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Master thesis

Project effectiveness and efficiency analysis: Sirens Stroke project

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Abstract

Every year, approximately 12 000 people are admitted to Norwegian hospitals with stroke. In addition to being a frequent cause of death, stroke is a dominant cause of severe disability with great strain on patients, their relatives and society in general. The number of stroke patients is expected to increase parallel with more elderly people in the population. This, together with reduced mortality, means that the number of people living with sequelae after a stroke will increase significantly. It is therefore important to map the treatment offer and ensure that treatment and follow-up of this large patient group has been well taken care of.

"*Time is Brain*" is a catchphrase that explains why it is so important for people experiencing symptoms of a stroke to receive prompt care. A stroke occurs when a blood vessel in the brain is either blocked or bursts. The longer the brain is deprived of oxygen-rich blood, the greater the chances of long-term disability and even death.

Sirens Stroke has worked systematically to reduce the door-to-needle time at Stavanger University Hospital since 2009. From 2014 onwards, a median door-to-needle time of less than 30 min was achieved. However, Sirens Stroke hypothesised that further improvement could be achieved through implementing a revised treatment protocol and in situ simulation-based team training sessions in a quality improvement project. This hypothesis proved to be true as a reduction in median door-to-needle time of 13 minutes was achieved. This reduction also lead to 6.36 deaths averted annually.

The objective of this thesis was to monetise and calculate Sirens Strokes social contribution through their quality improvement project. We used "new economic foundation's" guide to conduct a social return on investment analysis and calculated the social benefit to be 11 301 981.92 Norwegian kroner. The total cost of implementing and maintaining the quality improvement project added up to 426 655.67 Norwegian kroner which lead the total social return on investment to be 26.49. This indicates that every 1 Norwegian kroner invested delivered 26.49 Norwegian kroner in social value.

We showed that social return on investment analysis can be used in health related projects and recommend Sirens Stroke and other non profit organizations to use this analysis method to convey heir social contribution.

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Abbreviations

SROI	Social Return On Investment
mRS	Modified Rankin Scale
DNT	Door-to-Needle Time
CEA	Cost Effectiveness Analysis
nef	New economics foundation
SUS	Stavanger University Hospital
NIPH	Norwegian Institute of Public Health
NPO	Non-Profit Organizations
MSU	Mobile Stroke Unit
NOK	Norwegian kroner
CUSUM	Cumulative Sum

1. Introduction

This chapter presents the background for the topic to investigate and analyze, why this is a topic of interest, the researchs limitation and the structure of the thesis.

1.1 Background

Every year, about 12 000 patients suffer a stroke in Norway. Despite declining incidence rates and more advanced emergency treatment, stroke is the most common cause of disability and hospitalization, and the third most common cause of death in Norway (Hagberg et al. 2019). Stroke treatment therefore has significant health and economic consequences. Sirens Stroke is an innovation platform who mainly focuses on improving clinical outcomes in stroke treatment. They lead and participate in various innovation projects. These projects are within quality improvement, simulation and service- and product-development.

For patients with acute stroke, it is crucial to restore blood flow as fast as possible for good outcome. Efficient operating procedure, team coordination, and communication is therefore vital. At Stavanger University Hospital, the stroke team has worked systematically to reduce the time from arrival at the emergency room to start of thrombolysis administration (the so-called door-to-needle time (DNT)) since 2009. In 2014, the team achieved a median DNT of less than 30 min. Although this is well within Norwegian national target recommendations, it omitted many patients from treatment within the most beneficial time-window. In order to insure better patient outcome a further reductions in DNT was necessary. Studies has shown that human factors in the stroke team is suggested as the most important rate-limiting factor in acute stroke care. The Quality Improvement (QI) project was introduced to target this by implementing a revised treatment protocol and in-situ simulation-based team training sessions.

1.2 Problem definition

As a result of the QI-project, the median DNT has gone from 27 minutes to 13 minutes which is the best in the world per 2019, stated by Martin Kurz (head of stroke unit) to NRK Rogaland (NRK Rogaland n.d.). Just by looking at these numbers we can see that the QI project has had a very positive impact, but who has been effected and how big the impact has been is what Sirens Stroke needed our help to figure.

The purpose of this thesis is therefore to *monetise and calculate Sirens Stroke's social contribution trough their QI project.*

In order to find a way of closing this gap, the following three research questions have been developed

1. *What type of analysis method can be used to calculate Sirens Stroke's social contribution?*
2. *Do we have the data needed to calculate Sirens Stroke's social contribution trough their QI project. If not, can we find good estimates?*
3. *Even though Sirens Stroke's QI project is a non profit project, is it economically profitable?*

1.3 Scope and limitations

1.3.1 Time frame

This thesis is conducted by one student in the spring semester of 2021 at the University of Stavanger. It counts towards 30 credits and was conducted over the course of approximately 20 weeks. It is therefore reasonable to state that time has been a limitation and assume that a longer time frame would lead to a more representative and valid result. Thus, unveiling a larger and more accurate image of Sirens Stroke's social contribution.

1.3.2 Knowledge level

Before starting the thesis, the author had limited knowledge of stroke treatment and social contribution calculation, as it has not been a part of the learning objectives of other courses. All knowledge on these topics was acquired during the master thesis.

1.3.3 Country

The research in this study will be carried out with respect to a Norwegian standards, while bearing in mind that cost, treatment, benefit and stakeholders may vary in other countries.

1.3.4 Literature study

The literature search has been limited to mainly consisting of five searching phrases. This limitation of searching phrases may have resulted in the exclusion of relevant information. The literature search has also been limited to English and Norwegian literature.

1.4 Thesis outline

The chapters of this thesis were structured into seven parts:

Chapter	Description
1. Introduction	The reader is introduced to the motivation behind this thesis topic. Also the problem statements and research questions are defined.
2. Theory	Educates the reader in central terms within stroke treatment and gives the theoretical knowledge necessary to understand the thesis content.
3. Literature review	Presents the main sources used in this thesis and looks at their credibility, relevancy, reliability and validity.
4. Methodology	Consists of a thorough description of how the author has gone forward to answer the primarily purpose and accompanying research questions. The methods used are based on ″new economic foundation's″ guide to calculate Social Return On Investment (SROI).
5. Results	Presents the findings from calculating SROI.
6. Discussion	Discusses the findings and interprets the results. The discussion does also contain personal opinions and views of the author.
7. Conclusion	Carries out the purpose of the assignment by answering the primary purpose and accompanying research questions, in addition to recommendation for further research on the topic.

Table 1.1: *Thesis outline*

2. Theory

In order to better understand our calculations and thought process in this thesis, it is important to have some understanding about the central themes in stroke treatment. In this chapter we are looking to give that understanding without going to deep into medical therms. We will take a closer look at what the QI project is, how it was directed and what was achieved. Then the results of Cost Effectiveness Analysis (CEA) done by the stroke team will be presented and explained. Finally we will explain what SROI analysis is and how it is conducted.

2.1 Stroke thrombolysis

Stroke is a serious life-threatening medical condition that happens when the blood supply to part of the brain is cut off. There are two main types of stroke, ischaemic (which make up 85%) and hemorrhagic (which make up 15%). In ischaemic stroke, the blockage can be caused by a blood clot forming in an artery leading to the brain, or within one of the small vessels deep inside the brain. Patients diagnosed with ischemic stroke will usually be given aspirin to help stop clots forming in their blood. In some cases however, patients are eligible for a clot-busting drug. The drug aims to disperse the clot and return the blood supply to the brain. The process of giving this medicine is known as thrombolysis (association n.d.).

For most people thrombolysis needs to be given within four and a half hours after stroke symptoms starts. In some circumstances, the doctor may decide that it could still be of benefit within six hours. However, the more time that passes, the less effective thrombolysis will be. This is why its important to get to the hospital as quickly as possible after the symptoms appear. The sooner you are treated, the better the chances of improvement, and the lower the risk of harm. Thrombolysis has led to 10% more patients recovering with no significant disability. Despite its benefits, there is a risk that thrombolysis can cause bleeding in the brain and be fatal, especially if the patient is not eligibile for this treatment (association n.d.). One type of patients that is not suitable for thrombolysis is those who have hemorrhagic stroke.

Hemorrhagic stroke is when blood does not reach the brain because of leaks from a blood vessel in or around the brain. When this is the case, the patient is given drugs to lower blood pressure and sometimes emergency surgery is needed to remove blood or to repair blood vessel. Blood-thinning medicine for patients with hemorrhagic stroke only causes more brain bleeding and can be life threatening (association n.d.). It is therefore important that patients receive the right treatment as fast as possible. This is what Sirens Stroke looked to achieve trough their QI-project.

2.2 Quality improvement project

Sirens Stroke is a leading innovation platform. The foundation has about 10 employees and is involved in a large range of activities where their main focus is to improve clinical outcomes in stroke treatment. At Stavanger university hospital (SUS) they hypothesised that further improvement could be achieved through implementing a revised treatment protocol and *in situ simulation*-based team training sessions. In situ simulation is defined as, "Simulations that occur in the actual clinical environment and whose participants are on-duty clinical providers during their actual workday" (Patterson et al. 2008).

2.2.1 Treatment protocol

At SUS, patients with suspected acute ischaemic stroke were usually admitted directly to the emergency room for assessment by a round-the-clock on-call stroke treatment team (neurology registrar, two emergency room nurses, two radiographers, radiologist and phlebotomist). Before the patients are administrated to receive intravenous thrombolysis there are some procedures that has to take place. These procedures include National Institutes of Health Stroke Scale scoring, measurement of vital signs, peripheral venous cannulation, collection of blood samples and a non-enhanced head computed tomography (CT) scan. After it is clear that the patient does not have haemorrhagic stroke and that the patient is eligible for thrombolysis, the intravenous thrombolysis is administered in the CT lab (Ajmi et al. 2019).

In order to find the best possible treatment protocol to improve, stroke team members were surveyed through an anonymous online questionnaire (Survey Monkey) sent via email. The survey contained following questions:

1. Can you suggest any improvements that would reduce the in-hospital time to treatment for stroke patients eligible for thrombolysis? (Reducing DNT)
2. Can you suggest changes to the way the stroke team members interact that could lead to more efficient treatment?

When looking at the responses, it was clear that the most frequent answer for question one was that transporting the patient directly to the CT lab (as opposed to the emergency room first) would reduce DNT. For the second question it was lack of leadership skills that were the main problem. It was suggested that neurology registrars should be more ″visible″ as team leaders and ″share their thoughts″. Several of those surveyed had also mentioned the lack of clearly defined responsibilities for the different professions in the stroke team. Using this information along with a review of existing literature, the QI team suggested relevant changes to improve the treatment protocol. They also added learning objectives to the in situ simulation-based training sessions specifically for neurology registrars to address the issues raised in the survey. This lead to the following changes in the treatment protocol; prenotification of the in-hospital stroke treatment team through a dedicated stroke thrombolysis alarm, patient preparation during transport, direct transport to CT lab, delaying collection of blood samples to after intravenous thrombolysis administration whenever a decision regarding thrombolysis did not depend on the results. The QI team also presented treatment protocol with clearly defined assignments for each of the different professions in the stroke treatment team. This was to make it more clear what each of their responsibilities were. The assignments were also processed in parallel rather than sequentially to save time (Ajmi et al. 2019).

2.2.2 Simulation training

Starting in February 2017 the QI team had arranged one training session each week for 4 months. All stroke treatment team members and paramedics on-call the day of the session participated. The frequency of sessions allowed most members within each profession to attend at least one session. During these sessions the key learning objectives were adherence to the revised protocol and specific non-technical skills believed to improve team efficiency. With the collaboration of local stroke patient organisation, patient participated in scenarios and acted as simulated patients to make the scenarios as real as possible. Additionally, participants were instructed to be aware of potential areas of improvement within their role and report these. The QI team met regularly during the implementation phase to discuss and potentially act on feedback. With the purpose of further research in mind, all sessions were videotaped by a facilitator.

2.2.3 Outcome measures

When looking at the outcomes of the QI project, the team used Kirkpatricks four-level training evaluation model. The Kirkpatrick Model is a globally recognized method of evaluating the results of training and learning programs. It rates the programs against four levels of criteria: reaction, learning, behavior, and results.

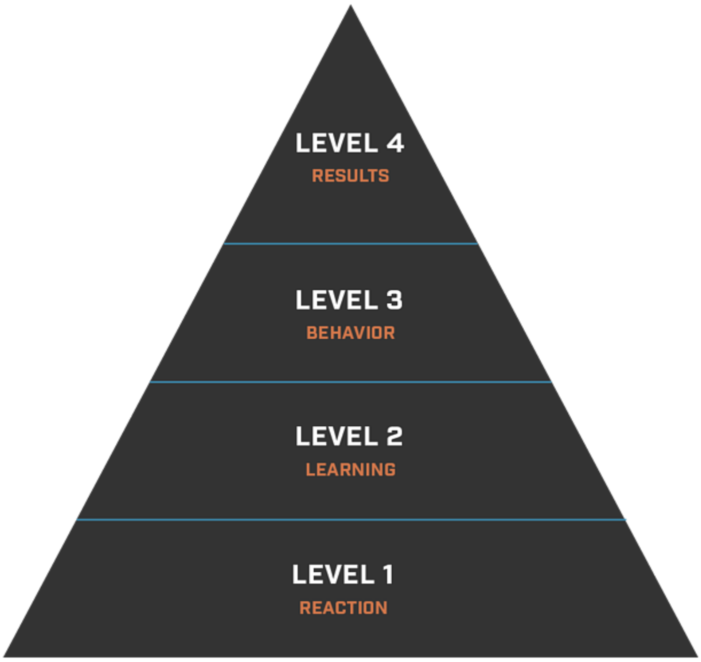

Figure 2.1: *Kirkpatricks four-level training evaluation model.* Source: (Learning 2019)

The first level looks at whether learners find the training engaging, favorable, and relevant to their jobs. To examine this, the QI team surveyed participants and asked the following questions:

1. Was this simulation session useful to you? Rate your response from 0 (not at all useful) to 10 (very useful).
2. Did you succeed in treating the simulated patient? Rate your response on a scale from 0 (not successful) to 10 (perfect).

The second level gauges the learning of each participant based on whether learners acquire the intended knowledge, skills, attitude, confidence and commitment to the training. It is not clear what methods the QI team used for assessment of learning.

One of the most crucial steps in the Kirkpatrick model, level 3 measures whether participants were truly impacted by the learning and if they are applying what they learn. The QI team assessed clinical behavioural change by measuring treatment times for all consecutive patients receiving intravenous thrombolysis for a suspected acute ischaemic stroke.

The final level, level 4, is dedicated to measuring direct results. The direct results measured by the QI team was patient outcome. This was assessed by measuring the degree of functional dependence and mortality using the modified Ranking Scale (mRS) outcome 90 days after stroke onset. MRS measures the degree of disability or dependence in the daily activities of people who have suffered a stroke or other causes of neurological disability. The scale ranges from 0 (no symptoms) to 6 (death). The Norwegian health directory (Helsedirektoratet) explains the mRS in the following way:

0. No symptoms at all
1. No significant disability despite symptoms; able to perform all tasks and activities as before

2. Mild disability; not able to perform all activities as before, but manages their daily chores.

3. Moderate disability; need some help but can walk on their own.

4. Moderate severe disability; unable to walk without help and unable to take care of their basics needs without help.

5. Severe disability; bedridden and needs constant supervision and help

6. Death

(Helsedirektoratet 2019)

The QI team divided patients into four categories. The first categori was patients with no symptoms (mRS 0). Patients with ″Excellent″ outcome was defined as mRS score of 0-1 (either no symptoms or symptoms without significant disability). ″Good″ outcome was defined as a mRS score of 0-2 (functional independence). Additionally, ″Worst″ outcome was defined as a mRS score of 5-6 (bedridden or dead). By collapsing mRS outcome 5 and 6 into one category any improvement from dead to bedridden is neglected. Patients and caregivers on average do not consider a mRS outcome of 5 as better than 6 (some even consider a score of 5 as worse) (Ajmi et al. 2019).

2.2.4 Result

All this led to a significant and sustained reduction in median door-to-needle time for stroke thrombolysis from 27 to 13 min after introducing in-situ simulation-based team training sessions in combination with a revised treatment protocol. With regards to outcome, the QI team reported that there was no signal of improvement for patients with ″Good″ or ″excellent″ outcome. It did however show improvement for patients with ″worst″ outcome (Ajmi et al. 2019).

2.3 Social Return On Investment analysis

SROI analysis is a process of understanding, measuring and reporting on the social, environmental and economic value that is being created by an organisation. This is done by producing a ratio that states how much social value (in monetary terms) is created for every $1 of investment. This analysis method was originally developed by the Roberts Enterprise Fund in 1996. Since then, there has been a gradual revision of the original methodology. SROI framework is an approach to measurement developed from cost-benefit analysis, social accounting and social auditing. There are mainly two ways of conducting SROI analysis. One can either conduct an evaluative analysis, which is based on actual outputs and outcomes that have already taken place or are currently in process, or forecast analysis which predicts how much social value will be created if the activities meet their intended outcomes (nef 2008).

A systematic review on the use of SROI methodology to account for value for money of public health interventions published by ”BMJ Public Health” showed that since 2005 when SROI was first used in the public health sector, 28 SROI studies were conducted in the UK. This is more than any other countries (Banke-Thomas et al. 2015). In the UK, SROI has been championed by nef (Edwards & Lawrence 2021). They have provided a guide which everyone can follow to conduct their SROI analysis.

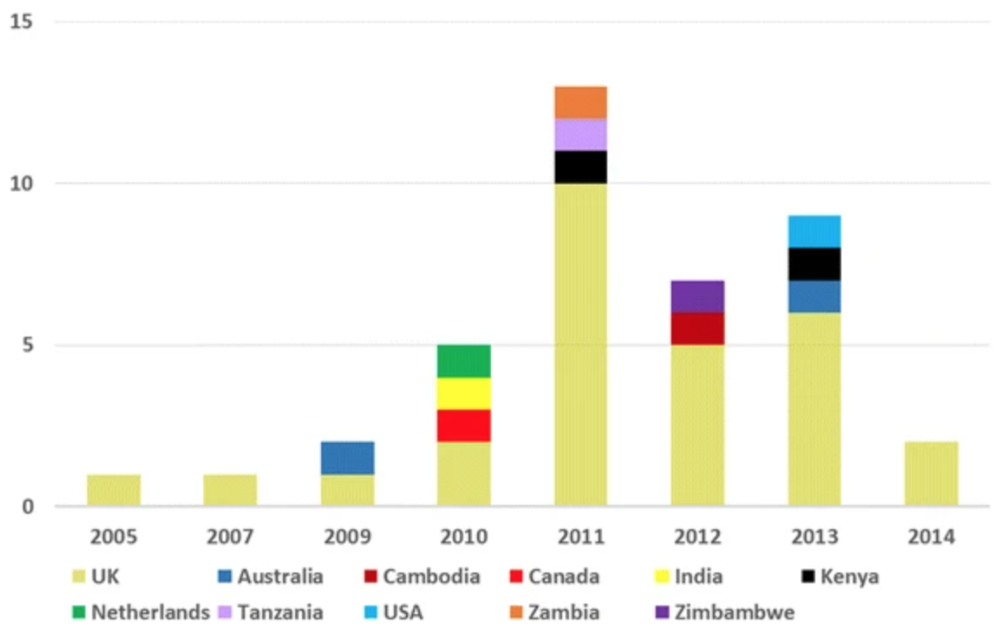

Figure 2.2: *Number of studies published by year in countries where SROI has been applied.* Source: (Banke-Thomas et al. 2015)

Nef's SROI analysis focuses on the people who are important to an organisation, its stakeholders. Moreover, it is based on social and environmental accounting principles which has a clear process for involving stakeholders. In this guide each stakeholder identifies their own social objectives for the project. Further, nef advises that a theory of change has to be taken into account. This is to reflect how an organisation makes a difference in the world. That is, how it delivers on its mission. "Impact map" is used as a tool to develop an organisation's theory of change. This provides a framework for organisations to better understand how their actions actually create change, by analysing the cause-and-effect chain of inputs, outputs, outcomes and impacts (nef 2008).

In conclusion, the SROI process involves:

- Communicating with stakeholders to identify what social value means to them
- Understanding how that value is created through a set of activities
- Finding appropriate indicators, or ways of knowing that change has taken place

- Putting financial proxies on those indicators that do not lend themselves to monetization
- Comparing the financial value of the social change created to the financial cost of producing these changes

3. Literature Review

An important basis for a thesis is the preparation of a theoretical platfrom and an understanding of the subject taken into consideration. In relation to this thesis an extensive literature study has been completed to create a theoretical platfrom for answering the research questions.

Before our literature study started, the problem statement had already been agreed on together with Sirens Stroke. We were referred to the QI report in order to get a better understanding on what the project was about and the results of the project. We also received the CEA conducted by Sirens Stroke. It was not easy to fully understand the content of these papers at first as there were used medical terms we were not familiar with. After getting an understanding of these terms we went on to search for possible ways to calculate Siren Stroke's social contribution when we fund nef's guide to calculate SROI.

We then hypothesized that we could look at patients outcome pre- and post-QI and compare treatment costs to estimate how much money was saved. For this, we had to find key costs related to patients treatment. We found a manuscript that looked at costs related to stroke patients with different degrees of disability, but this was from 2007. If we decided to use these numbers, we would have to take into account inflation and that cost of treatment today is different from 2007. However, Dr. Soffien Chadli Ajmi who is one of the authors of the QI report and Sirens Stroke's CEA introduced us to a report from 2019 published by The Norwegian Institute of Public Health (NIPH) on "Pre-hospital CT for early diagnosis and treatment of suspected acute stroke or severe head injury" (Ormstad et al. 2019). Here we could find relevant cost and probabilities relevant for our analysis.

When looking at and evaluating literature, it is important to look at whether they are credible and valid. Reliability can be seen by looking at who the author and publisher are. Validity on the other hand depends on whether the paper can be used to help answer the question in hand. We will review the four main sources we based our thesis on.

3.1 Quality improvement report

The purpose of this thesis is based on the report from the QI-project. Here the authors have presented how they proceeded to reduce DNT time. It does however not look at the bigger picture of how the stakeholders was affected. We used the report to get an understanding on how the reduced DNT changed patient outcome.

In the QI report the authors have divided the patients in four health states. Patients with ”No symptoms”, ”Excellent”, ”Good” and ”Worst” outcome. These are patients in mRS 0, 0-1, 0-2 and 5-6 respectively. However there were no data on patients in mRS 3 and 4. This theses aims to use the outcome data from this report to calculate the social return from the QI project. Additionally, we will estimate how all patients (mRS 0-6) were affected by the project.

3.2 Cost-effectiveness analysis

After looking at the results of QI project, the team presented a retrospective CEA. This paper represents cost of implementing and maintaining the QI project using recognized frameworks for cost reporting. Cost-effectiveness was presented as incremental cost-effectiveness ratios including costs per minute door-to-needle time reduction, and costs per averted death in the 13-month post-intervention period. The QI team also estimated incremental cost-effectiveness ratios for a projected 5-year post-intervention period and for varying numbers of patients treated with thrombolysis. All costs including fixed costs for implementing the QI project totalled $44 802 USD, whilst monthly costs were $2 141 USD when all costs were included. All costs were adjusted for inflation, expressed in 2019 prices, and converted from NOK to US Dollars as per 01.11.2019. The QI team calculated a mean reduction in door-to-needle time of 13.1 min per patient and 6.36 averted deaths annually. The estimated costs per minute reduction in door-to-needle time was $29 USD, and the estimated costs per averted death was $10 543 USD.

Traditionally, cost-effectiveness, cost-utility and cost-benefit analyses have been used to assess value-for-money of public health interventions. However when it comes to socio-economic outcomes and analysing views of multiple stakeholders, this traditional analysis methods fall short. We will use the total cost for implementing and maintaining the QI project as the total investment in our calculation of SROI. We will also use data available to estimate money saved from averting those 6.36 deaths and use logical thinking to predict those patients health status post stroke.

The CEA is under ethics approval before publication as studies involving human participants require evidence that the research has been approved by a human research ethics committee before it is published. However, we can trust numbers and calculations represented in the paper. When we have based our calculation or assumptions on content from the CEA we have clearly stated this in the text.

3.3 New economic foundation's SROI guide

As mentioned before, nef has championed the use of SROI and provided guides to help organisations and institutions demonstrate their social, economic and environmental impact. This means that nef has a lot of experience with SROI and their guide will be adequate to use. We found two guides provided by nef. The one we used was published in 2008 and the other one in 2009 (Nicholls et al. 2009). We chose to use the older version as we found it easier to follow. However both guides has the same principles and most of the steps are the same. Which guide we followed would not affect our result. Nef's guide has been written primarily with a third-sector audience in mind, but much of the content will be equally applicable to public and private sector organisations that want to demonstrate their social impact.

3.4 Norwegian Institute of Public Health

In this report, NIPH looked at if a mobile stroke unit (MSU) reduced time to thrombolysis and increased number of patients who receive thrombolysis compared with conventional care of acute stroke. MSU is described as an ambulance equipped with a CT scanner that helps bring the hospital to the patient (Ormstad et al. 2019).

In this report, NIPH presented estimates for overall costs associated with long-term follow-up, rehabilitation, secondary follow-up, nursing and care for patients who have undergone stroke. These costs are costs during the first year of stroke treatment and costs that accrue annually after the first year. Other key cost like cost related to recurrent stroke was also presented in this report. In absence of Norwegian estimates for overall costs for patients who have undergone stroke, they have used cost data from a report compiled by the Swedish study.

Further, NIPH represented estimates for ”Hazard ratio of death beyond 1 year for independent and dependent patients” and conducted a Markov analysis in order to calculate transition probabilities for patients in different health states post stroke. In the model represented, they divided patients into 3 categories, which correspond to the 3 main health states in the Markov model: independent, dependent, and dead. It was also assumed a cycle length of 12 months, meaning that any transition between different health states could happen once a year. At the end of each cycle the model evaluates how the cohort of patients move between the mutually exclusive health states based on transition probabilities, which vary with current health state, age and treatment.

The state ”dead” is modelled as an absorbing state. It is not possible to change state from the absorbing state. Once an individual makes a transition into the absorbing state, no further incurred costs or health outcome are included in the analysis. In addition, the model includes a transient state, recurrent stroke, which opens for revision of current state. Upon completion of each cycle, all patients could, depending on transition probabilities, remain in the same state or transfer to another state until death or the end of the simulation. Transition from dependent to independent state is only possible through rehabilitation and spontaneous regression of neurological outcomes within the first year after stroke (Ormstad et al. 2019). Figure 3.1 is a representation of how transitions can happen between each state.

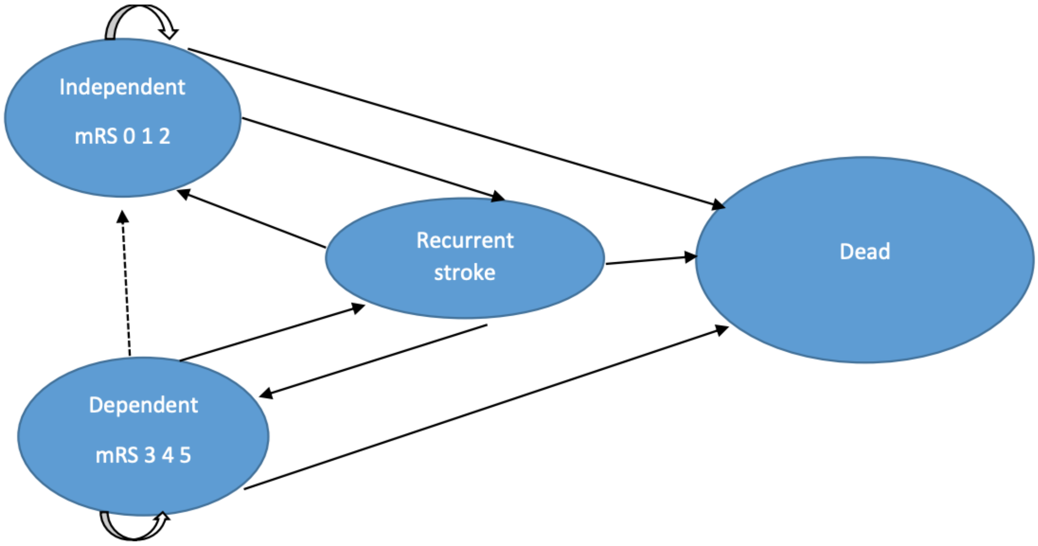

Figure 3.1: *State transition diagram. The dotted line illustrates that transition from dependent to independent state only is possible within the first year after stroke.The dotted line illustrates that transition from dependent to independent state only is possible within the first year after stroke.* Source (Ormstad et al. 2019)

We also fund other key numbers like the expected quality adjusted life expectancy for patients that are 70 years of age. At this age, patients are expected to have 12.7 Quality Adjusted Life Years (QALYs) for a presumably health population. This is based on mortality rates from a Norwegian life table used in their model combined with age adjusted quality of life weight for a healthy population of 0.80. We will show why these numbers are key in our thesis and how we used them in our calculation of Sirens Stroke's SROI for their QI project.

4. Methodology

In this chapter we will show how we used nef's guide to calculate SROI for the QI-project. The guide is divided into four main stages with each stage containing several steps. These stages and steps are shown in figure 4.1. We will show and explain what we did in each step.

The four stages of a nef SROI analysis	
Stage 1 - Boundary setting and impact mapping	Step 1: Establish the parameters for the SROI analysis Step 2: Identify, prioritise and engage stakeholders Step 3: Develop a theory of change
Stage 2 – Collecting data	Step 1: Select indicators Step 2: Identify financial values and proxies Step 3: Data collection
Stage 3 - Modelling and calculating	Step 1: Analyse inputs Step 2: Add up the benefits Step 3: Project value into the future Step 4: Calculate the SROI Step 5: Conduct the sensitivity analysis Step 6: Value added and payback period (optional)
Stage 4 – Reporting and embedding	Step 1: Prepare the SROI report Step 2: Communicate and embed

Figure 4.1: *The four stages of a nef SROI analysis.* Source: (nef 2008)

4.1 Stage 1: Boundary setting and impact mapping

4.1.1 Step 1: Establish the parameters for the SROI analysis

Step 1 is designed to help the user think through decisions regarding the scope, what resources are available, and broadly what the priorities are for measurement of the SROI.

After a fromal meeting with Sirens Stroke's representative, decisions about the scope of SROI report had been made. The primary motivation for undertaking the SROI was to better communicate impact, and to try to put monetary value to the social contribution of Sirens Strokes project. There was no dedicated funding available for the SROI. As such, it was decided that the SROI would be conducted by the author alone, under supervision of the project manager at the foundation. The time frame for completion of the SROI was set to coincide with the deadline for this theses, which was four months away from when we started. The short time frame and the fact that it had to be completed with limited resources meant that the author and Sirens Strokes project manager decided to focus on just one of its projects with a plan to consider other projects when possible. The first project to focus on was the QI project, which aims to reduce the time to treatment in patients with acute stroke by mapping and refining current process.

Sirens Strokes team has done a cost-effectiveness analysis for the QI-project where they considered a total of 399 patients pre-intervention and 190 patients post-intervention. Our SROI-analysis will be based on the same numbers of patients who were treated three years pre-intervention and 13 months post-intervention respectively.

4.1.2 Step 2: Identify, prioritize and engage stakeholders

As mentioned before, stakeholders are central in nef's guide to calculate SROI. A stakeholder is any person or group of people that can affect or is affected by the organisations activities. To determine who we considered as stakeholders, we used the following questions as a guide and listed the stakeholders in table 4.1

- Who are the direct beneficiaries?
- Who are the indirect beneficiaries?
- Who contributes to the project, either financially or otherwise?
- Who else either makes the project happen or is affected by it, even if only peripherally?

Table 4.1: *Stakeholders for Sirens stroke's QI project.*

Stakeholders
The stroke team (neurology registrars, ED nurses, paramedics, radiologists, radiographers and biochemists)
Patients with ischemic stroke eligible for thrombolytic treatment
Patient's family
The state
Stavanger municipality
Taxpayers
Board members

Now that the stakeholders have been identified they should be prioritized because it is neither possible nor relevant to consult all. In other words, key stakeholders should be identified. Key stakeholders are those who are either most affected by the impact or whose influence can most directly affect the outcome of an area of work.

It was decided that the areas of impact that were most important to Sirens Stroke were around patients treatment and outcome. Based on a quick review, stakeholders were either identified to be included, or excluded from the analysis. In each case, a reason was given. Excluding stakeholders from the SROI analysis does not mean that they are not important, nor does it diminish their input to the organisation. In some cases it simply means that value to them is being counted elsewhere.

Table 4.2: *Stakeholders and reason for inclusion/exclusion.*

Key Stakeholders	Reason for inclusion
The stroke team	The project is centered around the team and improving team performance
Patients	Direct beneficiaries. Central to the organization's mission
Patient's family	Also close to achieved outcomes
Stavanger municipality	The municipality is responsible for most local health and care services in Norway

Excluded stakeholders	Reason for exclusion
Board members	Not key beneficiaries
Taxpayers	Money would be used elsewhere if not for this project
The Norwegian Directorate of Health	Responsible for national health policy, but not crucial to consider in our case

The next task was to find out about key stakeholders goals and objectives for Sirens Stroke's QI-project. The infromation that is collected from stakeholders feeds into the theory of change that is to be develop in the next step and is therefore crucial in deciding what will be measured.

Nef describes three main ways of finding out about the objectives and goals of stakeholders.

1. Making assumptions

2. Collecting the infromation from existing sources, where this infromation has already been sought

3. Collecting the infromation directly from stakeholders

Originally, we would have to make a detailed engagement plan containing how, where and when to engage with key stakeholders to determine their goals and objectives. However, in our case because of the covid situation, timeframe and resources available, we collected the infromation mainly from existing sources or by making assumptions. The goals and objectives of key stakeholders is presented in the table below.

Table 4.3: *Key stakeholders goal and objective*

Stakeholders	Description	Goals	Objective for QI-project
Stroke Team	Neurology registrars, ED nurses, paramedics, radiologists, radiographers and biochemists	• Minimizing brain injury • Treating medical complications • Uncovering patient's symptoms	• Simulation-based interventions targeted at teaching the revised treatment protocol to ease the process of implementation • Improvements in specific team non-technical skills to further efficiate teams
Patients	People diagnosed with ischemic stroke eligible for thrombolytic treatment	• To get the best treatment • Surviving and be independent after treatment	• Reduce the DNT • Improve morbidity and mortality rate
Patient's family	Family members and partners living with patients	• Participant to recover from stoke • Patients to be healthy	• Respite from care of family member
Stavanger municipality	Stavanger municipality together with Finnøy and Rennesøy municipality.	• Provide quality health and welfare services for the inhabitants	• Reduce the overall treatment and rehabilitation cost

4.1.3 Step 3: Develop theory of change

In this step, we created an impact map to be able to develop a theory of change. The theory of change is an account of how the organisation takes in resources (inputs) to do its work (activities) which leads to direct results (outputs) and longer term or more significant results (outcomes), as well as the part of those outcomes that the organisation can take credit for (impacts) (nef 2008). By linking the impact map to key stakeholders objective, we were able to identify how stakeholders is affected.

As one can see on the impact map there are some blank boxes. This is because not every stakeholder will, for example, be involved in an activity or provide an input. Some may simply have an interest in the outcome. As for the case of the QI-project, the patients getting treated does not take part in any activity nor do they provide any output.

Table 4.4: *Impact map*

Stakeholders	Input	Activity	Output	Outcome	Impact
Stroke Team	• Time • Skills	• Diagnose patients with stroke • Treat patients	• The number of patients diagnosed • The number of patients treated	• Averted deaths • Reduced DNT	• Able to provide improved treatment • Increased self-esteem
Patients	• Time	Not applicable	Not applicable	• Increased quality of life	• Decreased chance of severe morbidity • More lives saved
Patient's family	• Time	• Support family member	Not applicable	• Less time spent on care for family member	• Decrease in loss of family • Decrease in disabled family members
Stavanger municipality	Not applicable	Not applicable	• Better stroke treatment for residents in Stavanger municipality	• Improved patient outcome	• Reduction on rehabilitation cost • Reduction in welfare costs

4.2 Stage 2: Data collection

This stage is about selecting indicators to measure change. We selected indicators for each of the outcome from the impact map. In the second step, we moved on to attaching financial values, or proxies where necessary, to these indicators. Finally, in step 3, we collected outcome data.

4.2.1 Step 1: Select indicators

"An indicator is a piece of infromation that helps us determine whether or not change has taken place. They are specific pieces of infromation, signs or signals that can be measured to determine whether a given output or outcome has occurred, or has been achieved" (nef 2008). Indicators are an important part of the SROI-analysis. We are therefore concerned with outcome indicators rather than measuring outputs as outputs alone tells only part of the story. Outputs, in and of themselves, are not a measure of how lives, communities and society have changed but rather the direct and tangible products from the activity; for example the number of people treated. Outcomes on the other hand are changes that occur for stakeholders as a result of the activity. We use the impact map as starting point for developing an indicator set by matching indicators to outcomes. The result can be seen in table 4.5.

4.2.2 Step 2: Identify financial values and proxies

We then moved on to find ways of expressing the indicators in financial terms. This monetization process can sometimes be difficult, especially when little or no data is available for your indicators. For outcomes where this were the case we used proxies. "A proxy is a value that is deemed to be close to the desired indicator, for which exact data is unavailable." (nef 2008) The monetizable outcomes is listed in the table below with their appropriate proxies.

Table 4.5: *From outcomes to indicators to proxies*

Outcome	Indicator	Monetizable y/n	Proxy?
Averted deaths	Les stroke related deaths post intervention	Yes	Willingness to pay for QALY's
Reduced DNT	DNT post intervention	No	
Increased quality of life	Les dependent patients	No	
Less time spent on care for family member	Les dependent patients	No	
Improved patient's outcome	Les dependent patients	Yes	Reduced cost in patient treatment and rehabilitation.

4.2.3 Step 3: Collect Data

In our data collection we mainly collected data from published research or from people directly involved in the creation of the QI-project. For data that was not available in those publications, we made calculated assumptions or gathered numbers from other research because of time constraints. However in some cases even if we had no time constrains we would need to use a lot of resources to gather data, which would not be reasonable for us.

We also had to be mindful to avoid double-counting when including valuations of indicators that relate to more than one stakeholder. Double-counting occurs when the same value is counted twice for the same stakeholder. For example, if a patient is able to go back to work because of the QI project, benefits might accrue to them (expressed through income), to their carer (respite time), and to the government (tax and benefits). Counting the value to all three stakeholders is not considered double-counting. However, if the income gained through employment was intended to represent the improved well-being that employment brings about, then valuing the well-being benefit again separately would constitute double-counting.

It is also easy to spend a lot of time seeking data that you think should be available but in the end isn't. Setting limits on how long you will spend finding data is therefore important. It would be good for us if we found data that would fit our analysis perfectly, but after using a lot of time researching, we decided to use proxies. We will come back to how we added these proxies and the assumptions we made later in this chapter.

4.3 Stage 3: Modelling and calculating the SROI

Now we have almost all information needed to calculate the social benefits from the QI project. When all the benefits have been calculated and added up, we plot this into equation (4.1) together with "net present value of investment," in order to calculate SROI.

$$SROI = \frac{Net\ present\ value\ of\ benefits}{Net\ present\ value\ of\ investment} \tag{4.1}$$

SROI measures the value of the benefits relative to the costs of achieving those benefits. Source: (nef 2008)

The first step in this stage is to analyse inputs. In other words, identifying relevant costs and investments to the project. From there we move on to calculating and adding up the benefits.

4.3.1 Step 1: Analyse inputs

As mentioned before, Sirens Stroke have already conducted a cost-effectiveness analysis. In this analysis the cost of conducting the QI project was represented in details. We have represented the fixed costs, monthly costs and the total costs in table 4.6. The detailed cost table can be found in Appendices.

Table 4.6: *Costs related to QI-project*

Fixed costs	**NOK**
Fixed paid costs	283 158.78
Costs of donated units within working hours	106 377.81
Costs of donated units outside working hours	17 657.78
Monthly costs	**NOK**
Monthly paid costs	758.59
Costs of donated units within working hours	18 702.71
Costs of donated units outside working hours	0
Sum	**426 655.67**

4.3.2 Step 2: Add up the benefits

In this section we will show how we monetized the benefits and add them up to find the social return. The numbers we used and assumptions taken in our calculation is listed in figure 4.2.

Numbers and assumptions used in the calculation

- Yearly stroke patients treated at SUS=200
(aproximatly 850 patients are admitted anualy with suspicion of acute stroke eligible for revascularization, 20 to 30% receive intravenous thrombolysis).

Patients health state (mRS):
- Independent patients (mRS 0-2)
- Dependent patients (mRS 3-5)
- Death=(mRS 6)

Costs:
- Costs during the first year for patinents in independent state = 103 328 NOK
- Costs during the first year for patinents in dependent state = 230 339 NOK
- Annual costs after first year for patients in independent state = 40 234 NOK
- Annual costs after first year for patients in dependent state = 102 964 NOK
- Costs associated with recurrent stroke = 89 462 NOK

- Hazard ratio of death beyond 1 year for independent patients (mRS 0-2) = 1.04
- Hazard ratio of death beyond 1 year for dependent patients (mRS 3-5) = 1.78
- Risk of recurrent stroke = 0.05
- Transition from dependent to independent = 0.11
- Expected quality adjusted life expectancy for patients aged 70 = 12.7 QALY

- Willingnes to pay for QALYs in Norway = 385 000 NOK

- Working patients before stroke = 21%
- Of those working before the stroke, 54% were still working after

- Average wage (per 2020) = 608 160,00 NOK anualy
- Tax rate= 27 % (For those earning 608 160,00 NOK anualy)
- Working patients before stroke = 21 %
- Average disability benefits (per 2018) = 276 800 NOK (after tax)

Figure 4.2: *Numbers and assumptions used in our calculation*

First we assumed that there are annually 200 patients eligible for thrombolysis treatment at Stavanger University Hospital (SUS). This is based on what is stated in Sirens Stroke CEA about approximately 850 patients being admitted annually with criteria-based activation of the acute stroke team (typically patients with a suspicion of acute stroke eligible for revascularization). Of patients with a diagnosis of acute ischemic stroke, 20-30% receive intravenous thrombolysis.

Then we defined three categories for patients. Those who were in mRS 0-2 were classified as independent. These are patients who have no symptoms at all to patients who are not able to perfrom all activities as before, but manages their daily chores. Patients classified as dependent were in mRS 3-5. These are patients who need some help but are able to walk on their own to patients who are bedridden and needs constant supervision and help. The third state is death. We decided to divide the patients in these three states for two reasons. The first reason being that when conducting health economic analysis one has to bear in mind that sickness can vary over time. By this we mean that a patient can move from mRS 1 to 0 or from mRS 3 to 2, some time after their treatment. These possibilities has to be taken into account and the way to do this is by Markov analysis. The Markov analysis process involves defining the likelihood of a future action, given the current state of a variable. If we divided the patients in seven states (mRS 0-6) we would have to find the possibility for patients moving between each state. This would be difficult and very time consuming. The second and main reason for us to divide the patients the way we did is because of available data. We were referred to a study done by NIPH as mentioned in chapter 3 literature review. In this study, they presented the following probabilities shown in the figure bellow.

Parameter	Value (standard error)	Interval
Hazard ratio of death beyond 1 year for independent patients (mRS 0-2)*	1.04 (0.08)	(0.89-1.30)
Hazard ratio of death beyond 1 year for dependent patients (mRS 3-5)*	1.78 (0.46)	(1.02-2.84)
Risk of recurrent stroke	0.05 (0.01)	(0.04-0.07)
Mortality when recurrent stroke (cycle-length 12 months)	0.19 (0.03)	(0.13-0.25)
Mortality between 90-365 days	0.07 (0.01)	(0.05-0.09)
Transition from dependent to independent (only first year)	0.11 (0.02)	(0.08-0.14)

Figure 4.3: *Probabilities used in SROI analysis.* Source: (Ormstad et al. 2019)

We can see that transition probabilities from dependent to independent during first year post stroke has been defined. Further, we can also see hazard ratios of death beyond year 1 for independent and dependent patients. By using fromula (4.2) we were able to calculate the probability of death for those patients.

$$Probability(\%) = \frac{Hazard\, ratio}{1 + Hazard\, ratio} \tag{4.2}$$

Equation 4.2 shows how to go from hazard ratio to probability. Source: (Thompson & Reid 2019)

Further, in figure 4.4 we can see costs related to dependent and independent patients during the first year, and the years after. This was also presented in NIPH report. In order to be able to calculate all the benefits we still had to monetize costs/rewards for deaths averted as there was not included any estimation for this in NIPH's paper. It is stated in Sirens Stroke's CEA that "whether an investment is deemed cost-effective from the perspective of society depends on what the society in question is willing to pay for the observed effects. With regards to deaths averted, the most common method in healthcare is considering the societies willingness to pay for the quality adjusted life years (QALYs) gained. There is no official willingness to pay threshold for QALYs in Norway, but a recent Norwegian health technology assessment suggests a threshold for stroke-patients of approximately 385 000 NOK". Because death can be seen as the worst possible outcome, we assume that society are willing to pay the threshold of 385 000 NOK for each deaths averted. Thus, we used societies willingness to pay as money saved for each deaths averted.

Parameter	Value (standard error)	Interval
Standard treatment with intravenous thrombolysis	89,462 (13,693)	(62,623 – 116,300)
Costs first year in independent state (mRS 0-2)	103,328 (15,815)	(72,329 – 134,326)
Costs first year in dependent state (mRS 3-5)	230,339 (35,256)	(161,237 – 299,440)
Annual costs in independent state (mRS 0-2) after the first year	40,234 (6,158)	(28,164 – 52,304)
Annual costs in dependent state (mRS 3-5) after the first year	102,964 (15,760)	(72,075 – 133,853)
Costs associated with recurrent stroke	89,462 (13,693)	(62,623 – 116,300)

Figure 4.4: *Probabilities used in SROI analysis.* Source:(Ormstad et al. 2019)

As we mentioned before, our calculation is based on looking at patients outcome and costs related to these patients treatment pre- and post-intervention. In order to do this, we used the distribution of mRS scores at 90 days pre- and post-intervention represented by Sirens Stroke to find out how many patients was in each of the three state pre- and post-QI.

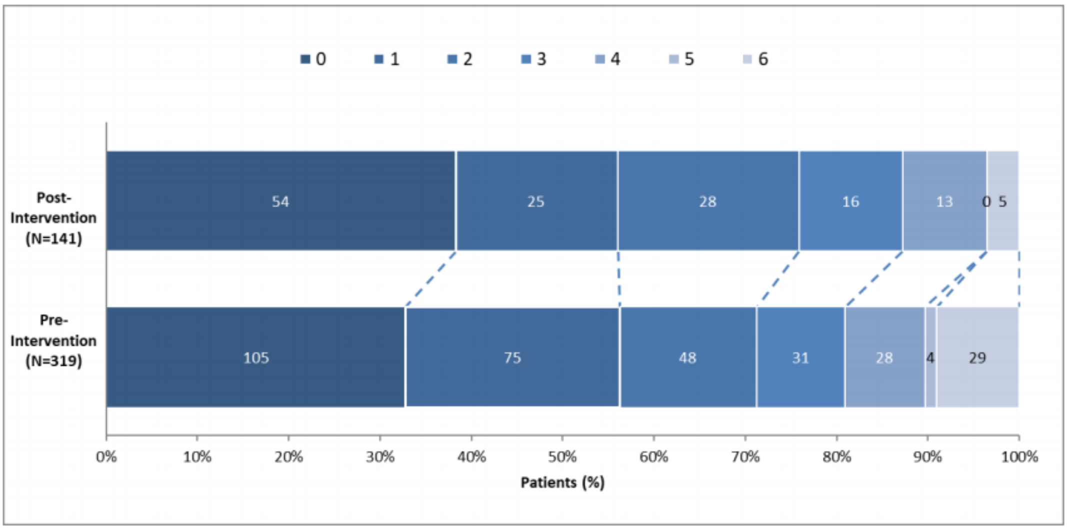

Figure 4.5: *Distribution of modified rankin scale scores at 90 days pre- and post-intervention.* Source: (Ajmi et al. 2019)

Table 4.7: *Health state of patients pre- and post-intervention*

Health State (mRS)	Pre-QI	Post-QI
Independent(0-2)	228	107
Dependent(3-5)	63	29
Death(6)	29	5
Sum	320	141

We then translated this distribution of patients into percentage.

Table 4.8: *Distribution of patients in different states pre- and post intervention*

(%) Patients in mRS	Pre-QI	Post-QI
Independent (0-2)	71.25%	75.89%
Dependent (3-5)	19.69%	20.57%
Death (6)	9.06%	3.55%
Sum	100%	100%

Using these percentages and our estimation that there is approximately 200 patients eligible for thrombolysis annually, we calculated the number of patients in each state pre- and post intervention.

Table 4.9: *Estimated number of patients in each state*

Estimated nr. Of patients in each state	Pre-QI	Post-QI	Difference
Independent (0-2)	142.50	151.77	9.27
Dependent (3-5)	39.38	41.13	1.76
Death (6)	18.13	7.09	-11.03

Now that we have our estimated number of patients, we can take into account that there are 11% chance for patient transition from dependent to independent state during the first year after stroke treatment as shown in figure 4.3. Estimated number of patients in independent and dependent state after transition is shown in the table below.

Table 4.10: *Estimated number of patients in each state after transition. Where the probability of patient transition from dependent to independent during the first year post stroke is 11%*

Estimated number of patients after transition	Pre-QI	Post-QI	Difference
Independent (0-2)	146.83	156.30	9.47
Dependent (3-5)	35.04	36.61	1.57
Death (6)	18.13	7.09	-11.03

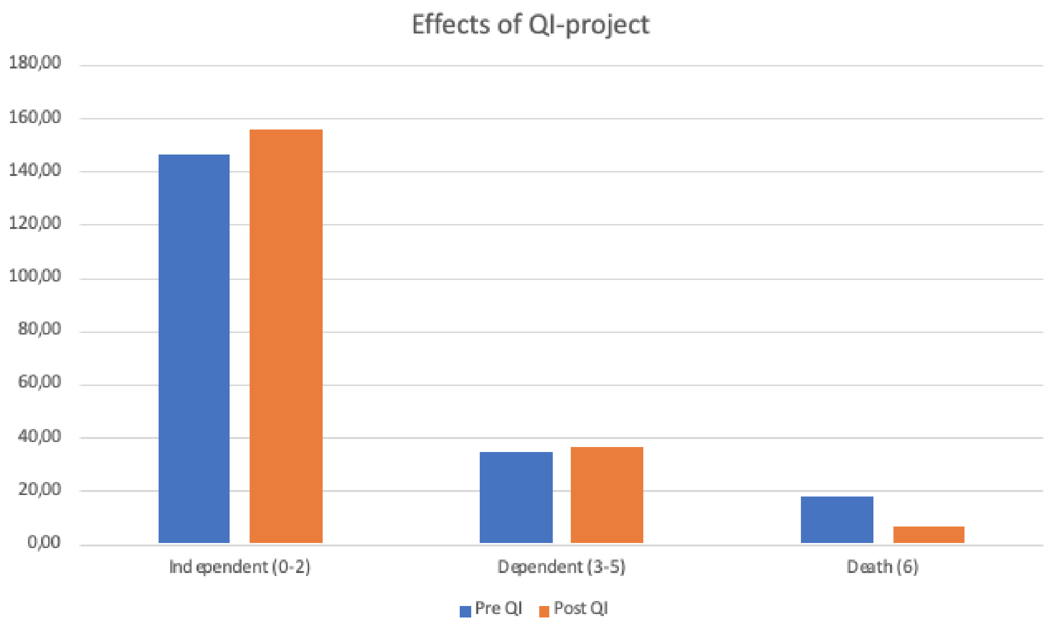

Figure 4.6: *Effects of QI-project*

We can see here that there is an increase in the number of independent patients and a small increase in dependent patients post intervention. These increases is a result of a decrease in patients who die from stroke. However, this number is not totally correct. As mentioned before, in Sirens Stroke's CEA they stated that deaths averted as a result of the QI project is 6.36 annually. This is a more precise estimation compared to 11.03 averted deaths annually which we calculated. This is because Sirens Stroke has taken into account patients premorbid status using risk-adjusted Cumulative Sum (CUSUM) charts. When looking at the number of deaths without adjusting, it may be that the population taken into account before QI was sick for other reasons before they received stroke treatment. It is therefore appropriate to adjust for underlying reasons. When these adjustments are taken into account, we are left with an estimated number of averted fatalities of 6.36 per year.

In the QI report published by BMJ journals it is also stated that the Risk-adjusted CUSUM charts gave no signal of improvement with regards to patients with "Good" outcome (Ajmi et al. 2019). Patients with good outcome is patients in mRS 0-2, refereed to as independent patients in our thesis. Taking this into account we can state that the increase of 9.47 patients pre- and post QI should be zero as QI-project did not lead to any improvement for these patients. As mentioned before, patients in mRS 3 and 4 was not tested for in Siren Strokes QI report. This is because they divided their patients in the following way: excellent=mRS 0-1, good=mRS 0-2 and worst= mRS 5-6.

Considering the fact that QI-project had no effects for independent patients and there was 6.36 averted deaths annually, we concluded that those death averted patients was moved to dependent state as a result of QI-project.

Table 4.11: *After taking into account Risk adjusted COSUM charts*

Estimated nr. Of patients after transition	Pre QI	Post QI	Difference	Adjusted numbers
Independent (0-2)	146.83	156.30	9.47	0
Dependent (3-5)	35.04	36.61	1.57	6.36
Death (6)	18.13	7.09	-11.03	-6.36

Even though we are using these adjusted numbers, we have to take into account the transition probability of 11% between independent and dependent patients.

Table 4.12: *Estimated number of patients after taking into account adjusted numbers of patients in each state and transition probabilities.*

Estimated number of patients	
Independent(0-2)	0.70
Dependent(3-5)	5.66
Death(6)	-6.36

Using these adjusted numbers and cost related to each state, we calculated the estimated money saved during the first year as a result of QI-project.

Table 4.13: *Estimated money saved (first year) as a result of QI-project after taking into account adjusted numbers of patients in each state.*

Estimated money saved	NOK
Independent(0-2)	- 72 288.27
Dependent(3-5)	- 1 303 810.88
Death(6)	2 448 600.00
Sum	1 072 500.86

After we had calculated money saved during the first year of QI-project, we moved on to considering what effects it would have in the years after. As mentioned before, we used formula (4.2) to convert from hazard ratio to probability in order to find the probability of death for independent and dependent patients beyond year 1. We then used these probabilities to calculate life expectancy for dependent and independent patients after year one. For independent patients, the probability of death was 51% and for dependent patients it was 64%. Using this together with the fact that life expectancy for a 70 year old person pre stroke is 12.7 QALY in Norway (Ormstad et al. 2019), we calculated the life expectancy for independent and dependent patients. For independent patients we estimated a life expectancy of 6.23 years after the first year of stroke treatment, and for dependent patients we estimated 4.57 years.

$$Life\,expectancy\,for\,independent\,patients(After\,year\,one) = 12.7 * (1 - 0.51) = 6.23 \quad (4.3)$$

$$Life\,expectancy\,for\,dependent\,patients(After\,year\,one) = 12.7 * (1 - 0.64) = 4.57 \quad (4.4)$$

We then moved on to calculate how much would be saved during these expected survival years. For independent patients we calculated an increase in cost of 175 233.27 NOK (0.70*40 234.00*6.23) because we estimated that 0.70 patients would transition from depended to independent. The annual cost for patients in independent state was 40 234.00 and we estimated a life expectancy of 6.23 years. Using the same calculation for dependent patients we estimated an cost increase of 2 662 511.26 NOK (5.66*102 964.00*4.57). The money saved comes from deaths averted and society's willingness to pay for QALYs. Using life expectancy for independent and dependent patients we calculated total money saved to be 11 632 395.70 NOK ((0.70*6.23*385 000.00)+(5.66*4.57*385 000.00)). The total cost saved from improved patients is shown in table 4.14.

Table 4.14: *Estimated money saved in improved patients outcome (after first year)*

Estimated money saved in improved patients outcome (after first year)	NOK
Independent (0-2)	- 175 233.27
Dependent (3-5)	- 2 662 511.26
Death	11 632 395.70
Sum	8 794 651.17

When considering the years after the first, we also had to calculate how much is saved with regards to recurrent stroke.

Table 4.15: *Recurrent stroke*

Patients with risk of recurrent stroke	6.36
Estimated nr. Of patients with risk of recurrent stroke	0.318
Cost related to patients with recurrent stroke	kr 28 448.92

The risk of recurrent stroke was 5% as shown in figure 4.3. The patients that have a risk of recurrent stroke if we compare pre- and post-QI is those 6.36 patients who has been affected. We calculated the expected number of patients with recurrent stroke to be 0.32 (0.05*6.36). The costs associated with recurrent stroke was said to be 89 462.00 NOK. Based on these numbers we estimated the cost related to patients with recurrent stroke to be 28 448.92 (89 462.00*0.32).

Now that we have calculated some of the benefits of QI-project, we can add them up. Here we can also add the benefits of better patient outcome by looking at how many more stroke patients are able to work as a result of QI-project. The following explains how we calculate the benefits for those patients that were able to go back on to full-time employment. First, our assumption is that each person who moves back to full-time employment will earn 608 160.00 NOK. This is based on the average yearly salary per 2020 (Pedersen 2021*a*). Those patients that regains employment have to pay taxes and they lose potential disabled benefits that they would receive if they were not able to work. The tax rate of people who earn about 600 000 was at almost 27% (Pedersen 2021*b*) and the average disability benefits (per 2018) was 276 800 NOK (after tax) (Normann 2021). This leads to a net benefit of 167 156.80 NOK for each patient that moves to a full-time job. Furthermore, we found out that the percentage of working patients before stroke is 21%. Of those 21%, the percentage of working patients after stroke is 54% (Fjrtoft et al. 2020). Again if we consider pre- and post-

QI, there are 6.36 patients we would have to take into account as these are the ones affected. Statistically, 21% of these patients worked pre stroke which is 1.34 patients. Out of these 1.34 patients, 0.72 got back to work post stroke. The total benefit for patients who are able to work adds up to 120 557.50 (0.72*167 156.80) each year. In our calculation we multiplied the net benefit to patients with the life expectancy of dependent patients to find the total benefit to patients after the first year. We used the life expectancy of dependent patients in stead of independent patients to avoid any overestimation. The total benefit from QI project to patients who are able to work because of QI added to 550 947.76 NOK (120 557.50*4.57).

Table 4.16: *Net benefit to patients*

Benefitts to patients	NOK
Patient wages (for some patients)	608 160.00
Less increase in tax contribution	- 164 203.20
Less welfare benefits lost (weighted average)	- 276 800.00
Net benefit per patient that moves on to full-time employment	167 156.80
Difference in number Of patients that works as a result of QI-project	0.72
Total benefit to patients	120 557.50

At last we can look at benefits to the national government. If the patients were not able to work, they would have needed to be supported trough disability benefits. We calculated that 0.72 patient no longer need disability benefits post stroke because of QI. Net savings in disability benefit expenditure is therefore 199 634.80 NOK for those 0.72 patients (0.72*276 800.00). Again taking into account life expectancy of independent and dependent patient to look at the total benefit in the years after the first. We calculated the total saving for national government to be 912 331.05 NOK (199 634.80*0.72*4.57). We can now add all the benefits up. Our calculation is shown in table 4.16.

Table 4.17: *Benefits added up*

Benefits added up	NOK
Estimated money saved in improved patients outcome (first year)	1 072 500.86
Estimated money saved in improved patients outcome (after first year)	8 794 651.17
Total benefit to patients (after first year)	550 947.76
Net savings in welfare benefit expenditure (after first year)	912 331.05
Cost related to patients with recurrent stroke	- 28 448.92
Combined benefits (across all stakeholders)	**11 301 981.92**

4.3.3 Step 3: Projecting value into the future

In this step nef recommends that we project the value into the future because outcomes can have longevity even if the organisations supporting them are no longer involved. In doing so, there are three things that need to be taken into consideration:

- Discount rate
- Benefit period
- Drop off

To calculate the SROI ratio, we need to compare the present value of benefits to the present value of the investment made to generate those benefits. Before this, we needed to consider time value of money and the uncertainty (or risk) of achieving the estimated benefits, as well as the uncertainty of our assumptions. However, nef have stated that for some benefits discounting may not be appropriate as the value of the outcome is not likely to decrease in the future. This is the case in QI-project. When it comes to the uncertainties in our assumptions, we will account for them in the sensitivity analysis and discuss them in chapter 6. Discussion.

The benefit period has already been discussed when adding up the benefits. Because we did not have data on how each year effected the patients and only had a collective concept on how it effected them the first year and after the fist year, this was what we included in our calculation. It of course has some downside which will be discussed later.

The final consideration when projecting into the future relates to drop-off. The concept of drop-off recognises that the benefits will not endure for all stakeholders over the entire benefit period. An example here is our calculation that there were 0.72 person more who are likely to go back to work post stroke as a result of QI-project. In our calculation we have stated that they will work for 4.57 years, but in reality we don't know if they are going to work all those years or fall off earlier. Because we did not have data on this either, we did not include any drop of rate.

4.3.4 Step 4: Calculate the SROI

Based on data available for us, we estimated social return for this project. Using formula 4.3 we calculated the SROI.

$$SROI = \frac{11301981.92}{426655.67} = 26.49 \tag{4.5}$$

SROI (Equation (4.2)) measures the value of the benefits relative to the costs of achieving those benefits. SROI=26.49 means for every 1 NOK invested, the social return was 26.49 NOK.

4.3.5 Step 5: Conduct the sensitivity analysis

Now that the SROI have been calculated it is important to assess the extent to which our results would change if our assumptions changed. This is referred to as a ”sensitivity analysis”. The aim of such an analysis is to show which assumptions have the greatest impact on our model (nef 2008). First we can look at what would happen if we did not adjust the number of patients in each state. Without adjusting and taking into account how many patients actually benefited from QI-project we would have calculated the estimated cost saved during the first year to be 2 908 709.27 NOK and not 1 072 500.86 NOK, which is a more precise estimate. Without adjusting, the combined benefits from QI project would add up to 27 733 303.82. This would lead to a SROI of 6.00, which is much larger than what we calculated and an overestimation. The return from QI project after year one, total benefit to patients and net savings in welfare expenditure without adjusting is shown in table 4.18.

Table 4.18: *Benefits added up without adjusting*

Combined benefits without adjusted numbers	NOK
Estimated return from QI-project (First year)	2 908 709.27
Estimated return from QI-project (After first year)	22 336 489.53
Total benefit to patients	955 392.50
Net savings in welfare benefit expenditure	1 582 063.34
Combined benefits	**27 733 303.82**

4.4 Stage 4: Reporting and embedding

The final stage of nef's guide focuses on representing and communicating the SROI report in a way that it can be used as a tool for both proving and improving. This stage is divided into two steps;

- Step 1: Preparing the SROI
- Step 2: Communicating and embedding

Because of our theses outline, we will not show how we completed these steps in this chapter, but both step 1: "Preparing the SROI" and step 2: "Communicating and embedding" has been considered and presented in other parts of this thesis.

5. Results

When we first had a meeting with Sirens Stroke and they presented the problem statement they wanted us to consider, which was to calculate QI the project's social contribution, we did not know how we should proceed in doing so. Most economical analysis methods which we are used to see and use does not consider benefits to the society. This is because value creation has been about delivering value or profit mainly to shareholders, generating a collective tunnel vision. However, after some research we found out that SROI analysis can be used to answer our problem statement.

The SROI equation is quite a simple equation to understand and calculate. However, we see that creating SROI calculations is about more than slotting figures into an equation. It is about thinking through inputs, activities, outputs, outcomes and impacts, and then making judgements about how each key stakeholder group is affected by this process. In doing so we calculated the social return on investment for the QI-project to be 26.49. As interpreted before, this means that for every 1 NOK invested, 26.49 NOK of social value is created for society in terms of reduced health care costs, reduced benefits costs, and increased taxes collected.

There are a number of other benefits we were not able to find appropriate proxies for such as ”benefits for patients family in less time spent on care for family member” and ”reduced DNT”. Other benefits like ”increased self-confidence of stroke team” and ”decreased divorce rate because of improved patient outcome” were also not included, suggesting that the social return calculations are likely to underestimate the true social value created by Sirens Stroke's QI project.

As the SROI analysis demonstrates, the main reason QI creates value for Sirens Stroke is because of better patient outcome and deaths averted. This then leads to saved cost in patient treatment, reduced benefits costs, increased number of working patients post stroke and therefore increased taxes collected. By adding all these benefits and taking into account life expectancy for patients, we estimated the social contribution of Sirens Stroke's QI project to be 11 301 981.92 NOK. It is important to understand that the SROI of 26.49 is not the annual SROI, but rather the SROI for averting 6.36 deaths. The 6.36 patients whose lives have been saved is expected to fall into dependent state (mRS 3-5) because QI project did not show any improvement for independent patients (mRS 0-2). After taking into account transition probabilities however, we expect some patients to move from dependent to independent state (through rehabilitation). In table 4.13 for example, the estimated money saved for independent and dependent patients is negative, because we expect more patients is these states.

We have already shown how much our calculation of the SROI would have changed if we did not adjust for patients premorbid status. Another assumption that could have changed the SROI ratio is if we in our calculation of "benefits to patients" and "net saving in welfare benefit expenditure" used another number than the life expectancy of dependent patients. As mentioned before in chapter 4 about drop-off which is about recognising that the benefits will not endure for all stakeholders over the entire benefit period. We can therefore look at how the SROI would changed if we used a different number of years (1-7) for patients to receive welfare benefit and benefit to patients who are able to work.

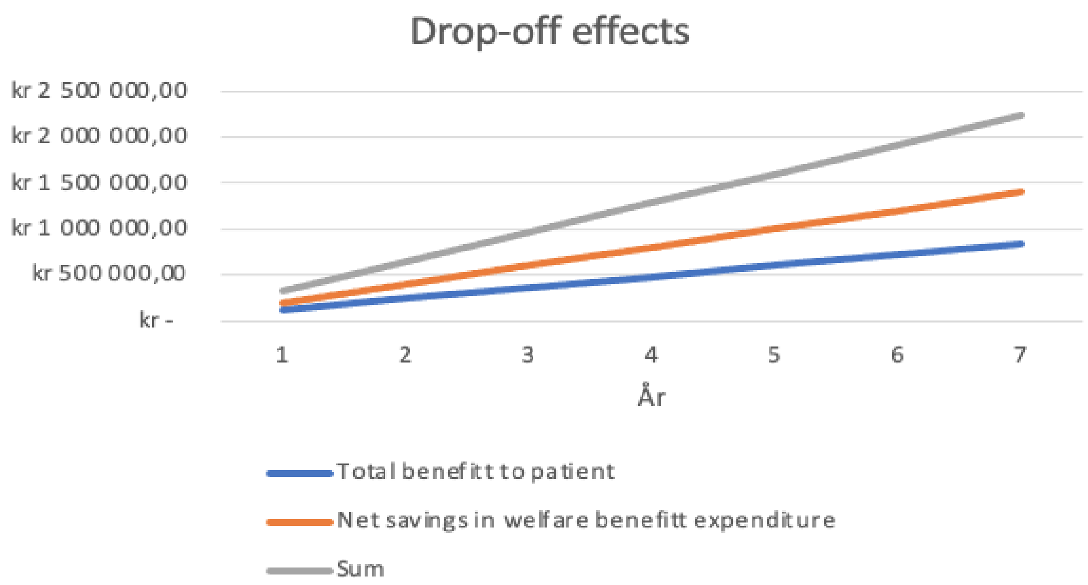

Figure 5.1: *The graph shows how the total social return form "benefits to patients" and "net saving in welfare benefit expenditure" would change with how many years we used in our calculation*

The SROI would then have ranged from 23.81 if we used one year to 28.31 if we used seven.

Table 5.1: *This table shows how the SROI ratio would have changed with the number of years we used in our calculation of "total benefit to patients" and "net saving in welfare benefit expenditure"*

Year	1	2	3	4	5	6	7
SROI	23.81	24.56	25.31	26.06	26.81	27.56	28.31

6. Discussion

Based on the data presented and the results in this thesis we are now going to discuss our interpretation and the general implications. The purpose of this thesis was to find a way to calculate Sirens Stroke's social contribution through their QI project. Using nef's guide, we managed to calculate their SROI. The four main reason we found this analysis somewhat challenging related to understanding the medical terms in order to get a full picture of QI project's impact, we had no previous experience with conducting a SROI analysis, finding appropriate proxies and making sensible calculation with the data available.

6.1 Interpretations

In social organizations or non profit organizations (NPOs), there are tendency of pressure both internally and externally from stakeholders to justify their use of resources and report their impact on society. This stakeholder pressure has resulted in many different approaches, methods, and tools for measuring the impact that organizations create in society. Traditional financial measures have failed to measure the impact and, as a result, SROI has been developed as one of many alternative methods for measuring social value. The SROI framework has its merits, as it compares outcomes with input, so NPOs and social enterprises can measure their efficiency by analyzing not only the input, but also the social value of their projects.

We chose to conduct a SROI analysis because after some brief research we believed that this analysis method can help answer our problem statement. We did not find any similar analysis done in relation to stroke treatment, but by looking at nef's guide and reading the examples they presented we believed it was possible to do a similar analysis for the QI project. Following nef's guide step by step, we were able to calculate a SROI equal to 26.49.

Just by reading the QI report where it is stated that the mean DNT was reduced by more than 13 minutes and that approximately eight patients avoided a worst outcome (Ajmi et al. 2019), we hypothesized that the QI project had a great social return. Further, when we look at the results of the CEA, we understood this even better. Here it is stated that the QI project has resulted in 6.36 averted deaths annually where the cost of averting a death was 10 543 USD. With the cost of implementing and completing the QI totaling up to 44 802 USD, we expected the SROI ratio to be somewhat large.

Because different outcomes measure, measurement methods, and data sets used can significantly affect the SROI calculation, comparing SROIs between organizations, especially in different industries, becomes of little value. This is one of SROIs weaknesses. It is difficult to say much about the SROI of 26.49 which we calculated. Technically, any ratio over 1:1 is a good social return on investment because it means that you are generating more social value than it costs to deliver the project, services, or activities. However, most organisations would like to have a social return on investment higher than just over 1:1. Because of increased scarcity of public resources organizations can not take on every project that provides a return higher then the investment. They have to look at opportunity costs and choose to invest in the projects that has the biggest return. However, based on the fact that most investors generally considers a 7% return annually a good investment (Learn 2021), our SROI calculation of QI project suggests that this was a good investment.

6.2 Implications

As mentioned before, we did not find any other SROI analysis on stroke treatment. Usually when it comes to analysing benefits from health related projects, cost-benefit or cost-effectiveness analysis is used. This analysis methods don't capture all the benefits, which can lead to underestimation of these projects. NPOs usually don't have private investors, but if these organizations are able to show their "true" value through analysis that capture their social contributions, public sectors may invest. Taking Sirens Stroke's QI project as an example which had no external investors, but by looking at the outcome it might be that other municipalities consider a similar project in their respective hospitals and decide to give financial support.

Our first contribution in this thesis is to show that it is possible to calculate social contribution for a project like Sirens Stroke's QI-project. This thesis provides a new insight into the relationship between stroke treatment and SROI analysis. SROI has not been used much as it is quite a new analysis method relative to other economical analysis. Our second contribution is therefore to promote the use of this analysis method as we believe it has great potential to show social contribution. Word Health organization (WHO) has published a discussion paper about SROI. This discussion paper reviews the main features of SROI (stakeholder engagement, the theory of change and accounting for social value) and finds that they are coherent with the key features of the "Health 2020 policy framework" and the "2030 Agenda for Sustainable Development". It concludes that SROI represents an interesting opportunity to evaluate cross-sectoral investments which aim to promote health and development, in the WHO European Region and beyond (WHO 2017).

Sirens Stoke and other NPOs that may not have heard about SROI analysis can use this thesis together with nef's guide as an example on how to calculate and represent their social contribution. Our calculation may not be perfect and it has several limitations which we will discuss in the next subsection, but when one takes these limitations into consideration, we believe that this thesis still can be a good example to use.

6.3 Limitations

Our calculation has several limitations. Before we look at what these limitations are, it is important to understand that our calculation is mathematical. By this we mean that in reality one can not talk about 6.36 deaths averted or that 0.72 more patients are able to work. This numbers are calculated based on statistical probabilities. Another thing to have in mind is that in realty it may not be economically beneficial to save lives or to avert deaths, especially a person who is 70 plus years in age and that may not be able to contribute to society. This is more an ethical ting to do rather than economical. This is also why we have used societies willingness to pay' when we have monetized the benefit of averting a death.

Before starting our calculation of Sirens Stroke's social contribution and using nef's guide to calculate SROI, we read trough a research article on challenges and boundaries in implementing social return on investment, published by Wiley Periodicals LLC (Nielsen et al. 2021). Here the authors seek to understand the challenges and boundaries of SROI, that is, the selection of proxies, identification of stakeholders, the long time horizon, and calculation of the dead-weight factor. The authors eventually decided against SROI due to four concerns: comparability, subjectivity, legitimacy, and resource utility. We used this research paper to be aware of difficulties and challenges of SROI. This was to make sure that our calculation is as reliable as possible.

The limitations in our calculation is mainly because all our data is gathered from other studies. We can be quite sure that the numbers gathered from the QI report and QI's CEA are reliable. These two papers are based on the same population and the same study. Other key numbers like transition probability, risk of recurrent stroke, costs related to independent and dependent state and cost related to recurrent stroke on the other hand is gathered from NIPH's report. In NIPS's report their population have an average age of 70, whereas the average age in Sirens Stroke's QI project was 71 years old. There might be a difference in transition probabilities, risk of recurrent stroke and hazard ratio of death beyond year one for independent and dependent patients. Also the number of working patients pre- and post-stroke is gathered from Norwegian Stroke Registers annual report from 2020 (Fjrtoft et al. 2020). The population in this report is all stroke patients in Norway, not only stroke patients eligible for thrombolysis treatment and the average age for patients are over 72 years.

The data available also lead us to not being able to monetize and calculate return on all outcomes listed in table 4.5. This is the reason why we have classified "Less time spent on care for family member" and "Reduced DNT" as not monetizable. We found an article published by Lippincott Williams & Wilkins on patient lifetime benefits gained from faster treatment. Here it is concluded that each minute of onset-to-treatment time saved granted on average 1.8 days of extra healthy life (Meretoja et al. 2014). However, the data used here is weak and we decided not to include this in our calculation. When it comes to "Increased quality of life" we classified this as not monetizable because we did not find an appropriate proxy. However, we believe that this outcome also gets accounted for in the calculation of "Improved patient outcome."

The second limitation in our analysis is that we have assumed there are no transition between independent and dependent patients, no recurrent stroke and no patient going back to work in year one post stroke. As mentioned before, we did not have data available to calculate each year by themselves and we therefore had to collect all the years after year one together. This of course makes the calculation easier but also not precise, because there would be a difference in cost saved if a patients is for example able to go back to work a few months post stroke or three years after.

As one can see, the rest of our calculation is based on the 6,36 deaths averted. Here, a factor that may effect our calculation is to what degree the patient outcome measures are limited by the prepost study design due to confounding by unrelated trends or other confounding factors the QI team might have been unable to adjust for. Even thought they have tried to account for for patient demographics, premorbid status and other cerebrovascular risk factors, some factors like concurrent improvement in treatment of vascular risk-factor may not have been counted for. The QI team has mentioned this in the QI report also (Ajmi et al. 2019).

However we believe that our results are none the less valid because most of our calculation is based on the fact that the QI project has led to 6.36 deaths averted. As mentioned before, most of the return or cost saved comes from better patients outcome and we believe that this calculation is quite reliable. The other calculation we have included may not be "perfect" but we have reasons to believe that it is not far from the return in reality.

6.4 Suggestion for Further research

Further research is required to establish whether numbers gathered from NIPH's paper can be used in our analysis. This can be done by conducting a Markov analysis on Sirens Stroke's QI project. Also if more data on costs related to stroke and how stroke patients are effected by better stroke treatment becomes available, the SROI for QI can be adjusted and recalculated.

7. Conclusion

This thesis aimed to identify a possible way to calculate Sirens Stroke's social contribution through their QI projects. We used nef's guide and data available to calculate the QI project's SROI to be 26.49. We interpret this as meaning that the project is financially profitable.

We have shown that NPOs like Sirens Stroke can use SROI analysis to see a fuller picture of the benefits that flow from their investment of time, money and other resources.

7.1 Recommendation

When it comes to future implication we believe that Sirens Stroke can use this thesis as an example to calculate and convey their social contribution for future projects. We have shown that it is possible to conduct a SROI analysis in the health sector and hope that more NPOs take use of this analysis method. We recommend organizations who considers using SROI analysis to read the article mentioned before on challenges and boundaries in implementing social return on investment published by Wiley (Nielsen et al. 2021). Here they can get a good picture on what challenges they may face. Further, we recommend to use nef's guide to calculate SROI as this is a step by step guide with examples and check lists to help the user.

All in all we recommend that organizations consider using SROI analysis. Even though SROI has some downside as discussed, we believe that these can be accounted for by the user if the user is aware of these downsides. We also believe that as more organizations use this analysis method, it will be developed further and can become very useful. Our last recommendation is that if organizations keep in mind that they are going to conduct a SROI analysis before the project is started, it becomes much easier to gather data needed to conduct an evaluative SROI analysis in the aftermath.

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A. Excel calculations

Numbers and assumptions used in the calculation

- Yearly stroke patients treated at SUS=200
 (aproximatly 850 patients are admitted anualy with suspicion of acute stroke eligible for revascularization, 20 to 30% receive intravenous thrombolysis).

Patients health state (mRS):
- Independent patients (mRS 0-2)
- Dependent patients (mRS 3-5)
- Death=(mRS 6)

Costs:
- Costs during the first year for patinents in independent state = 103 328 NOK
- Costs during the first year for patinents in dependent state = 230 339 NOK
- Annual costs after first year for patients in independent state = 40 234 NOK
- Annual costs after first year for patients in dependent state = 102 964 NOK
- Costs associated with recurrent stroke = 89 462 NOK

- Hazard ratio of death beyond 1 year for independent patients (mRS 0-2) = 1.04
- Hazard ratio of death beyond 1 year for dependent patients (mRS 3-5) = 1.78
- Risk of recurrent stroke = 0.05
- Transition from dependent to independent = 0.11
- Expected quality adjusted life expectancy for patients aged 70 = 12.7 QALY

- Willingnes to pay for QALYs in Norway = 385 000 NOK

- Working patients before stroke = 21%
- Of those working before the stroke, 54% were still working after

- Average wage (per 2020) ?= 608 160,00 NOK anualy
- Tax rate= 27 % (For those earning 608 160,00 NOK anualy)
- Working patients before stroke = 21 %
- Average disability benefits (per 2018) = 276 800 NOK (after tax)

Green cells: Numbers gathered
Blue cells: Numbers estimated/calculated
Orange cells: Objective

Figure A.1: *Numbers and assumptions used in our calculation*

A.1 Without adjusting

Patients eligible for thrombolysis	200		
Patient tranzition form dependent to indepedent	11 %		
Cost (first year)			
Rankin Scale 0-2	kr 103 328,00		
Rankin Scale 3-5	kr 230 339,00		

Health State (mRS)	Pre-QI	Post-QI
Independent (0-2)	228	107
Dependent (3-5)	63	29
Death (6)	29	5
Sum	320	141

(%) Patients in mRS	Pre-QI	Post-QI
Independent (0-2)	71,25 %	75,89 %
Dependent (3-5)	19,69 %	20,57 %
Death (6)	9,06 %	3,55 %
Sum	100,00 %	100,00 %

Estimated nr. Of patients	Pre-QI	Post-QI	Difference
Independent (0-2)	142,50	151,77	9,27
Dependent (3-5)	39,38	41,13	1,76
Death (6)	18,13	7,09	-11,03

Estimated nr. Of patients after tranzition	Pre QI	Post QI	Difference
Independent (0-2)	146,83	156,30	9,47
Dependent (3-5)	35,04	36,61	1,57
Death (6)	18,13	7,09	-11,03

Estimated costs	Pre-QI	Post-QI
Independent (0-2)	kr 15 171 779,40	kr 16 149 946,55
Dependent (3-5)	kr 8 071 942,33	kr 8 432 694,45
Sum	kr 23 243 721,73	kr 24 582 641,01

Willingnes to pay for QALYs in Norway	kr 385 000,00
Calculated deaths averted	11,03

Estimated money saved	
Independent (0-2)	-kr 978 167,15
Dependent (3-5)	-kr 360 752,12
Death (6)	kr 4 247 628,55
Sum	kr 2 908 709,27

Figure A.2: *This figure shows how we calculated money saved the first year post stroke without adjusting for patients premorbid status*

Hazard ratio of death beyond 1 year for independent patients (mRS 0-2)		1,04
Hazard ratio of death beyond 1 year for dependent patients (mRS 3-5)		1,78
Annual costs in independent state (mRS 0-2) after the first year	kr	40 234,00
Annual costs in dependent state (mRS 3-5) after the first year	kr	102 964,00
Costs associated with recurrent stroke	kr	89 462,00
Risk of recurrent stroke		5 %
Probability of death for independetnt patients (beyond 1 year)		51 %
Probability of death for dependetnt patients (beyond 1 year)		64 %
Life expectancy in 70-year patient pre stroke		12,70
Life expectancy for independetnt patients after year 1		6,23
Life expectancy for dependetnt patients after year 1		4,57
Estimated money saved on patient treatment (After first year)		
Independent (0-2)	-kr	2 371 165,22
Dependent (3-5)	-kr	736 691,65
Death (6)	kr	25 444 346,40
Sum	kr	22 336 489,53
Tax rate		27 %
Working parients before stroke		21 %
Working parients after stroke		54 %
Deaths averted (Population)		11,03
Working before stroke (Deaths averted)		2,32
Working after stroke (Deaths averted)		1,25
Patients With risk of recurrent stroke		11,03
Expected nr. Of patients with recurrent stroke		0,55
Cost related to patients with recurrent stroke	kr	49 350,82
Benefitts to patients		
Patient wages (for some patients)	kr	608 160,00
Less increase in tax contribution	-kr	164 203,20
Less welfare benefits lost (weighted average)	-kr	276 800,00
Net benefit per patient that moves on to full-time employment	kr	167 156,80
Differance in nr. Of patients that workes as a reslut of QI-project		1,25
Total benefitt to patients *life expectancy for dependent patients	kr	955 392,50
Benefitts to Nasjonal goverment		
Welfare benefits saved (weighted average)	kr	276 800,00
Number of patients that no longer require welfare benefits per annum		1,25
Net savings in welfare benefit expenditure*4,57	kr	1 582 063,34
Combined benefits	kr	27 733 303,82
Sum of costs	kr	426 655,67
SROI		65,00

Figure A.3: *This figure shows how we calculated benefits after year one without taking into account patients premorbid status*

A.2 Taking into account risk-adjusted CUSUM charts

Deaths averted	6,36
Hazard ratio of death beyond 1 year for independent patients (mRS 0-2)	1,04
Hazard ratio of death beyond 1 year for dependent patients (mRS 3-5)	1,78
Annual costs in independent state (mRS 0-2) after the first year	kr 40 234,00
Annual costs in dependent state (mRS 3-5) after the first year	kr 102 964,00
Costs associated with recurrent stroke	kr 89 462,00
Risk of recurrent stroke	5 %
Probability of death for independetnt patients (beyond 1 year)	51 %
Probability of death for dependetnt patients (beyond 1 year)	64 %
Life expectancy in 70-year patient pre stroke	12,70
Life expectancy for independetnt patients after year 1	6,23
Life expectancy for dependetnt patients after year 1	4,57

Estimated nr. Of patients after tranzition	Pre QI	Post QI	Difference	Adjusted numbers	After transitions
Independent (0-2)	146,83	156,30	9,47	0	0,70
Dependent (3-5)	35,04	36,61	1,57	6,36	5,66
Death (6)	18,13	7,09	-11,03	-6,36	-6,36

Estimated money saved in inproved patients outcome (first year)	
Independent (0-2)	-kr 72 288,27
Dependent (3-5)	-kr 1 303 810,88
Death (6)	kr 2 448 600,00
Sum	kr 1 072 500,86

Figure A.4: *This figure show our calculation of benefits during year one, when patients premorbid status has been taken into account*

Skatteprosent		27 %
Working parients before stroke		21 %
Working parients after stroke		54 %
Deaths averted (Population)		6,36
Working before stroke (Deaths averted)		1,34
Working after stroke (Deaths averted)		0,72
Patients With risk of recurrent stroke		6,36
Expected nr. Of patients with recurrent stroke		0,32
Cost related to patients with recurrent stroke	kr	28 448,92
Benefitts to patients		
Patient wages (for some patients)	kr	608 160,00
Less increase in tax contribution	-kr	164 203,20
Less welfare benefits lost (weighted average)	-kr	276 800,00
Net benefit per patient that moves on to full-time employment	kr	167 156,80
Differance in nr. Of patients that workes as a reslut of QI-project		0,72
Total benefitt to patients *4,57	kr	550 947,76
Benefitts to Nasjonal goverment		
Welfare benefits saved (weighted average)	kr	276 800,00
Number of patients that no longer require welfare benefits per annum		0,72
Net savings in welfare benefit expenditure*4,57	kr	912 331,05
Estmiated return form QI-project (after first year)	kr	8 794 651,17
Estmiated return form QI-project (first year)	kr	1 072 500,86
Combined benefits	**kr**	**11 301 981,92**
Sum of costs	kr	426 655,67
SROI		**26,49**

Figure A.5: *This figure shows how we calculated benefits after year one, when patients pre-morbid status has been taken into account*

A.3 Cost

Quality improvement process	Theory of effect	Actions	Cost-category*	Cost-ingredient	Fixed units†	Montly units	Paid units	Donated units
Sequence of improvement	Quality improvement is the right methodology to find, test and make changes that will lead to improved treatment times.	Educate project planner in QI methodology	Personell cost (Staff training)	Quality improvement lead/co-PD	200	-	140	60
			Personell cost (Staff training)	Quality improvement education participation fee	1	-	1	0
		Identify local quality issue (Problem, context (MUSIQ))	Personell cost (Staff fee)	Quality improvement team	3	-	0	3
			Personell cost (Staff fee)	Quality improvement lead/co-PD	5	-	0	5
		Understand the problem (Baseline data)	Personell cost (Staff fee)	Quality improvement team	1	-	0	1
			Personell cost (Staff fee)	Quality improvement lead/co-PD	20	-	0	20
		Develop a strategy and change ideas	Personell cost (Staff fee)	Quality improvement team	2	-	0	2
		Testing	Personell cost (Staff fee)	Program directors / Facilitators	10	-	0	10
		Sustaining and holding the gains	Personell cost (Staff fee)	Quality improvement team	-	1	0	1
Process mapping and redesign	Tailor interventions to local conditions in order to make targeted attempts at improvement. Process mapping with stakeholder leaders will lead to streamlined protocol.	Audit all stakeholders about current process	Personell cost (Staff fee)	All stakeholders	26		0	26
			Personell cost (Staff fee)	Quality improvement team	1		0	1
			Personell cost (Staff fee)	Quality improvement lead/co-PD	5		0	5
			Other program inputs (communication fees)	Subscription surveymonkey monthly fee	1		1	0
		Flowcharting, map process, identify time thieves	Personell cost (Staff fee)	Quality improvement team	4		0	4
			Personell cost (Staff fee)	Quality improvement lead/co-PD	8		0	8
			Equipment and materials (Materials)	Office supplies (Flipboard, postits etc)	1		1	0
		Meetings with all stakeholders pre-implementation	Personell cost (Staff fee)	Program directors / Facilitators	7		0	7
		Research relevant litterature	Personell cost (Staff fee)	Quality improvement lead/co-PD	20		0	20
Engange and communicate to stakeholders	Keep stakeholders informed about changes	Staff meetings during implementation	Personell cost (Staff fee)	Program directors / Facilitators	14		0	14
		Print and distribute flowcharts	Equipment and materials (Materials)	Office supplies (5 Charts)	5		5	0
			Personell cost (Staff fee)	Program directors / Facilitators	0,5		0	0,5
Improve teamwork and communication	Ease the process of implementation and through improvements in specific team non-technical skills lead to more efficient teams. Continious feedback from participants will provide further improvements both in speed and quality of care. Involde previous stroke patients to improve patient	Provide in-situ-simulation based team training (26 sessions provided through 2 clusters over 13 months)	Equipment and materials (Materials)	GoPro cameras	2		2	0
			Equipment and materials (Materials)	IV-needle		2	2	0
			Equipment and materials (Materials)	Blood glucose strip		2	2	0
			Equipment and materials (Materials)	Fuel (Ambulance)		2	2	0
			Equipment and materials (Deprecitation)	Estimated monthly deprecetation (GoPro cameras)		1	1	0
			Personell cost (Staff fee)	Program directors / Facilitators (1,5 hours per session)		3	0	3
			Personell cost (Administrative)	Quality improvement team (0,5 hour per session)		1	0	1
			Personell cost (Staff training)	Train the trainer course for facilitators	25		25	0
			Required client inputs (Learner costs - transport)	Simulated patient transport time		2	0	2
			Required client inputs (Learner costs - transport)	Simulated patient transport costs (bus)		2	2	0
			Required client inputs (Oppurtunity costs)	Stroke team participating in simulation sessions		2	0	2
			Communication (Surveymonkey)	Subscription surveymonkey monthly fee		1	1	0

Supplemental table 3. Details regarding the quality improvement process, theory of effect, actions and costs involved

PD, Programme Director; NOK, Norwegian Krone (1NOK = 0.11003 USD as per 01.11.2019)

*Cost categories according to table II in Zendejas B et.al[25]

†Unless otherwise specified, for personell costs units equal number of hours, personell involved in different roles are specified in supplemental table 2

‡Inflation adjustment as per 11.01.2019

Figure A.6: *First half of the cost table used in Sirens Stroke's CBA.* Disclaimer: This is unpublished data and should not be copied or used in other studies.

	J	K	L	M	N	O	P	Q	R	S	T
1						Fixed costs			Monthly costs		
2–3	Donated units inside working hours	Cost pr unit (NOK)	Year of cost	Inflation rate‡	Inflation adjusted cost per unit (NOK)	Fixed paid costs (NOK)	Costs of donated units within working hours (NOK)	Costs of donated units outside working hours (NOK)	Monthly paid costs (NOK)	Costs of donated units within working hours (NOK)	Costs of donated units outside working hours (NOK)
4	0	kr 436,98	2016	1,077	kr 470,63	kr 65 887,84	kr -	kr 9 412,55			
5	0	kr 156 217,00	2016	1,077	kr 168 245,71	kr 168 245,71	kr -	kr -			
6	3	kr 3 634,79	2017	1,058	kr 3 845,61	kr -	kr 11 536,82	kr -			
7	0	kr 436,98	2017	1,058	kr 462,32	kr -	kr -	kr 770,54			
8	1	kr 3 634,79	2017	1,058	kr 3 845,61	kr -	kr 3 845,61	kr -			
9	0	kr 436,98	2017	1,058	kr 462,32	kr -	kr -	kr 3 082,17			
10	2	kr 3 634,78	2017	1,058	kr 3 845,60	kr -	kr 7 691,19	kr -			
11	10	kr 1 476,98	2017	1,058	kr 1 562,64	kr -	kr 15 626,45	kr -			
12	1	kr 3 634,79	2017	1,058	kr 3 845,61				kr -	kr 3 845,61	kr -
13	26	kr 434,06	2016	1,077	kr 467,48	kr -	kr 12 154,55	kr -			
14	1	kr 3 634,79	2016	1,077	kr 3 914,67	kr -	kr 3 914,67	kr -			
15	5	kr 436,98	2016	1,077	kr 470,63	kr -	kr 2 353,14	kr -			
16	0	kr 399,00	2016	1,077	kr 429,72	kr 429,72	kr -	kr -			
17	4	kr 3 634,79	2016	1,077	kr 3 914,67	kr -	kr 15 658,68	kr -			
18	0	kr 436,98	2016	1,077	kr 470,63	kr -	kr -	kr 1 255,01			
19	0	kr 500,00	2016	1,077	kr 538,50	kr 538,50	kr -	kr -			
20	7	kr 1 476,98	2017	1,058	kr 1 562,64	kr -	kr 10 938,51	kr -			
21	0	kr 436,98	2016	1,077	kr 470,63	kr -	kr -	kr 3 137,52			
22	14	kr 1 476,97	2017	1,058	kr 1 562,63	kr -	kr 21 876,88	kr -			
23	0	kr 300,00	2017	1,058	kr 317,40	kr 1 587,00	kr -	kr -			
24	0,5	kr 1 476,97	2017	1,058	kr 1 562,63	kr -	kr 781,32	kr -			
25	0	kr 3 499,00	2017	1,058	kr 3 701,94	kr 7 403,88	kr -	kr -			
26	0	kr 15,00	2017	1,058	kr 15,87	kr -	kr -	kr -	kr 31,74	kr -	kr -
27	0	kr 6,00	2017	1,058	kr 6,35	kr -	kr -	kr -	kr 12,70	kr -	kr -
28	0	kr 16,50	2017	1,058	kr 17,46	kr -	kr -	kr -	kr 34,91	kr -	kr -
29	0	kr 195,00	2017	1,058	kr 206,31	kr -	kr -	kr -	kr 206,31	kr -	kr -
30	3	kr 1 476,98	2017	1,058	kr 1 562,64	kr -	kr -	kr -	kr -	kr 4 687,93	kr -
31	1	kr 3 634,79	2017	1,058	kr 3 845,61	kr -	kr -	kr -	kr -	kr 3 845,61	kr -
32	0	kr 1 476,98	2017	1,058	kr 1 562,64	kr 39 066,12	kr -	kr -			
33	2	kr 307,89	2017	1,058	kr 325,75	kr -	kr -	kr -	kr -	kr 651,50	kr -
34	0	kr 74,00	2017	1,058	kr 78,29	kr -	kr -	kr -	kr 156,58	kr -	kr -
35	2	kr 2 680,56	2017	1,058	kr 2 836,03	kr -	kr -	kr -	kr -	kr 5 672,06	kr -
36	0	kr 299,00	2017	1,058	kr 316,34	kr -	kr -	kr -	kr 316,34	kr -	kr -
37					SUM:	kr 283 158,78	kr 106 377,81	kr 17 657,78	kr 758,59	kr 18 702,71	kr -

Figure A.7: *Second half of the cost table used in Sirens Stroke's CBA.* Disclaimer: This is unpublished data and should not be copied or used in other studies.