 5.2.2 Results for DRGs 210 / 211 (hip)

For the diagnostic category hip an average cost of 4000 NOK per day is assumed which is lower than for AMI because less days at ICU and more ward days can be observed. Therefore not only the average costs per hospital day but also the marginal costs per day are assumed to be lower. 6 years of average survival after the event are inserted because people on average are older when hip related events occur than heart patients. The expected quality of life after the event with a value of 0.7 is ranging between 0.5 and 0.9 because the Qol after the event is dependent on the result of the treatment and the general health condition of the patients before the event and to some extend on lifestyle habits. The same arguments explain the variation in the life years gained through received treatment, ranging from 4.5 to 7.5 years.

Values representing the increased probability of survival due to an increase of the average LOS in a hospital are lower than those regarding to heart patients and are fixed at the following values of 0.099 in 2010, 0.102 in 2011 and 0.137 in 2012. This, together with the smaller average gain in life years and the smaller average expected Qol leads to higher costs per additional QALY. Nearly all results, except for 2012 are reaching about one million NOK per QALY gained, although the costs per hospital day are lower than for the DRG heart.
With an increased probability of survival in the year 2012, indicated through a value of 0.137 the cost for gaining an additional QALY displays the lowest value of the three years with a value of 695 169 NOK which is slightly beyond the threshold. From the cost-effectiveness plane there can be deduced that all calculated combinations of the costs and the effectiveness are in the upper right sector and therefore more effective but also more expensive.

However the money needed in order to gain a significant increase in the effectiveness is too much for the years 2010 and 2011. With the threshold of 700 000 NOK 47.3% of the combinations inserted are falling under the threshold in the year 2012, which means that for 473 out of the thousand random combinations an increase in the LOS in the diagnosis group hip is regarded to be useful. If the increased probability of surviving is lower than the value for 2012 - increasing the LOS by one day - is not regarded to be a useful option.

5.2.3 Results DRGs 14 A/B (stroke)

The DRG stroke stands out through high costs for an additional hospital day which can be explained by the usually long time spent at the ICU. The value for the cost per extra hospital day is assumed to be 6800 NOK, with a lower value of 3000 NOK per day representing a ward day without complications and a very high value of 20 000 NOK per day, for a day spent at ICU. The values for the average gain in life years are varying widely due to the

Figure 12: Cost-Effectiveness Plane for hip. Source: own presentation

Figure 13: Acceptability Curve for DRG hip. Source: own presentation
different diagnosis types, ranging from 4 to 12 years after the event, whereas a value about 8 years is most often assumed in the literature. The same applies for the QOL after stroke related medical events which is assumed to be 0.6 ranging from 0.3 to 0.9.

The increased probability of survival due to an additional hospital day varies strongly within the different years from -0.059 in 2012 over 0.122 in 2010 to the highest increased probability of surviving with a value of 0.17 in the year 2011. In 2012 an additional hospital day lead to a lower survival rate. Therefore $p$ is not showing an increased probability of survival due to the intervention (+1 day LOS) but a decreased probability of survival. As a logical consequence the incremental cost per QALY show negative values in the calculation, which means in a practical setting that an increase in the LOS would not be the best intervention to set, although the negative value for be could be a consequence of the mechanism, described in figure 9. In that case it could be that the patient casemix was absolutely not balanced and therefore influenced $p$ in a way that the value got negative.

In the cost-effectiveness plane from 2012 no clear picture can be observed and the acceptability curve has no meaning per se.

Still the result is interesting because it is the only year showing a negative value for the increased probability of survival from all years and all DRGs observed. Knowing only the results of 2012 one would assume that an increase in the average LOS has got a negative effect on the average health outcome in terms of survival rates for the hospitals.
Talking again about the overall picture, for 2010 and 2011 the opposite impact as for the year 2012 can be observed, which emphasises that viewing only the result of one year can be strongly misleading. In 2011 the value for $p$ is even that high, with a value of 0.17 that the cost per additional QALY is not far above the threshold, which would nearly change that intervention into a cost-effective one.

It can be stated that the only DRG where nearly all years are under the threshold of 700 000 NOK is the DRG regarding to heart issues. For the others diagnosis groups the intervention of increasing the average length of stay by one day shows too little benefits in order to be cost-effective.
5.2.4 Results for the Sensitivity analysis for 2012

The sensitivity analysis was conducted for all years, whereas only the table for the year 2012, as it is the most current year in this analysis, will be explained, the tables from the sensitivity analysis for the years 2010 and 2011 are in the appendix.

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Table 4: Sensitivity analysis for 2012 for all DRGs. Source: own presentation
For the values of the costs per hospital day, the approach for the three different diagnostic categories was the same only from a qualitative prospect, as the lowest and highest values based on the literature research were inserted. For the other values (p, q, l) the approach is additionally the same from a quantitative point of view. For the expected gain in life length and the expected quality of life after the event followed by treatment, the upper and lower values from the sensitivity analysis were conducted by calculating the values for a range of +-25%. This was thought to be the best option as it includes a considerable range and is widely consistent with the values found in the literature.

The values for the costs of additional QALYs for increasing the expected average gain in life length by 25% and the average expected quality of life by 25% are of course the same as both values are standing in the denominator of the formula. These results correspond with the results for reducing the value of these two variables by 25%. The exact values for the WTP of these variables are clearly not the same as the sample consists of 1000 random combinations generated by Excel, but show similar values.

For the DRG heart the costs per additional QALY are never exceeding the threshold, not even if the highest cost for a hospital day is used with a value of 18 000 NOK per day the cost per QALY is about 510 000 NOK and therefore under the approximate Norwegian threshold. If the cost for a hospital day is assumed to be 4600 NOK the marginal cost per QALY is about one fifth of the threshold. Very similar results are achieved if the expected life length and the expected quality of life are increased by 25%. If the expected life length and the expected QOL are decreased by 25% the cost per QALY is about one third of the threshold.

For the DRG hip, the costs per additional QALY are near the threshold for the observed values and therefore under the WTP threshold if the minimal value for the costs per hospital days is used. With an increased expected life length and an increased expected QOL of 25% the marginal cost per QALY is about 150 000 NOK lower than the threshold with a value of 556 135 NOK. If higher costs per hospital day are used, inserted a value of 5500 NOK, or if the expected life length or the expected QOL are decreased by 25%, the marginal costs are higher than 900 000 NOK which is clearly exceeding the threshold.

Especially for the DRG hip as the results, at least for some years, are allocated near the threshold, it is important to have clear results and an overview, how the costs develop in order to make evidence based statements and decisions according to the cost-effectiveness.
As for the DRG stroke, the value of the increased probability of surviving is lower than zero for the year 2012, the intervention of increasing the LOS by 1 day is not to perform.

The results from the sensitivity analysis for stroke show astonishing different results for the year 2011. Because of a higher value for p, some of the options would easily be cost-effective lying far below the threshold. For 2010 there cannot be made a clear statement as the values are varying too much.
6 Discussion

6.1 Discussion of the results

The results from the calculations are very different for all diagnosis groups and all years. For the DRG heart the results seem to be the most reliable ones as there is at least a clear time trend over the three years which were investigated. Although the values for the cost of a additional QALY are varying quite widely from about 100 000 NOK in 2011 to 1.5 million NOK in 2010 the intervention of increasing the hospital in patient time by one day is overall regarded to be cost-effective. Additionally the high cost per an additional QALY from the year 2010 can be explained by looking at the size of the value inserted for p, which was for that year on a low level of 0.00055, which is just about one-tenth the effect from the year 2012 with a value of 0.00552 inserted into the calculation. The percentage values, for how many of the 1000 random calculations by Excel, the intervention is regarded to be cost-effective, under a 700 000 NOK threshold, are higher than 80% for every year. The DRG heart is therefore the diagnosis group with the most reliable results and the clearest trend from the three groups analyzed in this thesis. An intervention of increasing the LOS by one day in this diagnostic category is most likely a useful intervention, granted that the values are showing the approximately same trend in the years from 2013 until now.

For the DRG hip the results are not that explicit, as for the DRG heart although the costs per an additional QALY gained are very stable over the three years viewed, ranging from about 700 000 NOK in 2012 to 900 000 NOK in the other two years. Unfortunately, this makes it difficult to decide whether this intervention can be regarded to be cost-effective or not. In the year 2012, the value falls slightly under the threshold and in the other years above. The picture gets clearer when the cost-effectiveness acceptability curve is viewed. Also, in the best year of the years included – namely 2012 - the intervention is regarded to be effective for only 47.3% of the 1000 calculations, whereby in the other years the intervention is regarded to be effective under the 700 000 NOK threshold for only 23.4 and 23.5 percent.

Within the DRG stroke, the intervention is not regarded to be useful at all in the year 2012. Whereby the effect of getting a negative value for p – a decrease in the 30-day survival rate by increasing the LOS by one day – can have different causes and does not necessarily indicate that an increase in LOS is reducing the 30-day survival in reality. This can be due to different reasons whereby one is explained in figure 9 showing that the results for the values
for p might be biased. Nevertheless, the intervention is not seen to be the correct one for the DRG stroke especially because the results for the other years are very unstable as well. In the year 2011 for example the cost per additional QALY is not that far from the threshold with 833 333 NOK but far above in the year 2010 with about 1.2 million NOK.

### 6.2 Discussion of the results with different approaches from the literature

This thesis shows that the intervention of increasing the length of stay in a hospital by one day can be regarded to be a useful intervention in terms of patient outcomes in special diagnosis groups. For the DRG heart, the intervention of increasing the LOS by one day is shown to be cost-efficient. This is to a certain extent consistent with representations made by Romley et al. (2011), stating that for AMIs, strokes and hip fractures a higher resource use is connected to lower mortality rates. Although the only representative results in this work are related to heart issues the other diagnosis groups do not disprove these results. Furthermore every result, except the one related to stroke in the year 2012, is underscoring the results of Romley et al., because in each calculation an increase of the LOS is correlated with higher survival rates, although not being regarded to be cost efficient by the Norwegian willingness to pay threshold of approximately 700 000 NOK. Even for the DRG stroke in the year 2012 where an increase of the inpatient time is negatively correlated to the 30-day survival rate it cannot be clearly stated that higher resource use is leading to worse average patient outcomes for a hospital. Nevertheless it can be determined that in this year, for stroke related issues, the average increase of the time spent in a hospital by one day, may be the wrong intervention if one intends to increase the overall patients outcome in terms of survival rates.

Comparing the results from above with the article by Nordström et al. (2015), where they state for hip patients that there is a critical value in the length of stay involved, leads to interesting conclusions. If the LOS of patients is reduced to the exact critical value this has no influence on the patient’s survival rate after discharge but if the inpatient time is reduced to a value lying under that specific value this leads to a reduction in the survival rates. This thesis was not meant to find any critical value but the general results according to the hip DRG are in line with the statements by Nordström et al.. Although in the thesis the increase of the length of stay of one day was not regarded to be cost-effective, except for 2012, the cost-effectiveness pairs for all hospitals in the cost effectiveness plane are in the upper right sector, which means the intervention is more expensive but also more effective. A very interesting
fact is that in the DRG related to hip issues, the LOS decreased from an average number of more than nine days in 2010 to less than seven days in 2012. The only year where the intervention - although always being in the upper right sector of the cost-effectiveness plane but not in such a magnitude to be seen as cost-effective - is regarded to be really cost-effective, with a value slightly under the Norwegian threshold, is the year 2012. Of course, it is not possible to state that between 2010 and 2012 the average length of stay was reduced too far and therefore fell under the critical minimum time patient’s should stay in Norwegian hospitals, but that line of thought is interesting and should be further tested. Also due to the fact, that it is possible that this could be the reasoning behind the cost-effectiveness in 2012.

In a study by Martin et al. (2008) where the question was whether a general increase in health care spending improves health outcomes, the results showed a 1% increase in health spending leads to a reduction of 1.4% of life years lost (YLL) in the medical field of cardiovascular diseases. In that study the cost of a QALY summed up to £11 960 which is about 140 000 NOK. This result corresponds to the values calculated for the costs per QALY of this paper for the years 2011 and 2012. In 2011 the cost per QALY adds up to 107 556 NOK and in 2012 to 155 684 NOK. This again leads to the conclusion that the field of cardiovascular diseases, which are represented in that study through the DRGs regarding to acute myocardial infarctions, is an interesting field in terms of setting cost-effective interventions to influence health outcomes.

The study of Filmer and Pritchett (1999) points out, that interventions in the health sector always have to be viewed from different angles, more precisely the one of cost-effectiveness, the impact of public sector supply and the public sector efficacy. They further underline that an intervention has to be useful in terms of creating valuable services, it has to change the number of services consumed and the additional services have to be cost-effective in order to be overall effective - and all this three points act like a chain. The first point that spending must create effective services is not an issue directly covered in this thesis, as in all hospitals viewed, there are departments for treating heart, hip and stroke related diseases. Hence in comparison with other countries as can be discovered in the studies of Häkkinen et al. (2015), Piscitelli et al. (2012) and Claxton et al. (2013), that Norwegian hospitals are successful in treating patients, with regard to cost-effectiveness and low mortality rates. The second point - additional services should not crowd out others and should change the total number of services consumed – is only useful for public health interventions. In the context of this thesis as the amount of services, which are chosen to be consumed, are not changing due to the
The results as well as the values inserted in the calculations of the thesis, correspond to a certain extent with those of Claxton et al. (2013). The life expectancy for people at risk of circulatory diseases for example was estimated to be 83 years for man and 86.5 years for women and 79 for men at risk of neurological diseases and 83 for women. In this thesis life expectancy from people at risk was not used but rather for those who actually had one of this three medical conditions. Therefore, the average age when the medical incidence happens was used and the expected life length after the event was added. As the events are estimated to happen at the age of 75 for hip fractures, slightly less than 70 years for AMIs and over 70 years for stroke related issues like mentioned above. The expected average gain in life years was based on the literature being six, eight and eight years, respectively. According to the
costs of a life year, the results of the thesis supplement the information given by the paper by Claxton et al. for circulatory diseases and neurological problems, in the category trauma and injuries, results are missing in the publication. Claxton et al. estimate the costs per additional life year which is gained to be £11 779 for the timeframe between 2008 and 2010. This is about 140 000 NOK and therefore in line with the results for AMIs in the thesis with the cost per life year of about 150 000 NOK in 2012. The same logic although not with similar values applies for neurological problems which are estimated by the authors to sum up to £388 267 per additional life year gained which are about 4 million NOK. In the thesis the values for the marginal cost per QALY gained are varying strongly between the years but are mostly far beyond the willingness to pay threshold.

As the main objective of the thesis was to figure out in which medical field additional spending leads to better patient outcomes at the hospital level it can be stated that from the three categories tested, the group of heart related issues seem to benefit the most. If these findings are influenced by the way healthcare is organized in Norway, is difficult to say. Additionally there cannot be made an evidence based statement, if there are changes in the results due to the Norwegian development in the payment system and the rating of the DRG points. Although of course the way DRGs are set, influences the way patients are treated and therefore the patient outcomes following the results of Hafsteinsdottir and Siciliani (2010). The same applies for the way the payment system is structured where the share of ABF strongly influences the number of DRG points produced according to Januleciciute et al. (2011). As for all years included in the thesis 2010, 2011 and 2012 the same share of ABF applied in Norway and as stated above all this diagnosis are acute ones - and therefore their incidence should not be influenced exogenously at least not due to health policy decisions - this is not a point to be concerned about.

A clear source of possible mistakes would be the common practice of “upgrading” patients into a DRG group which is better reimbursed, which is examined in the paper of Leemore (2005). This problem is most likely not applicable for this thesis because in the various diagnosis groups which had been examined the subgroups got summed up because the survival rates were only given for example for DRG 210 and DRG 211 together.

In the interest of completeness there has to be mentioned that according to all consideration about staffing in hospitals no statement for this thesis can be made as no values reflecting those issues are included in the data from the Norwegian patient registry. Nevertheless, staffing decisions seems to be highly influential in terms of patient outcomes following the
results of the studies from for example Aiken et al. (2011 & 2012), Needleman et al (2011), Or (2001), Penoyer (2010), Southern and Arnsten (2015) and West et al. (2006). Therefore variables recording staffing issues in different occupation groups in hospitals could possibly be added to the survey from the Norwegian patient registry.

6.3 Limitations of the study

One limitation of the study is that the values inserted for p, q and l are based on assumptions. Although the assumptions are based on available literature, in order to decrease potential deviations from the true values there is some risk that the values depart from those which can be observed in a practical setting for Norway. Additionally some effort was made to reduce the bias that could result from these assumptions. An extensive sensitivity analysis was conducted in order to control for possible divergences due to the assumptions and for being able to make secured assertions about the correlations between the resources used and the outcomes.

Another point which could be seen as a limitation is that results can only be stated for data on the hospital level and not for single patients. This can also be seen as a positive characteristic because the results enable to make statements about the overall health situation according to these diagnostic fields in Norway. This is especially interesting because it is difficult to make general statements for Norway because of the huge variation in the country’s geography and varying population density issues, but as this data is not based on a sample but is including the whole population the results are more meaningful.

Another limitation with regards to hospitals could be that there are different types of hospitals included which could lead to some bias because of a different patient “case-mix”. Therefore it would be interesting to adjust for the average patient’s general condition which is not possible as there is no information about that included in the dataset.

One more issue, which has to be mentioned is that the data for p is deduced only from the years 2010, 2011 and 2012. In order to be informed about the actual situation, the calculations should be redone with more current values, especially because the results already might have changed – like it can be seen in the thesis – that an intervention can switch from being effective to ineffective within one year.
Additionally, $p$ is not a probability per se but is used, as it would be, because for this short section viewed at $p$ is acting like a probability.

An important aspect which can be seen more as a remark than as a limitation is that in the dataset the resource use can only be estimated with the length of stay although it would also be interesting to have data about staffing issues and other possible influences due to resource use.
7 Conclusions and recommendations

The aim of this research was to find out the differences in resource use and outcomes in the diagnostic categories hip, heart and stroke in Norwegian hospitals. One clear goal thereby was to show, the amount which has to be paid in the different categories for an additional QALY and whether the intervention of increasing the length of stay by one day can be considered to be cost-effective or not, under the approximate threshold of 700 000 NOK. Such considerations are important for an economically useful way of utilizing resources in order to keep the health system sustainable. With a view to the conspicuous about the developments in the Norwegian population, described in the theoretical part, particularly with regards to the aging population and the trend towards single households, the need for cost-effective interventions in order to maintain the actual health standards are obvious.

Different approaches for intervention in terms of resource use, in order to increase the patients outcomes are presented in the theoretical part and later on discussed whether they lead to similar conclusions as the results from this research.

In this work, the resources used and the health outcomes in all Norwegian hospitals in the DRGs hip heart and stroke for the years 2010, 2011 and 2012 were compared. As a first step, linear regression were conducted including the LOS and the 30-day survival in order to show whether an increase of the inpatient time leads to an in - or decrease of the 30-day survival in Norwegian hospitals. In the second step, the incremental gain of the intervention – including the gain in terms of life length, the gain in terms of quality of life and the gain calculated from the regressions, the increased or decreased probability of survival - was compared to the incremental costs of the intervention, the costs of increasing the length of stay in the different DRGs by one day. The results from that analysis are presented in cost-effectiveness planes and cost-effectiveness-acceptability-curves, which include the approximate Norwegian threshold of the WTP.

The first part of the research question, how much Norwegians have to pay in the different diagnostic categories for an additional QALY, can be answered for the three diagnosis groups hip, heart and stroke for the three years 2010, 2011 and 2012. The cost per additional QALY ranges from about 150 000 NOK in the DRG heart in 2012 to 1.6 million NOK for the DRG stroke as an average value of all three years. These results indicate that policy decisions in this field have to be based on evidence, furthermore all calculations have to be based on the most
actual values, because the fact whether the intervention of increasing the average length of stay in all hospitals is regarded to be cost-effective or not can dramatically change from one year to the next. Therefore it is recommended that research should not focus on one year only, but on a bigger time frame in order to see the trends in the development within the different diagnosis groups.

As a further objective of this work was to find out in which diagnosis group additional spending is regarded to be most beneficial, it can be stated, that in the years 2010, 2011 and 2012 the DRG heart was the only DRG viewed, where the intervention was regarded to be overall cost-effective with an average cost per QALY of 190 972 NOK, which is less than one third of the 700 000 NOK threshold. In more detail it was established, that for the year 2010 the intervention is not cost-effective by being more than double of the threshold, which is the reason for the recommendation of viewing a time trend in order to decide. Nevertheless, within the DRG heart it can be a good intervention to increase the “inpatient” time. At least it should be checked whether the time spent in hospitals maybe too short and therefore falls under some critical minimum time patients should stay for a special diagnosis. Additionally it should be checked, whether the way a DRG is described and accounted for, is incentivizing hospitals to shorten the LOS too drastically. Still this field is an interesting one for action as this intervention is regarded to be relatively cheap and shows great outputs in increasing the 30-day survival rates. For the diagnosis group hip the intervention is a positive one although the benefits due the intervention of increasing the LOS by one day are too little in order to be cost-effective. In the DRG stroke a check is recommended whether the year 2012 is the only year, where an increase in hospital days leads to a reduced 30-day survival or if there are also other years. The intervention based on the results of this thesis strongly recommended it not to be implemented.

The results from this research show the importance of evidence based decisions and emphasize that research in relation to this topic should include more years and different diagnosis groups as substantial fluctuations can be observed in and within the DRGs for the different years. Therefore it is not possible to generalize the results from one diagnosis related group.
References


Appendix

Search in Cinahl, Pubmed, Medline and with Google scholar

**KEY words DRG 210/211**
1. femur neck fracture + hospital costs
2. hip replacement + QALY
3. DRG 210/211 + costs
4. hip and femur fractures hospital costs
5. QALY femur+hip fracture
6. cost of hip fractures
7. cost of hip and femur neck fractures
8. Qol + hospital cost of hip and femur neck fractures
9. hip fracture + Norway
10. Quality of life after hip replacement
snowball (10): quality of life after hip replacement
11. norway cost per hospital day hip fracture

**Viewed abstracts**
1. --> 7
2. --> 4
3. --> 6
4. --> 5
5. --> 3
6. --> 4
7. --> 2
8. --> 3
9. --> 6
10.--.18+9
11.--.3

**Used articles**
1
2
3
4
5

**Viewed abstracts DRG 210/211: 70**

**Used articles: 24**

**KEY words DRG 112 E/F & 122**
1. acute myocardial infarct + hospital cost
2. economic evaluation of myocardial infarction
snowball (2): economic evaluation of myocardial infarction
3. economic evaluation of acute myocardial infarction + hospital days
4. Acute myocardial infarction + Qol
5. articles from DRG 210/211 including AMI and stroke

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1. --> 5
2. --> 7+8
3. --> 8
4. --> 9
5. --> 2

**Used articles**
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2+3
3
2

**Viewed abstracts DRG 112 E/F & 122: 39**

**Used articles: 13**

**KEY words DRG 14A/B**
1. cost effectiveness + stroke
2. cost effectiveness + stroke + hospital days
3. stroke + lenght of stay + costs
snowball (3): stroke + lenght of stay + costs
4. stroke + Qol
5. articles from DRG 210/211 including AMI and stroke

**Viewed abstracts**
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3. --> 12+5
4. --> 9
5. --> 2

**Used articles**
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**Viewed abstracts DRG 14A/B: 48**

**Used articles: 22**

**Used articles for the assumptions: 59**

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Appendix 1: Literature research for assumptions. Source: own own presentation
## Articles for heart

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<td>Qol 53% - 14% -- social: 0.58/</td>
<td>60% are alive after</td>
<td>72</td>
<td>505</td>
<td></td>
<td>1992-1997 Norway</td>
<td>Norrhol et al. 2010</td>
<td>4</td>
</tr>
<tr>
<td>AMI</td>
<td>Self rated health: 33%</td>
<td>all 0.82-0.87 after 10 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Norrhol et al. 2010</td>
<td>4</td>
</tr>
<tr>
<td>AMI qual/satisf</td>
<td>Heigher satisfied not</td>
<td>satisfied / very satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hanssen et al. 2008</td>
<td>4</td>
</tr>
<tr>
<td>AMI</td>
<td>Resituated 50%</td>
<td></td>
<td></td>
<td></td>
<td>69</td>
<td>Finland 2007-2008</td>
<td>Håkkinen et al. 2015</td>
<td>5</td>
</tr>
<tr>
<td>AMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1910</td>
<td>Italy 2007-2008</td>
<td>Håkkinen et al. 2015</td>
<td>5</td>
</tr>
<tr>
<td>AMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10558</td>
<td>Norway 2009</td>
<td>Håkkinen et al. 2015</td>
<td>5</td>
</tr>
<tr>
<td>AMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46304</td>
<td>Sweden 2007-2008</td>
<td>Håkkinen et al. 2015</td>
<td>5</td>
</tr>
<tr>
<td>AMI</td>
<td></td>
<td></td>
<td></td>
<td>85</td>
<td></td>
<td>Italy 2001-2005</td>
<td>Piscitelli et al. 2012</td>
<td>5</td>
</tr>
<tr>
<td>AMI</td>
<td></td>
<td></td>
<td></td>
<td>85</td>
<td></td>
<td>Italy 2001-2005</td>
<td>Piscitelli et al. 2012</td>
<td>5</td>
</tr>
</tbody>
</table>

| 5500 NOK | 0.8 | 8 | 69 |
| 4000/18000 | 0.6/0.98 | 6/10 |

Appendix 2: Literature table for heart. Source own presentation
### Articles for hip

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Cost/DALY</th>
<th>Cost/hospital q.</th>
<th>QALYS</th>
<th>Time gap</th>
<th>Ave Age</th>
<th>When/Where</th>
<th>Article</th>
<th>Key word</th>
<th>Additional</th>
</tr>
</thead>
<tbody>
<tr>
<td>THA (both OA)</td>
<td>$12,772 (base)</td>
<td>6.5 QALYs</td>
<td>345</td>
<td>January 10, 2010</td>
<td>70</td>
<td>Scotland</td>
<td>Jenkins et al., 2013</td>
<td>THA</td>
<td>60% and 42% of men and women replaced</td>
</tr>
<tr>
<td>THA (both OA)</td>
<td>$12,772 (base)</td>
<td>6.5 QALYs</td>
<td>345</td>
<td>January 10, 2010</td>
<td>70</td>
<td>Australia</td>
<td>Chang et al., 1996</td>
<td>THA</td>
<td>Cost and QALYs for both men and women</td>
</tr>
<tr>
<td>THA (both OA)</td>
<td>$12,772 (base)</td>
<td>6.5 QALYs</td>
<td>345</td>
<td>January 10, 2010</td>
<td>70</td>
<td>Saudi Arabia</td>
<td>Chang et al., 1986</td>
<td>THA</td>
<td>Cost and QALYs for both men and women</td>
</tr>
<tr>
<td>THA (single OA)</td>
<td>$12,772 (base)</td>
<td>6.5 QALYs</td>
<td>345</td>
<td>January 10, 2010</td>
<td>70-75</td>
<td>Egypt</td>
<td>Hegazy et al., 2011</td>
<td>THA</td>
<td>60% and 42% of men and women replaced</td>
</tr>
<tr>
<td>THA (single OA)</td>
<td>$12,772 (base)</td>
<td>6.5 QALYs</td>
<td>345</td>
<td>January 10, 2010</td>
<td>70-75</td>
<td>Australia</td>
<td>Chang et al., 1996</td>
<td>THA</td>
<td>Cost and QALYs for both men and women</td>
</tr>
<tr>
<td>THA (single OA)</td>
<td>$12,772 (base)</td>
<td>6.5 QALYs</td>
<td>345</td>
<td>January 10, 2010</td>
<td>70-75</td>
<td>Saudi Arabia</td>
<td>Chang et al., 1986</td>
<td>THA</td>
<td>Cost and QALYs for both men and women</td>
</tr>
</tbody>
</table>

### Appendix 3: Literature table for hip. Source: own presentation
## Articles for stroke

### Literature Table for Stroke

<table>
<thead>
<tr>
<th>Diagnosis (DNG)</th>
<th>Cost/DAY</th>
<th>Cost/s hospital</th>
<th>Q-Linc. Wit.</th>
<th>60% to 71%</th>
<th>N.E.</th>
<th>When/Where</th>
<th>Article</th>
<th>Key word</th>
<th>Additional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>IKB per QALY 6296/62 to 11669/98</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Panel et al. 2000</td>
<td>1</td>
<td>1 year costs; 11450/7 for stroke unit; 9527/4 for stroke team</td>
</tr>
<tr>
<td>Ischemic Stroke</td>
<td>72944</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Von B10e et al. 2010</td>
<td>1</td>
<td>and 890/5 for domiciliary care QALY gained 0.28/79, 0.216/0, 0.221</td>
</tr>
<tr>
<td>Stroke in AF</td>
<td>QALY gain 0.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Harrington et al. 2013</td>
<td>1</td>
<td>40% died within the 4 year follow up</td>
</tr>
<tr>
<td>Stroke metaanalysis</td>
<td>6000/2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hughes et al. 2000</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>1331 bed days per 100 percent</td>
<td></td>
<td></td>
<td>0.47 to 0.66</td>
<td>1/3 + 3 or after t</td>
<td>73.5</td>
<td>1241</td>
<td>Friborg et al. 2000</td>
<td>1</td>
</tr>
<tr>
<td>Stroke</td>
<td>limit 35000/4</td>
<td>2-8 days range [15/32]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jorgensen et al. 1995</td>
<td>1</td>
<td>LOS general ward about 30 days/LOS stroke unit 35 days!!!</td>
</tr>
<tr>
<td>Stroke</td>
<td>4.6 days/274/455 (990/155) + 213/25 per additional day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>van Es et al. 2000</td>
<td>2</td>
<td>EuroQol AD cost per patient 1600/4 for 6 months</td>
</tr>
<tr>
<td>Stroke</td>
<td>52377/11, 5 days (219/20) + 150/45 per additional day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Read et al. 2001</td>
<td>3</td>
<td>LOS 11 to 28 days</td>
</tr>
<tr>
<td>Stroke metaanalysis</td>
<td>70% + 7 years</td>
<td>75.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stroke Unit Trilateral Collaborat</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>13390/27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rotter et al. 2012</td>
<td>3</td>
<td>LOS 35 days</td>
</tr>
<tr>
<td>Optimal stroke care</td>
<td>acute day: 4879 to 1807/1 ward</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Krupe et al. 2012</td>
<td>4</td>
<td>63800/24,000/day/4.5 million annualized care days</td>
</tr>
<tr>
<td>Stroke</td>
<td>15900/4 for 3 more days (159/6/4) + 367/4 for an additional day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Huang et al. 2013</td>
<td>4</td>
<td>13 to 45 days average cost 1490-2984 (US)</td>
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<tr>
<td>Stroke</td>
<td>5629/62 days to 624/62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Luengo-Fernandez et al. 2013</td>
<td>4</td>
<td>5624/62 in the post year event/LOS 32</td>
</tr>
<tr>
<td>Metastases QOL</td>
<td>80 days (55/65) for 31 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sander et al. 2001</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Compr. Review</td>
<td>2698/62 (58/58) for 28 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tang et al. 2001</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Compr. Review</td>
<td>529/62 (58) for 28 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tang et al. 2001</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Compr. Review</td>
<td>529/62 (58) for 28 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tang et al. 2001</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>QOL 3/6/12 m. stroke</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Suenkelser et al. 2002</td>
<td>4</td>
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</tr>
<tr>
<td>QOL 3/6/12 m. stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Suenkelser et al. 2002</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>QOL 5 yr. Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paul et al. 2002</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
<tr>
<td>Stroke</td>
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<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 years after stroke 0.8</td>
<td>97/5</td>
<td>Paul et al. 2002</td>
</tr>
</tbody>
</table>

**Appendix 4:** Literature table for stroke. Source: own presentation
Regressions and survival rates gathered from the calculations in SPSS

<table>
<thead>
<tr>
<th>Survival rates [average/minimum/maximum] &amp; regressions from all years (arithmetic mean) and each year</th>
<th>All Years Heart DRG 112 E/F &amp; 122</th>
<th>All Years Hip DRG 210/211</th>
<th>All Years Stroke DRG 14 A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>average survival rate</td>
<td>87,4575667</td>
<td>91,3543333</td>
<td>86,4140667</td>
</tr>
<tr>
<td>minimum survival rate</td>
<td>84,2113333</td>
<td>88,809</td>
<td>83,862</td>
</tr>
<tr>
<td>maximum survival rate</td>
<td>88,122</td>
<td>92,1283333</td>
<td>87,438</td>
</tr>
<tr>
<td>regression</td>
<td>0,453</td>
<td>0,1</td>
<td>0,087</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2010 Heart DRG 112 E/F &amp; 122</th>
<th>2010 Hip DRG 210/211</th>
<th>2010 Stroke DRG 14 A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>average survival rate</td>
<td>87,8743</td>
<td>91,376</td>
</tr>
<tr>
<td>minimum survival rate</td>
<td>85,152</td>
<td>88,49</td>
</tr>
<tr>
<td>maximum survival rate</td>
<td>90,249</td>
<td>92,019</td>
</tr>
<tr>
<td>regression</td>
<td>0,055</td>
<td>0,099</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2011 Heart DRG 112 E/F &amp; 122</th>
<th>2011 Hip DRG 210/211</th>
<th>2011 Stroke DRG 14 A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>average survival rate</td>
<td>87,2267</td>
<td>91,5</td>
</tr>
<tr>
<td>minimum survival rate</td>
<td>83,377</td>
<td>89,316</td>
</tr>
<tr>
<td>maximum survival rate</td>
<td>86,579</td>
<td>91,992</td>
</tr>
<tr>
<td>regression</td>
<td>0,799</td>
<td>0,102</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2012 Heart DRG 112 E/F &amp; 122</th>
<th>2012 Hip DRG 210/211</th>
<th>2012 Stroke DRG 14 A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>average survival rate</td>
<td>87,2917</td>
<td>91,187</td>
</tr>
<tr>
<td>minimum survival rate</td>
<td>84,105</td>
<td>88,162</td>
</tr>
<tr>
<td>maximum survival rate</td>
<td>87,538</td>
<td>92,374</td>
</tr>
<tr>
<td>regression</td>
<td>0,552</td>
<td>0,137</td>
</tr>
</tbody>
</table>

Appendix 5: results from the linear regression and the survival rates for each DRG each year. Source own presentation
### Sensitivity Analysis for 2010

#### Heart DRG [2010]

<table>
<thead>
<tr>
<th></th>
<th>Cost/QALY</th>
<th>WTP 0</th>
<th>100000</th>
<th>700000</th>
<th>1000000</th>
<th>2000000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actual Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost (min value)</strong></td>
<td>4600</td>
<td>0,00055</td>
<td>8</td>
<td>0,8</td>
<td>1306818</td>
<td>47,7</td>
</tr>
<tr>
<td><strong>Cost (max value)</strong></td>
<td>18000</td>
<td>0,00055</td>
<td>8</td>
<td>0,8</td>
<td>5113636</td>
<td>45,5</td>
</tr>
<tr>
<td><strong>Life length (-25%)</strong></td>
<td>5500</td>
<td>0,00055</td>
<td>6</td>
<td>4,5/7,5</td>
<td>2083333</td>
<td>49,4</td>
</tr>
<tr>
<td><strong>Life length (+25%)</strong></td>
<td>5500</td>
<td>0,00055</td>
<td>10</td>
<td>7,5/12,5</td>
<td>1250000</td>
<td>50,5</td>
</tr>
<tr>
<td><strong>quality of life (-25%)</strong></td>
<td>5500</td>
<td>0,00055</td>
<td>8</td>
<td>0,6</td>
<td>2083333</td>
<td>49,2</td>
</tr>
<tr>
<td><strong>quality of life (+25%)</strong></td>
<td>5500</td>
<td>0,00055</td>
<td>8</td>
<td>1</td>
<td>1250000</td>
<td>49,5</td>
</tr>
</tbody>
</table>

#### Hip DRG [2010]

<table>
<thead>
<tr>
<th></th>
<th>Cost/QALY</th>
<th>WTP 0</th>
<th>100000</th>
<th>700000</th>
<th>1000000</th>
<th>2000000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actual Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost (min value)</strong></td>
<td>3500</td>
<td>0,00099</td>
<td>6</td>
<td>0,7</td>
<td>841751</td>
<td>0,6</td>
</tr>
<tr>
<td><strong>Cost (max value)</strong></td>
<td>5500</td>
<td>0,00099</td>
<td>6</td>
<td>0,7</td>
<td>1322751</td>
<td>0</td>
</tr>
<tr>
<td><strong>Life length (-25%)</strong></td>
<td>4000</td>
<td>0,00099</td>
<td>4,5</td>
<td>3,375/5,625</td>
<td>1282668</td>
<td>0,1</td>
</tr>
<tr>
<td><strong>Life length (+25%)</strong></td>
<td>4000</td>
<td>0,00099</td>
<td>7,5</td>
<td>5,625/9,375</td>
<td>769601</td>
<td>0,1</td>
</tr>
<tr>
<td><strong>quality of life (-25%)</strong></td>
<td>4000</td>
<td>0,00099</td>
<td>6</td>
<td>0,525</td>
<td>1282668</td>
<td>0</td>
</tr>
<tr>
<td><strong>quality of life (+25%)</strong></td>
<td>4000</td>
<td>0,00099</td>
<td>6</td>
<td>0,875</td>
<td>769601</td>
<td>0,2</td>
</tr>
</tbody>
</table>

#### Stroke DRG [2010]

<table>
<thead>
<tr>
<th></th>
<th>Cost/QALY</th>
<th>WTP 0</th>
<th>100000</th>
<th>700000</th>
<th>1000000</th>
<th>2000000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actual Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost (min value)</strong></td>
<td>3000</td>
<td>0,00122</td>
<td>8</td>
<td>0,6</td>
<td>512295</td>
<td>42,5</td>
</tr>
<tr>
<td><strong>Cost (max value)</strong></td>
<td>20000</td>
<td>0,00122</td>
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Appendix 6: Sensitivity Analysis for all DRGs for 2010. Source: own presentation
### Sensitivity analysis for 2011

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<td>58.6</td>
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<td>66.3</td>
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References, which were used in order to establish values for the assumptions according to the variables l, q and C and the results of the regressions inclusive the graphical presentation of all years together and the years 2010/2011 and 2012 for all diagnosis included, are available upon request.