# FINANCIAL EFFECTS OF MOVING PATIENTS FROM AN INPATIENT TO AN OUTPATIENT SETTING

Providing financial insight in the effects of discharging patients the same day as surgery instead of keeping them overnight

**Master thesis**
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## Management Summary

Menzis is a nationwide operating healthcare insurer in the Netherlands with a strong regional base in the east of the Netherlands, the region of Groningen and Arnhem. As the healthcare expenditures in the Netherlands continue to rise Menzis tries, as any other healthcare insurer, to control this rise of the expenditures. Next to supporting multiple healthcare costs reduction initiatives Menzis wants to better utilise the data they collect in order to show hospitals how new approaches can be beneficial for both the hospital and Menzis. One of these new approaches is to discharge patients the same day as surgery (outpatient setting) instead of keeping these patients overnight (inpatient setting). This thesis is a first step for Menzis in providing insight in whether discharging patients the same day as surgery instead of keeping them overnights leads to a cost reduction for hospitals. Therefore, the goal of this thesis is as follows:

*Provide quantitative financial insight in the effects of discharging patients the same day as surgery instead of letting them stay overnight.*

As a first step we identified five procedures for which evidence from literature showed that that performing these procedures in an outpatient setting is safe and feasible. We will then provide insight into the impact of this strategy for the five selected procedures. The five selected procedures are as follows:

- Percutaneous Coronary Intervention (PCI)
- Total Hip Arthroplasty (THA)
- Total Knee Arthroplasty (TKA)
- Implantation of a Pacemaker
- Cholecystectomy

For the procedures described above we first determined a baseline of the current costs, based on the costs of a diagnosis-treatment combination (DBC), of performing the selected procedures. This baseline is based on the historical data (from 2016 and 2017) available at Menzis of declared care activities in hospitals for each individual patient (PCI: n = 5174, THA: n = 2338, TKA: n = 2038, Pacemaker: n = 1262, Cholecystectomy: n = 2204). This data provides us insight in some patient characteristics as sex, age and patient type (inpatient or outpatient). Based on findings in literature we then added inclusion and/or exclusion criteria for each procedure in order to show how many patients potentially can be shifted from an inpatient to an outpatient setting. In addition to the care activities and patient characteristics found in the data we also added some additional patient characteristics found in literature for each procedure to improve the fit of the patient characteristics used in the simulation and the patient characteristics found in the used literature.

Based on the declared care activities for each patient automatically a so-called DBC code is assigned for this group of care activities. Menzis and hospitals make price agreements for these DBC codes each year. The price for a DBC without hospitalisation is typically lower than the price for a DBC with hospitalisation. By shifting the patients who meet the criteria for undergoing surgery in an outpatient setting the DBC code will change and subsequently the reimbursement. In this study we conducted several analyses for four hospitals in order to provide quantitative financial insight in the effects of this shift. The four hospitals selected are all important hospitals for Menzis as they all have a relatively large number of patients insured at Menzis. Figure 1 shows the potential mean saving per year for each selected procedure and hospital. In addition, we performed a sensitivity analysis to

show the effect of the independent variables. We also conducted a scenario analysis in which, in addition to the already determined criteria for patient characteristics found in literature, the care activities were used as criteria whether to shift patients to an outpatient setting or not. This analysis shows how using care activities as a criteria to shift patients affects the potential savings.

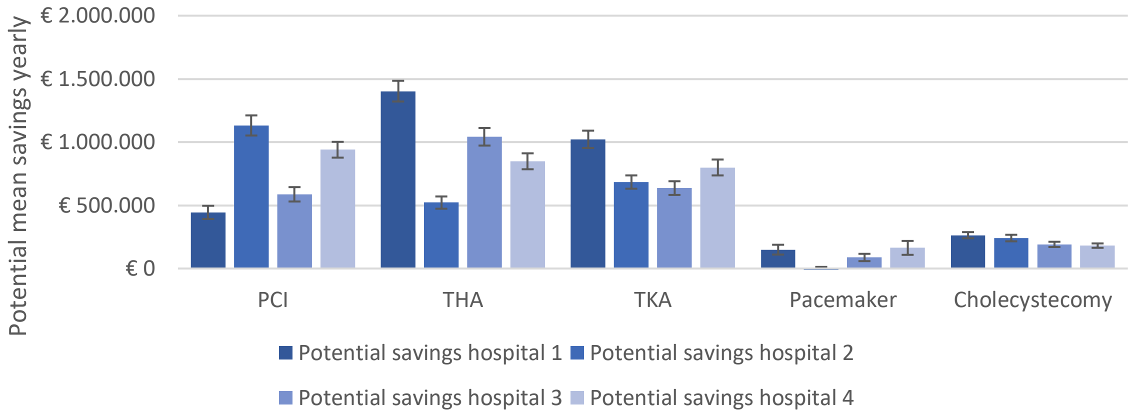


*Figure 1: potential mean saving per year for selected procedures*

Figure 1 above shows that the PCI, THA and TKA procedures are for all hospitals the procedures that are potentially the most promising. The scenario analysis for the PCI showed that not shifting patients who have the care activity “acute PCI” assigned to an outpatient setting lead to a significant decline in the potential savings. Shifting patients undergoing such an acute procedure to an outpatient setting may not be directly desirable for hospitals. The scenario analyses show for both the THA and TKA procedure that not shifting patients undergoing the procedure under general anaesthesia to an outpatient setting leads to a significant decline in the potential savings. Hospitals may have to adapt their standard procedure protocols in order to achieve the savings as presented. The simulation shows that although three procedures can potentially significantly impact the cost reduction in healthcare there are still some difficulties to overcome.

Based on this simulation study, the most important recommendations for Menzis are:

- Cooperate with one or more hospitals in order to be able to include the (expected) costs for the hospital of performing an care activity. Adding the costs of care activities leads to robust results since the costs of shifting patients from an inpatient to an outpatient setting are also considered.
- Implement time-dependent variables, like patients returning to the hospital with complications, in order to fully show the financial effects. In addition to that, costs outside the hospitals should also be taken into consideration.
- The current scenario analysis can be updated when Menzis cooperates with hospitals in order to obtain better insight in which patients are suitable for undergoing a certain procedure in an outpatient setting.

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# 1 Introduction

## 1.1 Background

Healthcare expenditures in the Netherlands are rising the past few years due to technological improvement, an increase in the number of elderly people and chronical ill patients. The RIVM estimates that in 2040 the expenditures for healthcare are around 174 billion (RIVM, 2018). For comparison, the Netherlands spent 97,5 billion euro for providing healthcare in 2017 (CBS, 2018). The RIVM estimates that a third of the rise in healthcare expenditures is due to aging and population increase. The other two thirds is due to the increase in welfare and the technological improvement that comes with it. As figure 2 shows the RIVM estimates that the expenditures are rising the most for the neoplasms and mental disorders. Mental disorders are in 2040, just as in 2015, the group that is responsible for the most healthcare expenditures in the Netherlands.

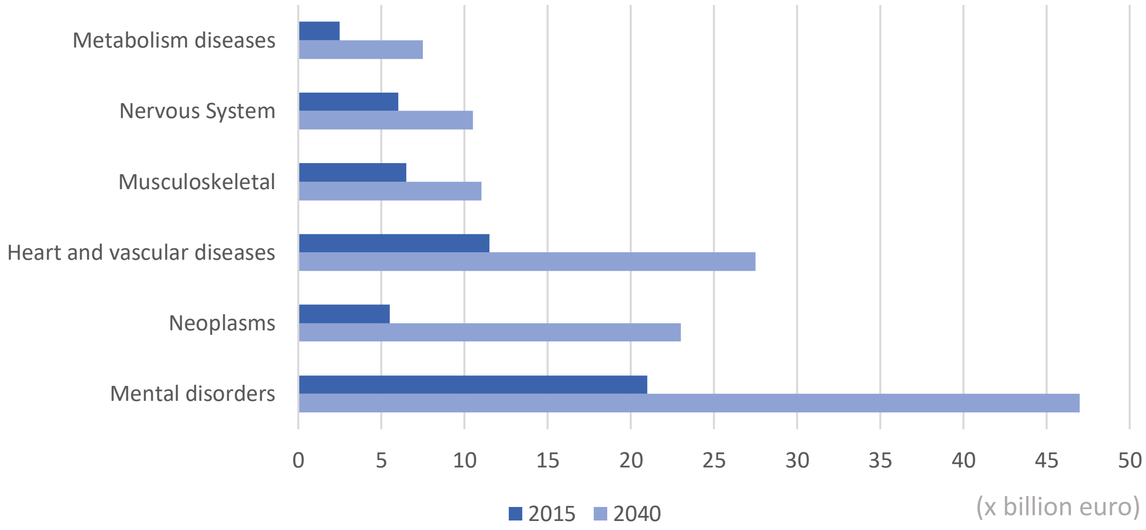


*Figure 2: healthcare expenditures various disease classes 2015 versus 2040 (RIVM, 2018)*

Currently, secondary healthcare is responsible for more than a quarter of the healthcare expenditures as figure 3 shows (CBS, 2018). With the current technological progress and with more advanced surgical techniques, cost reductions can be achieved in this area by moving patients from an inpatient setting into outpatient facilities. The Deloitte Center for Health Solutions in the United States of America conducted analyses using Medicare claims data collected between 2012 and 2015 and describes three key findings why hospitals should shift patients to an outpatient setting (Abrams et al., 2018).

- Hospitals with greater revenues from quality and value contracts provide more outpatient services than other hospitals
- The association between having these contracts and higher outpatient services was even more pronounced for diseases of the circulatory system and the musculoskeletal system.
- All hospitals saw declines in inpatient revenues, but hospitals with greater revenues from quality and value contract had lower declines than other hospitals.

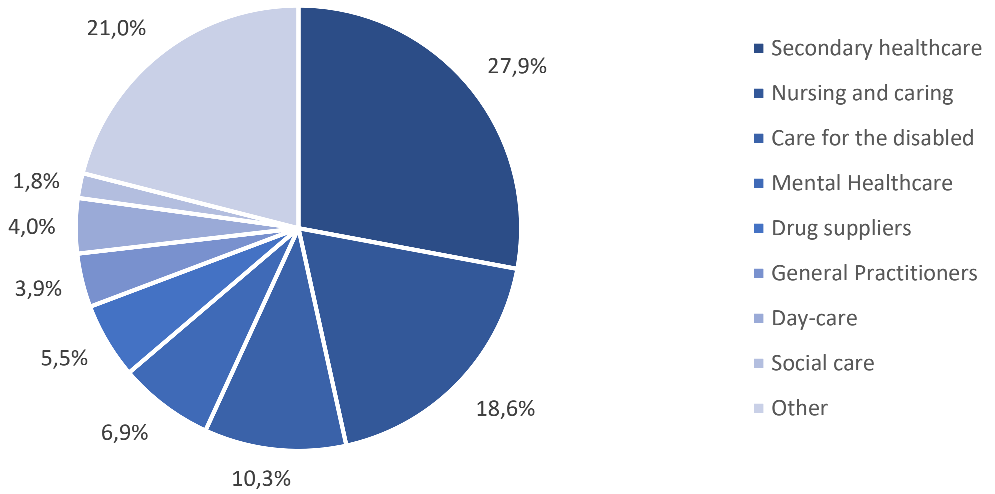


*Figure 3: healthcare expenditures in the Netherlands in 2017*

In order to make sure that healthcare in the Netherlands stays affordable for everyone, the rise of healthcare expenditures should be controlled.  Cost reduction can be achieved in different ways. A study conducted in 2010 by Martin et al. found a strong association between the increase in the outcome of quality indicators and the cost reduction of stroke care. Improvements in the primary care of strokes may have reduced secondary care costs by some 165 million pounds (Martin et al, 2010). But also in the Netherlands initiatives like these are successful, *The Haaglanden Medisch Centrum* works together with twenty general practitioners in order to reduce the unnecessary number of visits of patients with vascular diseases at the cardiologist. The number of hospital visits is reduced by 50%. With an average saving of 150 euro per patient, this leads to a substantial cost reduction.

In order to reduce costs hospitals are tended to reduce the length of stay of patients. Since 2000, in nearly all EU countries the average length of stay has decreased because hospitals choose to reduce the number of hospitals beds.  In 2000 the average length of stay in the EU was ten days, in 2016 this was less than eight days (OECD & Union, 2018). As the *Health at Glance* rapport of the OECD in 2018 shows, the Netherlands is among the countries with the least hospital days. However the length of stay in the Netherlands is under-estimated because it only includes stays for curative care that are typically shorter. The trend in decrease of hospital beds is however clearly visible in the Netherlands. In 2009 there were 44.827 hospital beds available, in 2015 this was reduced to 41.103 hospital beds (EJZ, 2015).

Next to the reduction in length of stay there are many other initiatives in the Netherlands to counter the rising healthcare expenditures. Examples are, ‘Hoofdlijnen akkoorden Curatieve Zorg’, ‘Pact voor de Ouderzorg’ and ‘Ontregel de Zorg’ (Bruins, 2018b, 2018a; de Jonge, 2018). Recently, a taskforce consisting of experts from different medical areas published the report ‘de Juiste Zorg op de Juiste Plek’ to contribute to the necessary transformation in the Dutch healthcare system and to provide insight in how to flatten the rise in healthcare expenditures.(Rijksoverheid, 2018).

As any other healthcare insurer Menzis tries to contribute to the cost reduction as Menzis initiates and supports many different initiatives. An example is the multi-year contracts that Menzis closes with different institutions to make sure these institutions can take care for the growing number of patients (Skipr, 2018a). Another example is the often discussed compensation for treating patients with depression or anxiety. Menzis will reimburse the care providers based upon the result, instead of the number of patients treated which is normally the case (Skipr, 2018c).

## 1.2 Menzis

Menzis is a national operating healthcare insurer in the Netherlands with a strong regional connection with the east of the Netherlands, the region of Groningen and Arnhem. Menzis was founded in 2006 with the merge of Amicon, Geové and NVS. The headquarters of Menzis is located in Wageningen, but Menzis also has offices in Groningen, Enschede and The Hague with in total approximately 1600 employees. Menzis is a non-profit healthcare insurer and has around 2,2 million clients. Menzis offers its products through two brands: Menzis and Anderzorg. The main motto is 'insuring the best and affordable care while strengthening the life of each human'. In 2017 Menzis had a turnover of €6,14 billion and a net result of €45,4 million.

The healthcare procurement of Menzis is divided into multiple divisions. One of these divisions is the secondary healthcare division which procures care and cure in all Dutch hospitals. This division makes sure that clients have access to the best affordable care and the division is therefore constantly looking for ways to reduce healthcare costs while maintaining the quality of care. This department also initiated this study.

## 1.3 Problem description

As mentioned there are many different approaches ongoing to control healthcare expenditures. Most of these approaches unfold on a small scale and therefore have limited impact. As one of the larger healthcare insurance companies in the Netherlands Menzis studies many of these approaches and tries to support the implementation of them on a larger scale. Currently, most of these approaches are quality driven and therefore the result is often not directly tangible nor do they contribute to the cost reduction. Next to that Menzis encounters that hospitals are not always willing to cooperate since they already have their own focus areas. Menzis wants to optimise the data they have in order to show hospitals how approaches can be beneficial for both the hospital as Menzis.

One of the possible interventions to investigate is the use of digital innovations such as tele-monitoring. Tele-monitoring can be beneficial, as it reduces the number of visits of patient to the hospital. A study conducted in 2015 which investigated the use of tele-monitoring in patients with chronic health failure concluded that tele-monitoring was effective in reducing emergency room visits and saved significant resources in care during follow-up (Pérez-Rodríguez et al., 2015). Another intervention which can help reduce healthcare costs is the so-called shared decision methodology ("samen beslisen"), a subject that currently is very popular among several insurers and patient representative organisations. Shared decision making can ensure that medical care aligns better with the preferences of patients. As many as 20% of patients who participate in shared decision making choose less invasive surgical options and more conservative treatment than those patients who do not use decision aids (O'Connor et al., 2009).

This thesis will however be focused on the question how to stimulate hospitals to treat more patients without an overnight stay. Menzis often encounters difficulties in the negotiation with hospitals about the prices of DBC's. One of the difficulties Menzis encounters is that hospitals are often not willing to support new approaches in hospital management Menzis suggests in order to tackle the rising healthcare expenditures. Due to the hospital information systems that hospitals use, they have the possibility to explore new or different approaches of providing care leading to a reduction in their healthcare expenditures. These approaches do not necessarily lead to an cost reduction for a healthcare insurer due to the price negotiations. This is due to the fact that a hospital can sometimes increase their earnings by letting patients (knowingly or not) stay overnight. Letting a patient stay overnight sometimes costs less for the hospital than the hospital earns due to the difference in the negotiated price of the corresponding DBC.

This thesis will be focused on the question how to stimulate hospitals to treat more patients without an overnight stay. Not all procedures can be investigated in this study. Therefore this study first reviews all performed surgical procedures in the Netherlands to make sure that selected procedures have an impact on the cost reduction in healthcare. Next to that the selected procedures must have been comprehensively studied whether they are safe and feasible to be conducted in an outpatient setting.

## 1.4 Research Goal

Menzis is interested in optimising procedures in order to taper off the ever increasing healthcare costs. For this thesis the focus is reducing the length of stay of yet to be selected procedures. Literature must show that patients undergoing these procedures can be discharged the same day safely. Therefore the main research goal will be as follows:

*Provide quantitative financial insight in the effects of discharging patients the same day as surgery instead of letting them stay overnight.*

The research goal will be achieved by answering the following research questions:

1. Which procedures should be considered for this study?
    a. Which change in procedure setting (inpatient versus outpatient) can be adapted by hospitals?
    b. Which procedures and have a significant impact on the healthcare costs in the Netherlands?
    c. Which procedures are currently often performed without discharging the patient the same day while literature shows that this is possible?
2. What is written in literature about how to provide insight in healthcare initiatives leading to cost reduction?
3. How can one evaluate the financial benefits for Menzis of discharging more patients at the same-day of the yet to defined procedures?
4. What are the financial benefits of the changes in the selected procedures?
5. How can the results of shifting patients to an outpatients setting be interpreted?

# 2 Context analysis

In this sector we first describe examples of hospitals reducing the length of stay of patients. We then investigate different procedures which are possibly adequate for this study. Subsequently, these selected procedures are comprehensively discussed in order to determine whether evidence from literature indicates that it is feasible and safe to conduct these procedures in an outpatient setting.

## 2.1 Moving Patients from an Inpatient to an Outpatient Setting

This study explores the possibility of shifting patients from an inpatient to an outpatient setting for selected procedures. As described by the report of the OECD hospitals in the EU are already tended to reduce the length of stay of patients (OECD & Union, 2018). The NHS recently published a report to help hospitals use effective improvement approaches to ensure that new approaches to reduce the length of stay are implemented in a way that works for the hospital. The NHS states that tackling long stays in hospital will reduce risks of patient harm. Unnecessarily prolonged stay in hospital is bad due to the risk of unnecessary waiting, sleep deprivation, increased risk of falls and fracture, prolonging episodes of delirium and catching healthcare-associated infections (NHS, 2018). The NHS proposes multiple methods to reduce the length of stay of patients on adult inpatient wards which can be helpful for all hospitals.

In the Netherlands there a number of hospitals continuously trying to reduce the length of stay of patients. Most of these hospitals are focusing on reducing “waste” as they use for example the lean six sigma method. The Jeroen Bosch Hospital reduces the waiting time of patients waiting on a radiologic screening and works together with healthcare organisations in their region to enable a quick return of patients to their homes (Skipr, 2017). The Martini Hospital in Groningen developed a method to enhance recovery after intestinal surgery to reduce the number of complications. This method led to a decrease of severe complications from 4.8% to 1.2% and also reduced the average length of stay of patients with two days (Skipr, 2018b).

These examples show that when it is feasible to conduct procedures with same-day discharge this can lead to both positive financial effects for a hospital as a reduction of the length of stay and severe complications of patients. In 2017, the Bernhoven hospital moved to a new facility with less hospital beds than the old facility in order to make sure that the length of stay of patients decreased. They showed that a decrease in the length of stay of patients is possible for almost all inpatient wards (van Leersum et al., 2019).

## 2.2 Selecting Procedures

Different studies have for various procedures shown that it is not harmful to discharge patients the same day of the surgery. To make sure that the procedures which will be investigated have an substantial impact on the cost reduction in healthcare we have listed all procedures performed in the Netherlands in table 1, sorted on the number of times these procedures were claimed by all healthcare providers in 2016 (Nederlandse Zorgautoriteit, 2018). This list only shows the most often claimed procedures by DBC code. Other procedures can also be claimed quite often, but then there are many different codes one can declare this procedure on. This list is only meant to give a first insight and is therefore suitable to shortlist all the procedures performed in the Netherlands.

*Table 1: Most often performed procedures in the Netherlands in 2016* (Nederlandse Zorgautoriteit, 2018)

| **Procedure** | **Inpatient** | **Number of patients** |
|---|---|---|
| Cataract | No | 94488 |
| Adenoid / tonsil surgery | No | 21250 |
| Total hip arthroplasty | Yes | 19994 |
| Total knee arthroplasty | Yes | 19594 |
| Gallbladder / bile ducts surgery | Yes | 16547 |
| Removal of osteosynthesis material | No | 7709 |
| Percutaneous coronary intervention (class 4) | Yes | 7129 |
| Adenoid / tonsil surgery | Yes | 7035 |
| Removal of osteosynthesis material | No | 6442 |
| Pacemaker intracardial | Yes | 6107 |
| Breast cancer surgery | Yes | 5205 |
| Percutaneous coronary intervention (class 2) | No | 4987 |
| Gastric bypass (endoscopic) | Yes | 4953 |
| Gallbladder / bile ducts surgery | No | 4537 |
| Breast cancer surgery | No | 4304 |
| Percutaneous coronary intervention (class 2) | Yes | 3316 |
| Catheter ablation (class 4) | Yes | 3252 |
| Percutaneous coronary intervention (class 4) | No | 3081 |
| Gastric bypass (endoscopic) | No | 2438 |
| Percutaneous coronary intervention (class 1) | No | 2369 |

All procedures which are already most often performed in an outpatient setting were removed from this list, therefore the most often performed procedures (cataract and adenoid / tonsil surgery) are eliminated. In addition to that cancer procedures are also removed from this list as patients follow a lot of different pathways for the same diagnosis and therefore are difficult to group. Table 2 shows the procedures suitable for analysis based upon the above mentioned excluding criteria.

*Table 2: Most often performed procedures suitable for analysis in the Netherlands in 2016* (NZA, 2018)

| **Procedure** | **Inpatient** | **Number of patients** |
|---|---|---|
| Total hip arthroplasty | Yes | 19994 |
| Total knee arthroplasty | Yes | 19594 |
| Gallbladder / bile ducts surgery | Yes | 16547 |
| Percutaneous coronary intervention (class 4) | Yes | 7129 |
| Pacemaker intracardial | Yes | 6107 |
| Percutaneous coronary intervention (class 2) | No | 4987 |
| Gastric bypass (endoscopic) | Yes | 4953 |
| Gallbladder / bile ducts surgery | No | 4537 |
| Percutaneous coronary intervention (class 2) | Yes | 3316 |
| Catheter ablation (class 4) | Yes | 3252 |
| Percutaneous coronary intervention (class 4) | No | 3081 |
| Gastric bypass (endoscopic) | No | 2438 |
| Percutaneous coronary intervention (class 1) | No | 2369 |

As one can see the top five most often performed procedures as listed above are all performed in an inpatient setting. When reducing the number of inpatients in those procedures this will have an impact on the healthcare costs in the Netherlands. Therefore these procedures are interesting to take a further look at.

The total hip arthroplasty, total knee arthroplasty and cholecystectomy surgery are the most performed procedures in the Netherlands. The percutaneous coronary intervention is an special case, due to the large number of different classes this procedure has. In the eventual analysis these declaration classes combined. The pacemaker intracardial is another cardiologic procedure performed quite often. Next to the intracardial procedure there are many more DBC codes for different types of pacemaker implantation. These procedures will also be taken into account.

Although there some cases known in the Netherlands where the gastric bypass is conducted in an outpatient setting. Literature, like the study of Inaba et al. (2018), does not show a unambiguous outcome in whether it is safe. Therefore the gastric bypass procedure is not taken into consideration in this study.

This thesis will focus on the top five performed procedures based upon the procedures as listed in table 2. The top five is listed below:

- Total hip arthroplasty
- Total knee arthroplasty
- Cholecystectomy
- The percutaneous coronary intervention
- Implantation of pacemaker

## 2.3 Safety and Feasibility of Performing Selected Procedures

The sector describes the safety and feasibility of performing one of the selected procedures. All literature is found following the search strategy and selection criteria described in Appendix A.

### 2.3.1 Percutaneous Coronary Intervention

Percutaneous coronary intervention (PCI) is a nonsurgical procedure for treating obstructive coronary artery diseases. The procedure uses catheterization to visualise the blood vessels on X-Ray imaging. After this, an interventional cardiologist can perform a coronary angioplasty, using a balloon catheter in which a deflated balloon is advanced into the obstructed artery and inflated to reduce the narrowing (George A Stouffer et al., 2016). PCI is the most commonly performed cardiac intervention worldwide. A number of studies have described the safety of same-day discharge. Abdelaal et al. (2013) tried to evaluate all these studies in order to create a large enough sample size to better evaluate whether same-day discharge (SDD) is comparable to an overnight stay with respect to the patient outcomes.

The systematic review and meta-analysis cannot, despite the spreading adoption of SDD after PCI in practices worldwide, scientifically resolve the question whether SDD after uncomplicated PCI in a selected subgroup of patients is as safe as or safer than with overnight stay. In order to resolve this question a large sample size of >17,000 patients would be required. Abdelaal et al. (2013) concludes that hesitance in changing current practice can broadly be attributed to 4 potential challenges. First, there seems to be the medicolegal concerns from the medical community, which relate to the safety of same day discharge. Second, there may be concerns on the part of physicians that a same day discharge strategy may not provide enough time to educate patients about their underlying disease and/or their PCI procedure. Third, there is in the United States a misconception that the current payment system provides a disincentive to hospitals and physicians. And fourth, patients may be reluctant to accept a same day discharge strategy after uncomplicated PCI.

A study conducted by Heyde et al. (2007) in the Netherlands investigated the effect of discharging patients which received coronary angioplasty the same day. During enrolment from July 1, 2000, until March 21, 2003, a total of 4602 PCIs were performed in this medical centre. 1453 of which were elective in patients with stable complaints. In total, 403 patients were randomized to same-day discharge and 397 to overnight hospital stay. Heyde et al. (2007) concludes that same-day discharge after elective PCI is feasible and safe in the majority (80%) of patients selected for day-case PCI. Same-day discharge does not lead to additional complications compared with overnight stay.

To give an indication of how many patients are currently held overnight in hospitals while they could be discharged the same day we use the diagnosis angina pectoris (stable). These patients were also included in the study of Heyde et al. in 2007. In total 6703 patients, diagnosed with a stable form of angina pectoris, received PCI and were discharged the same day. At the other hand, 9126 patients, also diagnosed with a stable form of angina pectoris, received PCI and stayed overnight in the hospital. This shows that in 2013 42% of the patients were discharged the same day. In 2016 this percentage already increased to 51%, showing that more patients undergoing PCI were discharged the same day (Nederlandse Zorgautoriteit, 2018). This is however not close to the roughly 80% of patients which, according to the study of Heyde et al. (2007), can safely undergo day-case PCI. Table 3 shows the number of patients which were diagnosed with a stable form of angina pectoris in all the hospitals in the Netherlands and did undergo PCI between 2013 and 2016. In comparison with the current practice, between 5000 and 6000 patients extra can be discharged the same day.

*Table 3: number of patients diagnosed with a stable form of angina pectoris and underwent PCI (NZA, 2018)*

| | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|
| Total number of patients same-day discharge | 6701 | 7863 | 7846 | 9153 |
| Total number of patients overnight hospital stay | 9126 | 9372 | 9180 | 8653 |
| Percentage same-day discharge | 42% | 46% | 46% | 51% |
| | | | | |
| Potential percentage same-day discharge | 80% | 80% | 80% | 80% |
| Potential number of patients same-day discharge | 12662 | 13788 | 13621 | 14245 |
| Potential difference in number of patients | 5961 | 5925 | 5775 | 5092 |

### 2.3.2 Total Hip Arthroplasty

As many other surgical procedures the length of stay after a total hip arthroplasty (THA) has slowly decreased over the last two decades. In addition to the decrease in the length of stay, modern surgical techniques, advances in regional anaesthesia, improved postoperative pain management, and rapid rehabilitation protocols have allowed patients undergoing THA to be discharged from the hospital as early as the day of surgery (Goyal et al., 2017).

The study of Goyal et al. (2017) examined differences between patients who are discharged at the day of the surgery and patients who stayed overnight with regard to the following outcomes: postoperative pain, perioperative complications and healthcare provider visits, and relative work effort for the surgeon’s office staff. Patients were included in this study if they are younger than 75 years of age, able to walk without walker, not chronical using opioids, and if the body mass index less than 40 kg/m$^2$. A total of 220 patients participated in the study. 112 were randomized to the outpatient group (same-day discharge) and 108 were randomized to the inpatient group (overnight stay). In the outpatient group 76% were discharged as planned. On the first day after surgery, outpatients had higher visual analog scale (VAS) pain than inpatients (3.7 ± 2.3 versus 2.8 ± 2.1, mean difference 0.9, 95% CI, 0.3–1.5, p = 0.005). There was no difference in the number of reoperations, hospital readmissions with reoperation, emergency departments visits without reoperation, or acute office visits. At the 4-week follow-up there is also no difference in the number of phone calls and/or emails to the surgeon’s office. Goyal et al. (2017) concludes that THA can be implemented in a defined patient population without requiring additional work for the surgeon’s office.

Klein et al. (2017) studied the 90-day complication rate by performing same day THA. A total of 549 patients that underwent THA were reviewed. Known orthopaedic complications including infection and deep vein thrombosis were consistent with the literature. Therefore Klein et al. (2017) concludes that THA is safe and effective when performed on the appropriate indicated patients. A smaller study was conducted in the Netherlands in 2014. A total of 27 patients were included to undergo THA in an outpatient setting. 3 of the 27 patients did not go home on the day of surgery because of nausea and/or dizziness. All of the remaining patients went home, PROMs improved substantially in these patients. They therefore conclude that, with a fast-track protocol, outpatient THA is feasible in selected patients with satisfying results up to 3 months postoperatively (Hartog, Mathijssen, & Vehmeijer, 2015).

### 2.3.3 Total knee arthroplasty

The number of knee joint replacement surgeries in Western countries is increasing due to the ageing of the population and the implantation of prosthesis in younger patients (Ostendorf et al., 2002). An outpatient surgery pathway for a patient is accomplished by a patient-specific approach, this process requires a proactive patient. Although the information on the safety of outpatient total knee arthroplasty (TKA) is scarce, some articles investigated the feasibility and effectiveness of conducting TKA while discharging patients the same day. Berger et al. (2005) described a successful outpatient TKA in 48 patients. Between August 2003 and August 2004 one surgeon performed 135 primary TKAs. Of these 135 patients 50 were enlisted in this study. Of these 50 patients 96% were discharged the day of surgery.

The study of Berger has however no control group, therefore no comparison can be made in outcome related measures. To provide some detailed evidence of the safety of the outpatient procedure Bovonratwet et al. (2017) studies if a difference in 30-day complication rates and readmissions exist for outpatient versus inpatient TKA. Only patients who underwent primary, elective, and unilateral TKA were included. In total 112,922 patients remained for the analysis. In this study each outpatient case was matched with one inpatient case with regard to age, gender, body mass index, American Society of Anaesthesiologists classification, functional status before surgery, and smoking status. Only 642 (0.57%) of the 112,922 patients underwent outpatient TKA. Patients who were discharged on the same day of the operation were slightly younger (64 years versus 67 years). There was no difference in adverse events (both minor as serious) in the 30-day postoperative period. Therefore this study concludes that in selected patients the perioperative course of outpatient TKA procedures is similar to that of a matched inpatient TKA. There is only a slight difference in the number of patients that require a blood transfusion post discharge. This study supports the safety of ambulatory knee replacement, but suggests a higher post discharge surveillance of patients who receive outpatient TKA.

Lovald et al. (2014) compared, besides outcome measures, also the costs for outpatient TKA and inpatient TKA. There were 71,341 3-4 day standard-stay patients and 454 outpatients included in the study cohort. Outpatient patients tended to be younger compared to the 3-4 day standard-stay group. At two years costs associated with outpatients patients were $8527 lower than the 3-4 day standard-stay group. In addition patients discharged the same day as the surgery had after 2 years less pain and stiffness than the 3-4 day standard-stay group. The same holds at 90 days, were this outpatient group had significantly fewer diagnoses for pain in comparison with the 3-4 day standard-stay group. This study however only considered patients who were discharged routinely, therefore not all diagnosis post discharge were taken into account. The study also observed a trend of increased risk for dislocation, infection, and implant loosening in the outpatient group. These complications lead to an increased adjusted risk for revision and readmission.

As was the case with PCI and THA it is important to determine the percentage of patients that potentially can be treated as outpatient instead of inpatient. The study of Berger et al. (2005) included patients between 50 and 80 years of age and further excluded patients with a history within 1 year of myocardial infarction, pulmonary embolism, or on anticoagulation therapy. Also, patients with significant obesity or with 3 or more significant medical comorbidities were excluded. Between August 2003 and August 2004 135 patients underwent primary TKA. Eventually 93 patients met the criteria (50 patients were eventually treated as outpatient because the surgery had to be conducted at the beginning of the day). The 93 patients selected for the outpatient surgery pathway is 68.9% of the total of 135 patients.

The percentage mentioned above is used to give a first estimate of the number of patients that can be treated in the Netherlands in an outpatient setting instead of an inpatient setting. In 2016 19,629 patients underwent a TKA in an inpatient setting in Dutch hospitals, only 245 underwent the same procedure in an outpatient setting. The means currently that 1.2% of all patients in the Netherlands are discharged at the same day as the TKA procedure. Taken the above mentioned percentage in account potentially 13,693 patients can undergo a TKA procedure in an outpatient setting.

### 2.3.4 Implantation of a Pacemaker

A retrospective study conducted already in 2004 by Villalba et al. looked at the data of 2108 patients with permanent pacemakers implanted between January 1991 and December 2001. They divided their patients into four groups based on pacemaker dependency and the length of stay in the hospital. Patients who are pacemaker dependent are not eligible for same-day discharge, therefore this group is not of interest for this study. Of the 2108 patients included by Villalba et al. 1109 (52.6%) were pacemaker dependent. 371 patients did not want to be included in the study and 248 patients were excluded based on social exclusion criteria like no suitable means of transport, having a long way to travel to the hospital, or having no one to look after them. Of the 2108 patients included, only 76 (3.6%) experienced complications associated with the pacemaker implantations. There was no significant difference in the incidence of complications between groups. Both the mortality and morbidity rate was even slightly higher for patients with hospitalisation. Therefore this study concluded that same-day discharge of patients undergoing pacemaker implantation is feasible and safe to conduct.

A study conducted in the United Kingdom scheduled 780 patients for elective new permanent pacemaker implantation as a same day procedure. 272 single-chamber devices were implanted and 508 dual chamber devices. 41 (5.3%) required an in-hospital stay after implantation because of hematoma formation, pneumothorax, angina pectoris or at the physicians request (Osman et al., 2010). Although this study concludes that same day permanent pacemaker implantation is feasible and safe because it was associated with a low prevalence of complications and only a few patients required an overnight stay, no control group was monitored. Therefore no final conclusion can be drawn from this study.

Although no large randomised control trials are conducted in order to conclude that same-day discharge after undergoing a pacemaker implantation is safe it is already quite common to perform this surgery in an outpatient setting. In the Netherlands 775 biventricular pacemakers were placed in patients in 2016. 180 (23.2%) of these patients were discharged at the same day, the other 595 stayed overnight. In 2016, also 9,229 single- or dual-chamber pacemakers were implanted. Of these patients which underwent a single-/dual-chamber pacemaker implantation procedure 2097 (22.7%) were discharged the same day and 7132 patients stayed overnight. Although for both the single- and dual-chamber pacemakers quite a group is already discharged the same day as surgery the study of Villalba et al. (2004) shows that this can increase to roughly half of the patients.

### 2.3.5 Cholecystectomy

Removal of the gallbladder, cholecystectomy, can be conducted in two different ways. There is the classical procedure in which a larger incision in the abdominal area is made to remove the gallbladder and there is the laparoscopic procedure in which small incisions are made and therefore is less invasive than the classical procedure. The laparoscopic way is the preferred procedure, but is not always safe to conduct. When due to an infection the gallbladder is very stiff and/or gallstones in some bile ducts prove difficult to reach the classical procedure is conducted. The classical procedure always include hospitalization with multiple overnight stays due to the risks involved in a 'open' surgery. The laparoscopic procedure is suitable for same-day discharge, but most hospitals in the Netherlands keep patients overnight ("Galblaas operatie," n.d.). In the Netherlands both procedures are allocated to the same DBC. Therefore it is difficult to determine how many patients undergo the laparoscopic procedure. In 2016 21% of all patients in the Netherlands who underwent cholecystectomy were discharged the same day.

A study conducted in Italy examined the feasibility and outcomes of 400 patients undergoing laparoscopic cholecystectomy (LC) and were discharged on the same day of the operation. Of the 730 patients scheduled for cholecystectomy between March 2003 and June 2011 400 patients were selected for outpatient LC based on the following inclusion criteria.

- Age < 70 years
- ASA classification I or II
- BMI <35 kg/$m^2$
- Uncomplicated gallstone disease
- No history of jaundice
- No high risk of common bile duct calculi
- No anxious personality
- Living less than 50 minutes from the hospital

380 of the 400 patients were satisfied with the outpatient LC. 387 (96.7%) patients were successfully discharged after 8-10 hours of observation and none of the patients needed to be readmitted after discharge. The authors did not use a control group, therefore it is difficult to determine whether patients experienced more or less pain than the inpatient LC patients. However, the mean VAS score of 1.5 shows a good pain control (Brescia et al., 2013).

A study which investigated the safety of outpatient LC in the elderly (over 65 years of age) used the NSQIP database to include 15,248 patients. 49.9% of the patients were treated in an outpatient setting. A significant higher rate of postoperative complications in the inpatient group was detected, but that is probably partly due to a higher average age of that patient group. Predictors for inpatient stay were also identified in this study. The most significant predictors were dialysis, bleeding disorder, ASA classification of IV, and congestive heart failure. This study concludes that is safe to conduct LC in an outpatient setting for elderly patients (Rao et al., 2013).

A large review study conducted by Vaughan et al. in 2013 studied the outcomes of six studies involving 492 patients undergoing outpatient laparoscopic cholecystectomy (n = 239) versus overnight stay laparoscopic cholecystectomy (n = 253). No significant difference in primary and secondary outcomes were found. This study concludes that day-surgery is just as safe as overnight stay surgery in laparoscopic cholecystectomy. It however does not seem to result in improvement in any patient-oriented outcomes such as return to normal activity or earlier return to work (Vaughan, Gurusamy, & Davidson, 2013).

## 2.4 Conclusion

We described examples of hospitals in the Netherlands which actively try to conduct as many procedures as possible in an outpatient setting. We also showed that healthcare inspections, like the NHS, are promoting surgery in an outpatient setting.  This thesis will be focused on the percutaneous coronary intervention, total hip arthroplasty, total knee arthroplasty, implantation of a pacemaker and cholecystectomy. Findings in literature show that these procedures are feasible and safe to be conducted in an outpatient setting.

# 3 Financial Analysis

In order to determine whether a procedure performed in an outpatient setting has economic benefits in comparison with performing the same procedure in an inpatient setting we conduct a cost analysis. To determine how this study expresses the differences in the number of patients undergoing one of the selected procedure in an outpatient setting or in an inpatient setting as good as possible this chapter describes the use of different financial analysis techniques.

A common financial analysis technique, which also considers the benefits an intervention has, is health economic evaluation. The purpose of health economic evaluation is to support the making of decisions by providing insight in costs and benefits, so the key inputs to any economic evaluation are evidence about the costs and effects of alternative courses of action. Much of this evidence will be drawn on the results of clinical evaluations. Economic evaluation therefore provides a framework on how to make best use of this clinical evidence through a structured consideration of the effects of all the available alternatives on health, healthcare costs, and other effects that are regarded as value (Drummond et al., 2005).

Health economic evaluation is historically often based on a single study such as a randomized controlled trial (RCT). Such studies are still undertaken, but there is a growing use of decision-analytic modelling as an alternative (Drummond et al., 2005). In 2006 Sculpher et al. estimated that 30% of published economic evaluations on the NHS Economic Evaluation Database between 1994 and 2006 have been based on data from a single RCT. They address that using a trial as a framework for economic analysis falls short in terms of many requirements of economic evaluation for decision making. For example, they deem that using a trial as a framework fail to compare all relevant options. Other shortcomings are: the truncated time horizon, inability to incorporate all evidence and the inadequate quantification of decision uncertainty. Therefore, economic evaluation for decision-making should be drawing on evidence from a range of sources. These could include clinical, resource use, and outcome data collected alongside RCTs, but are also likely to include evidence from other types of study. A decision-analytic model brings together a full range of evidence and directs it at a specific decision problem being addressed by a health system (Drummond et al., 2005).

Although this study is focused on analysing the available data regarding patient characteristics and declared care activities at hospitals in order to show the financial effects of moving patients, fitting the criteria of studies, from an inpatient to an outpatient setting we chose to explore the options of decision-analytic modelling. We chose to explore the option of using decision-analytical modelling as we want to provide Menzis a profound basis for analysing different procedures for different hospitals in the future. A decision-analytic model can give this basis, as it is usually gives a flexible and robust framework.

## 3.1 Decision-Analytic Modelling

Decision-analytic modelling provides a framework for decision-making under conditions of uncertainty. For any type of economic evaluation decision analysis should satisfy objectives like the following (Drummond et al., 2005):

- Providing a structure that reflects on the variability between similar individuals in the effect of interventions. But the structure can also provide insight in the possible prognoses that individuals may experience.
- Evidence relevant to the study questions is brought forward, the evidence is used to derive estimates for the input parameters of the model.
- Decision analysis provides an evaluation that can be used to determine the best option.

- A model facilitates an assessment of various types of uncertainty relating to the evaluation.
- Due to the assessment of uncertainty the model can be used to estimate the value of future research.

Drummond et al. (2005) describes in the often cited book for economic evaluation in health care that there some key elements to decision analysis that are common to all models. These are the use of probabilities to reflect the likelihood of events or changes in health, and the expected values to inform decisions.

When clinical situations can be described in terms of the conditions that individuals can be in (states), how they can move among such states (transitions), and how likely such moves are (transition probabilities) state-transition modelling (STM) suits well to help make a certain decision. When the interactions between individuals are not relevant, and the population of interest is a closed cohort STM is a reasonable choice. A STM can be either a cohort model, with no heterogeneity at patient-level or a patient-level model with heterogeneity on patient-level.

Among STM there are other types of models that can be used to evaluate health economics. A review study performed by Degeling et al., in 2017 identified the most observed methods for the health economic modelling in personalised medicine. In the following subchapters the most common types, based on the most observed models as found by Degeling et al., used in health economic evaluation will be introduced to determine which type fits the needs of this study best.

### 3.1.1 Decision Tree

A decision tree represents a patients possible prognoses, following a certain intervention. A decision tree consists of decision nodes, which represent the decision being addressed, and chance nodes, which make up the range of possible pathways that characterize the effect of the different therapies. Then there are the branch probabilities and conditional probabilities which respectively represent the likelihood of an event and the likelihood of subsequent uncertain events (Drummond et al., 2005). Based on the nodes and corresponding probabilities different pathways can be determined. Following these different pathways, one can then calculate the probabilities and costs of these pathways.

Although those pathways show a good overview of the different possibilities for a patient a decision tree has some limitations. For example, time is not explicitly defined in a decision tree. Elements which are time depended are therefore difficult to implement. Another example of a limitation is that they can become very complex. Especially when there are a lot of different variables that are being used to characterize a patients pathway (Drummond et al., 2005).

### 3.1.2 State-Transition Modelling

#### *3.1.2.1 Markov Models*

A Markov model can be used when one is interested in how a random variable changes over time. The random variable should then change over time by a stochastic process. Suppose $X_t$ is a value of a system at a certain time $t$, The value $X_t$ is not known with certainty before $t$ and therefore the value may be viewed as a random variable. A discrete-time stochastic process describes then the relation between the random values $X_t$ in different points of time (i.e. $X_0$, $X_1$, $X_2$). A Markov model is a special type of discrete-time stochastic process which says that the probability distribution of a state ($i_{t+1}$) at time $t + 1$ depends on the state $i_t$ at time $t$ and does not depend on the states the model passed through on the way to $i_t$ at time $t$ (Winston, 2004).

The Markov model is often used to avoid the limitations associated with decision trees. The states $i_t$ that are described by a Markov model give a good insight on how a patient moves through a process over time. The key assumption underlying Markov models is described as the memoryless feature of these models. The probability of a transition is therefore independent of the nature or timing of earlier transitions (Drummond et al., 2005).

#### *3.1.2.2 Monte Carlo simulation*

Due to the above mentioned 'Markov assumption' and the time dependency of Markov models, for some studies modelling individual patients moving through a system can be a better option. When this individual sampling is used in the context of state transition models with discrete cycles, this is referred to as microsimulation or first-order Monte Carlo simulation. Monte Carlo simulation draws samples from the required distributions, and then forms sample averages to approximate expectations. Monte Carlo simulation can also be used in combination with Markov chains by running these chains for a long time (Gilks & Richardson, 1997).

The conceptualisation of an Monte Carlo simulation should begin by identifying states that reflect the health process, with transitions among the states that would be expected. These states should be specified as mutually exclusive and every individual must be in a state during each cycle. In addition to that a Monte Carlo simulation should adequately capture the benefits or harms of any intervention. The main disadvantages of a Monte Carlo simulation is that it is computationally intensive and often requires simulation of millions of individuals to obtain stable values for the outcomes of interest (Siebert et al., 2012).

#### *3.1.2.3 Markov Models versus Monte Carlo simulation*

Markov models and Monte Carlo simulation are next to decision trees the most popular ways of modelling health economics (Degeling et al., 2017). Therefore this subchapter describes the main differences in order to give a better overview. Table 4 shows the main differences between cohort state-transition (Markov) and individual-level state-transition (Monte Carlo) models.

*Table 4: Cohort versus individual-level state-transition models*

| | **Cohort STM** | **Individual-level STM** |
|---|---|---|
| *Ease of model development* | Higher (if the number of states is limited) | Lower |
| *Ease of model debugging* | Higher (if the number of states is limited) | Lower |
| *Ease of communication to nonexperts* | Higher | Lower |
| *Memoryless* | Yes | No |
| *Ease of modelling many different subgroups* | Lower | Higher |
| *Danger of explosion in number of states* | Yes | No |
| *Distribution of outcomes* | Possible | Yes |
| *Report of individual patient histories* | No | Yes |
| *Decision-analytic software available* | Yes | Yes |

Advantages of using an individual-level STM are the ability to model individual characteristics and the ability to evaluate dynamic intervention strategies. Siebert et al. (2012) concludes that if the decision problem can be represented with a manageable number of health states that incorporate all characteristics relevant to the decision problem and does not need to show patient-specific characteristics a Markov model should be chosen because of its transparency, efficiency, ease of debugging, and ability to conduct specific value of information analyses. If, however, a representation would lead to an unmanageable number of states then a microsimulation on individual-level is recommended.

### 3.1.3 Discrete Event Simulation

Discrete Event Simulation is a flexible modelling method which can be used to evaluate health economic outcomes. DES is characterized by the ability to represent complex behaviour within, and interactions between individuals, populations, and their environments. This means that events occurring in hospitals (or other healthcare organisation) to an individual and how that individual interacts with the healthcare system can be modelled simultaneously. DES moves forward in time at discrete intervals and the events are mutually exclusive. Therefore, DES is flexible and therefore efficiently can used over a wide range of problems (Karnon et al., 2012).

#### *3.1.3.1 Discrete Event Simulation versus State-Transition Modelling*

A study of Degeling et al. (2018), investigated whether cost-effectiveness outcomes were different when using DES or STM. Both models were populated using individual patient data of a phase III study in metastatic colorectal cancer patients. They found that the time-dependent transitions probabilities for the STM were irregular and more sensitive to single events due to the required small cycle length and limited number of event observations. Both the STM and DES model yields similar time-to-event curves, but the DES model represented the trial data more accurately in terms of mean health-state duration. They conclude that DES represents time-to-event data from clinical trials more naturally and accurately than STM when few events are observed per time cycle.

### 3.1.4 Other Models

Another model mentioned once in the review study of Degeling et al. (2017) is the partially observable Markov decision process (POMDP). In a POMDP an agent is no longer able to determine the state it is currently in with complete reliability. To achieve this reliability the agent has the use the memory of previous actions and observations. Thus, a POMDP differs from a Markov model because it is not memoryless (Kaelbling et al., 1998).

Mathematical or statistical models developed to support medical decision-making are the final models that are reviewed by the study of Degeling et al. (2017). These models are based upon equations that underly the specific needs of a certain study best.

## 3.2 Conclusion

In order to be able to answer the research question of this study, this study must find the financial effects of moving patients from an inpatient setting to an outpatient setting. This is nothing more than multiplying the number of patients with the difference in the costs of a DBC. However, the aim of this study is also to provide Menzis with some tools needed to make a change in the price agreements with hospitals. Therefore, this thesis should link available literature to the possibility of moving patients between different settings. In order to do so, different characteristics of patients should be modelled.

The modelling can be conducted on different levels. The most important one is of course the distinguishing between in- and outpatients based on the DBC code. A level down are the characteristics of the DBC codes, the care activities. These care activities give a better insights in the differences between both groups. These care activities can be modelled for both groups. This level also contains the follow-up of these patients. The question is whether the available data can provide in determining differences in outcomes measures, like mortality and complication rate, for both patient settings.

We have selected five different procedures to look into. Because these procedures are all structured with different care activities it is important that the basis of the model is easy to adapt. The used method should be able to answer the research question for different hospitals and procedures as there will be differences in the care activities used by hospitals for the procedures. Due to the fact that this study is a first start at exploring the use of care activities we will not use time-dependent pathways. Looking at the different methods described for health economic health evaluations, the Markov model, Monte Carlo simulation or discrete event simulation seems best fit. The Markov model looks at a cohort per state, which might be suitable but when the model eventually also should provide insight in individual patient characteristics this is not the best option. The study of Degeling et al. (2018) shows that a DES seems more accurate in representing time-to-events. As no time-to-events are currently part of this study the use of DES can be a next step for Menzis. In this study we will focus on time-independent variables for patients and therefore we will conduct a Monte Carlo simulation.

# 4 Study Design

This study will be evaluating the financial effects of shifting patients from an inpatient setting to an outpatient. Therefore this study first sets a baseline of the current costs involving the selected procedures by analysing available data and performs measurements for this baseline when relevant. In this chapter we will further discuss the possible care pathways of patients and the used variables for the baseline

## 4.1 Study scope

In this study we focus on the five procedures elaborated on in chapter 2. Next to that the scope of this study is limited to four hospitals. These four hospitals are situated in the strategic area of Menzis as they deliver care to a large number of patients insured at Menzis. These four hospitals perform the five procedures selected the most often of all contracted hospitals by Menzis. This study is limited to hospitalised patients and therefore does not consider care performed at other healthcare organisations.

## 4.2 Available data

Menzis monitors and collects the declared care activities and corresponding care products of all healthcare providers in the Netherlands. Therefore, for all patients insured at Menzis data regarding their care activities is available. Not known, is the patient information regarding complications and other medical information saved in a medical information system. The costs of all contracted care products for hospitals in the Netherlands are available via Menzis.

For this study data of procedures performed between 1 January 2016 and 31 December 2017 is used.

## 4.3 Care pathways

For this study we are interested in two different pathways of patients undergoing a procedure. A patient can either undergo a procedure in an inpatient setting or an outpatient setting.

We are interested in the financial effects of shifting patients from an inpatient setting to an outpatient setting. Next to that, we are also interested in the difference in the care activities between both patient groups. In order to determine what the financial effects will be of shifting these patients setting a baseline is important. The baseline is based on the distribution of different variables of patients undergoing a procedure in an inpatient or outpatient setting in a certain hospital. These variables will be discussed in the next subchapters.

Whether the patient undergoes the procedure in an outpatient setting is in the baseline based on the probability (which differs per hospital) of undergoing the procedure in an outpatient setting. In the experimental set-up a patient is shifted when the patient meets patient-specific predictor criteria. Figure 4 shows the flowchart for the baseline. In the flowchart not all assigned attributes for the variables of both care pathways are shown.

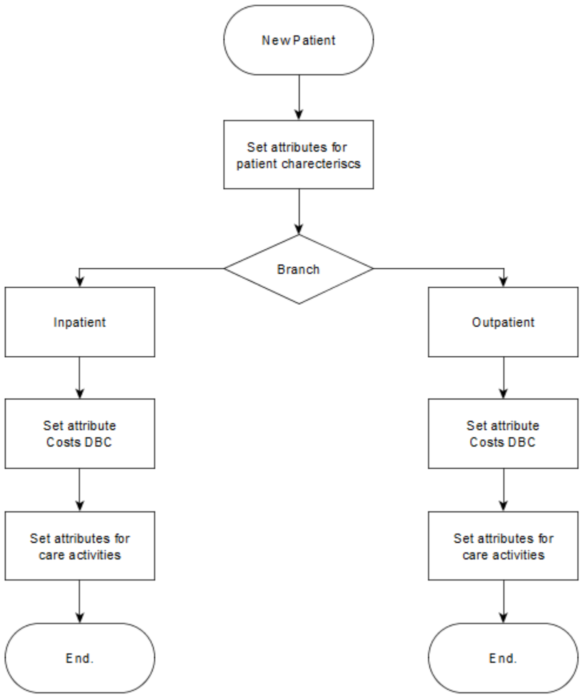


*Figure 4: flowchart of care pathways of the baseline*

## 4.4 Independent Variables

Whether a patient can be shifted from an inpatient to an outpatient setting in the experimental set-up is dependent of multiple parameters. These predictors are based on the literature study conducted in chapter 2 and are therefore different for the different procedures studied. In this sector we will describe the used parameters.

### 4.4.1 Patient type

For each procedure and hospital the probability that the patient is treated in an inpatient or outpatient setting is different. Therefore for each hospital , the baseline assigns a patient to either the inpatient pathway or the outpatient pathway based on the probability that the patient is treated in an inpatient or outpatient setting for that hospital.

Table 5 below shows the percentage of patients being treated in an inpatient or outpatient setting for all procedures and all hospitals in 2016 and 2017.

*Table 5: percentage of patients being treated in an inpatient or outpatient setting*

| | **PCI** | | **TKA** | | **THA** | | **Pacemaker** | | **Cholecystectomy** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | In | Out | In | Out | In | Out | In | Out | In | Out |
| Hospital 1 | 48.4% | 51.6% | 100% | 0% | 99.8% | 0.2% | 70.7% | 29.3% | 94.3% | 5.7% |
| Hospital 2 | 54.1% | 45.9% | 100% | 0% | 99.7% | 0.3% | 68.3% | 31.7% | 97.8% | 2.2% |
| Hospital 3 | 72.2% | 27.8% | 96.9% | 3.1% | 98.9% | 1.1% | 70.0% | 30.0% | 98.4% | 1.6% |
| Hospital 4 | 72.3% | 27.7% | 99.6% | 0.4% | 100% | 0% | 68.2% | 31.8% | 91.2% | 8.8% |

### 4.4.2 Age of patients

The distribution of age is different for each procedure, but is assumed the same for the different patient groups and hospitals. Therefore a different distribution for the age of the patients fitted for each procedure. The distribution is fitted based on visual inspection of the P-P and Q-Q plot and the results of the Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling statistic. The results of these goodness of fit statistics of the age of patients for the THA procedure can be found in table 6.

*Table 6: goodness of fit statistics of the age of patients for the THA procedure for multiple distributions*

| | Gamma | Lognormal | Normal | Weibull | Exponential | Poisson | Geometric |
|---|---|---|---|---|---|---|---|
| **Kolmogorov-Smirnov** | 0.090 | 0.103 | 0.065 | 0.029 | 0.470 | 0.108 | 0.474 |
| **Cramer-von Mises** | 29.828 | 42.721 | 11.960 | 1.895 | 1114.601 | 52.628 | 1131.267 |
| **Anderson-Darling** | 184.288 | 261.794 | 76.116 | 10.644 | 5220.120 | 401.397 | 5287.617 |

Based on the statistics and the visual inspection of the P-P and Q-Q plots the Weibull distribution seems the best fit for the distribution of the age of patients undergoing a total hip arthroplasty. The probability density function is shown below in figure 5.

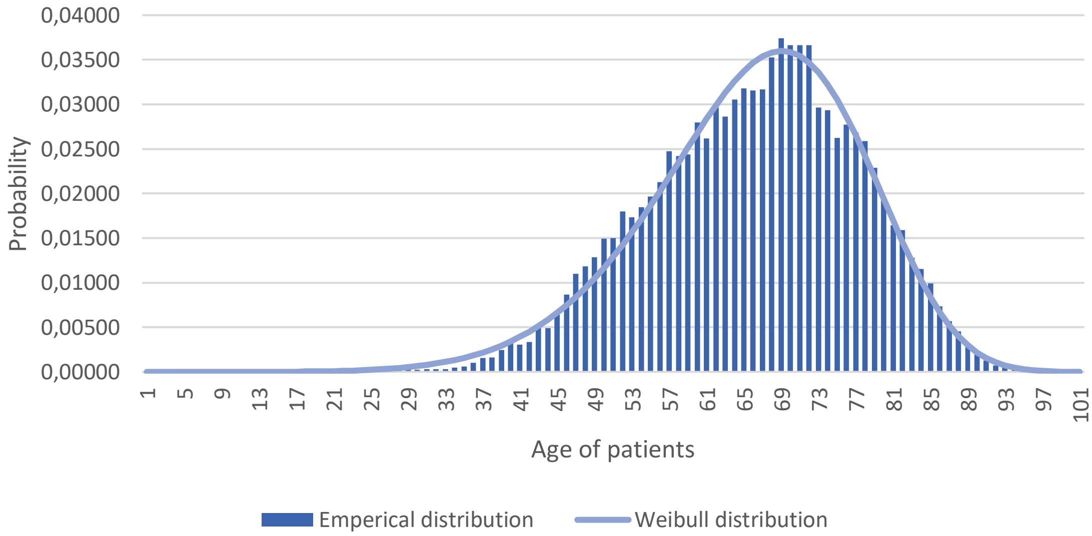


*Figure 5: probability density function of empirical and fitted Weibull distribution for the age of patients undergoing THA*

The same method has been used for fitting the distributions of the age of patients for the other procedures.

### 4.4.3 Shifting Criteria

Due to the absence of data of patient characteristics like comorbidities, BMI and ASA score it is hard to determine whether a patient would meet the criteria found in the studies described in chapter 2. In order to shift the patients accordingly to the found literature we have found multiple literature studies describing the prevalence of these patient characteristics. This sector describes for each procedure the criteria for shifting patients and the patient characteristics found.

#### *4.4.3.1 Percutaneous coronary intervention*

In the study of Abdelaal et al. (2013) multiple studies were compared. These studies all excluded patients to undergo PCI in an inpatient setting with angina class III or higher. In addition to that most studies did not include patient in their study which exceed the age of 80. Both the angina class as the age can be determined by the data available at Menzis. Next to these criteria, most studies also exclude patients with a recent myocardial infarction, this is however a characteristic that cannot be determined by both the available data and literature as studies do not specify the time passed since a myocardial infarction.

#### *4.4.3.2 Total Hip Arthroplasty*

In the study of Namba et al. (2005) 1071 THA patients and how their characteristics effect perioperative morbidity were prospectively evaluated. The probability of being obese (BMI > 35) while undergoing the THA procedure is 0.12 for men and 0.15 for women. The comorbidities (and corresponding probabilities) taken into account are diabetes (obese: 0.14, non-obese: 0.09), cardiac problems (0.07, 0.09), hypertension (0.53, 0.36), gout (0.03, 0.03), current steroid user (0.01, 0.02), alcohol abuse (0.07, 0.07) and current smoker (0.09, 0.06). A patient cannot be treated in an outpatient setting when he or she is obese or has 3 or more comorbidities. Patient exceeding the age of 80 are also not shifted to an outpatient setting.

#### *4.4.3.3 Total Knee Arthroplasty*

Namba et al. (2005) studied the effect of obesity on perioperative morbidity in total hip and total knee arthroplasty patients. 1813 TKA patients and how their characteristics effect perioperative morbidity were prospectively evaluated. The probability of being obese (BMI > 35) while undergoing the TKA procedure for men is 0.15, for women this is 0.28. The comorbidities (and corresponding probabilities) taken into account are diabetes (obese: 0.21, non-obese: 0.12), cardiac problems (0.08, 0.10), hypertension (0.54, 0.44), gout (0.04, 0.03), current steroid user (0.002, 0.02), alcohol abuse (0.08, 0.05) and current smoker (0.03, 0.05). A patient cannot be treated in an outpatient setting when he or she is obese or has 3 or more comorbidities. Patient exceeding the age of 80 are also not shifted to an outpatient setting.

#### *4.4.3.4 Implantation of pacemaker*

Both the studies of Osman et al. (2010) and Villalba (2004) do not exclude patients undergoing an implantation of a pacemaker in an inpatient setting based on age of comorbidities. The only exclusion criteria used is social reasons. Social reasons are not taken into account in this study. There is however a difference between the pacemaker dependent and non-dependent patient groups. All pacemaker dependent patients are not shifted to an outpatient setting. The data available at Menzis does not describe pacemaker dependency, therefore we use the percentage of pacemaker dependent patients in the study of Villalba (2004) which is 47.3%.

#### *4.4.3.5 Cholecystectomy*

A study of Brescia et al. (2013) evaluated the feasibility and safety of performing laparoscopic cholecystectomy in a day surgery setting in Italy. Inclusion criteria for their study were: age below 70, ASA I/II, BMI below 35 kg/m2, uncomplicated gallstone disease, no history of jaundice, no high risk of common bile duct calculi, no anxious personality and living less than 50 minutes from the hospital. Social factors cannot be taken into account in this study. Additional patient characteristics like the ASA score and elective or emergency operation are however found in a study conducted by Giger et al. in 2006. They studied the perioperative complications in patients undergoing laparoscopic cholecystectomy of 22,953 patients in Swiss. 85.3% of the operations was elective operation, 88.3% of the patients operated had a ASA score of I or II.

### 4.4.4 Care activities

The data available at Menzis provides insight in the number of different care activities declared for a certain patient undergoing a certain treatment. These care activities may say something about whether an patient can be sifted to an outpatient setting. But since there is no further data available at Menzis about patient characteristics this statement cannot be supported. We do however want to provide insight in the number of different care activities in order to conduct a scenario analysis.

There are for each procedure a lot of different care activities that can be analysed and modelled. In order to provide insight in some of these declared care activities we have fitted a distribution for the most common (on average declared once or more per patient) care activities for all procedures. Next to that for each procedure care activities that are normally declared once or not per patient are added by their probability to give some additional insight when needed. When a care activity occurs on average more than once we fitted for each hospital a distribution, if this is not the case the probability of occurring is used. Table 7 shows a list of all care activities analysed for each procedure

*Table 7: list of all care activities considered for each procedure. * indicates that a distribution was fitted, for the other care activities a probability of occurring is determined*

| **PCI** | **TKA** | **THA** | **Pacemaker** | **Cholecystectomy** |
|---|---|---|---|---|
| Length of stay* | Length of stay* | Length of stay* | Length of stay* | Length of stay* |
| Examining ECG | Regular physiotherapy* | Regular physiotherapy* | Examining ECG* | Revisit |
| Heart catherization | Radiologic screening* | Radiologic screening* | Radiologic screening thorax | Laparoscopic cholecystectomy |
| Acute performed PTCA | Number of revisits* | Number of revisits* | Polyclinical test pacemaker | First polyclinic visit |
| First polyclinic visit | Anaesthesia control | Anaesthesia control | Placing pacemaker | Initiate general anaesthesia |
| Telemetry monitoring | Infusion | Infusion | Telemetry monitoring | End general anaesthesia |
| Radiologic screening thorax | Epidural Anaesthesia | Epidural Anaesthesia | Echo graphic of heart | Anaesthesia control |
| Regular physiotherapy | First polyclinic visit | First polyclinic visit | First polyclinic visit | Infusion |
| Emergency contact on A&E | Intake physiotherapy | Intake physiotherapy | Physiotherapy regular | Emergency contact of A&E |
| Emergency contact inpatient | Review of tests | Review of tests | Revisit | Ultrasound abdomen |
| PTCA one branch | Injections | Injections | Emergency contact on A&E | Inpatient dietetics |
| Physio direct revalidation | Initiate general anaesthesia | Initiate general anaesthesia | Inpatient dietetics | Injections |
| Fractional flow reserve | End general anaesthesia | End general anaesthesia | Infusion | Examining ECG |
| Inpatient dietetics | Physio direct revalidation | Physio direct revalidation | Subcutaneous pacemaker | Regular physio |
| Physio indirect revalidation | Physio indirect revalidation | Physio indirect revalidation | Radiologic screening thorax | Radiologic screening thorax |
| Infusion | Physio long session | Physio long session | Emergency contact inpatient | CT abdomen |
| PTCA multiple branches | Radiologic screening leg | Radiologic screening leg | Analysis of 24h ECG | Cholecystectomy |
| Revisit | Anaesthesia peripheral | Anaesthesia peripheral | Physio direct revalidation | Diagnostic laparoscopic |
| Day nursing | Day nursing | Day nursing | Day nursing | Day nursing |

The length of stay (LOS) is a care activity returning in each studied procedure and therefore a distribution is fitted for each procedure and hospital. For the total hip and knee arthroplasty there is in addition a distribution fitted for the number of regular physiotherapy sessions, revisits and radiologic screening due to that these care activities are also often declared. The implantation of a pacemaker has also distribution fitted for the examining of an ECG.  .

The length of stay (LOS) is of course only found in patients undergoing a procedure in an inpatient setting. The number of revisits, physiotherapy sessions and radiologic screenings are fitted based on both the inpatient as the outpatient group. Below we will only describe the method for fitting a distribution for the length of stay of patients undergoing a total hip arthroplasty in an inpatient setting in hospital 1.

The distribution of the LOS for each hospital is fitted in the same way as described in chapter 4.5.2. For the LOS of patients undergoing an inpatient total hip arthroplasty in hospital 1 the method is described below. First different distributions are determined and plotted in a histogram, P-P and Q-Q plot. In addition to this three goodness of fit statistics are calculated, which are shown below in table 8.

*Table 8: goodness of fit statistics for LOS of patients undergoing THA in hospital 1*

| | Gamma | Lognormal | Normal | Weibull | Exponential | Poisson | Geometric |
|---|---|---|---|---|---|---|---|
| **Kolmogorov-Smirnov** | 0.220 | 0.208 | 0.272 | 0.233 | 0.367 | 0.201 | 0.46 |
| **Cramer-von Mises** | 82.607 | 55.913 | 187.623 | 114.877 | 231.773 | 71.336 | 382.707 |
| **Anderson-Darling** | Inf | 290.59 | Inf | Inf | 1175.512 | Inf | 1790.11 |

Based on the goodness of fit statistics and visual inspection of the plots the best fitting distribution is chosen. For the length of stay of patients undergoing a total hip arthroplasty this the lognormal distribution. The corresponding probability density function is shown in figure 6.

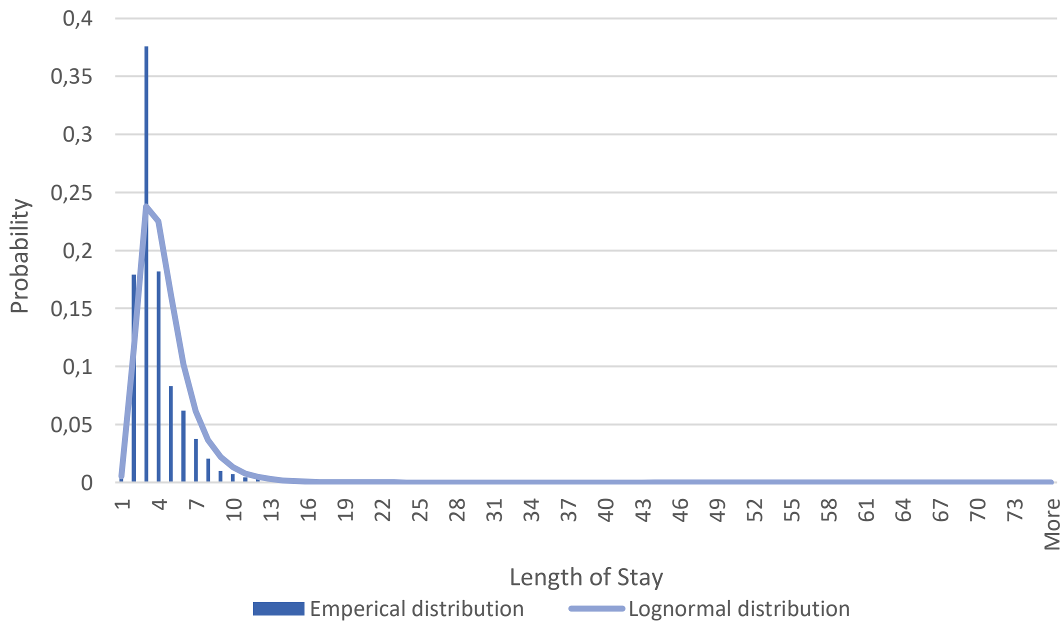


*Figure 6: probability density function of l distribution for the length of stay of patients undergoing THA in hospital 1*

## 4.5 Dependent Variable

Due to the limited amount of data available at Menzis we can only use the costs as a dependent variable. To evaluate the costs of performing one the procedure for one of the four hospitals all relevant DBC products that are involved in the treatment will be identified. For the same surgery more than one DBC code can exist. Table 9 below shows all the different DBC codes identified for the different procedures for procedures performed in an inpatient setting. Table 10 does the same but for procedures performed in an outpatient setting.

*Table 9: DBC codes used for inpatients*

| PCI | Total Hip Arthroplasty | Total Knee arthroplasty | Implantation of pacemaker | Cholecystectomy |
|---|---|---|---|---|
| 14D079 | 15B034 | 15B067 | 15A749 | 15A977 |
| 14D081 | 15D057 | | 15B780 | |
| 14D083 | | | 15E743 | |
| 14D085 | | | | |

*Table 10: DBC codes used for outpatients*

| PCI | Total Hip Arthroplasty | Total Knee arthroplasty | Implantation of pacemaker | Cholecystectomy |
|---|---|---|---|---|
| 14D078 | 15B033 | 16B066 | 15A748 | 15A976 |
| 14D080 | 15D056 | | 15B779 | |
| 14D082 | | | 15E744 | |
| 14D084 | | | | |

For this study only the costs of four hospitals are considered. These four hospitals perform the to be studied procedures the most often for Menzis. The agreed prices of the DBCs between the selected hospitals and Menzis can be found in Appendix C This study is limited to hospitalised patients only and therefore does not consider other costs of other healthcare organisations. In addition to that, costs outside of the healthcare sector are not part of the scope of this study.

## 4.6 Conclusion

In this chapter we described the study design for the effects of shifting patients from an inpatient to an outpatient setting. We set the baseline for the simulation study by identifying the available data, independent variables and dependent variables. Also, we discussed the criteria for shifting patients to an outpatient setting, which will be used for the experimental set-up.

# 5 Solution Approach

## 5.1 Monte Carlo simulation

In order to provide the insight needed to reach the goal of this thesis Monte Carlo simulation was selected as a suitable technique in chapter 3. R is a software environment for statistical computing and is therefore used to build the simulation.

## 5.2 Design of the baseline

In this study we investigate the financial effects of shifting patients from an inpatient to an outpatient setting for five different procedures. As each procedure has different care activities and patient characteristics the baseline for each procedure slightly differs. The baseline calculates the current costs of performing a certain procedure in a hospital based on the used data of 2016 and 2017. However, each procedure is simulated by performing the same steps, these steps are described in following sectors. For this study, we first designed the baseline which does not include the criteria for shifting patients found in sector 2.3. These criteria are implemented in the experimental set-up to show the differences.

In this Monte Carlo simulation we first of all assign different characteristics to each patient simulated. These attributes are their sex, age and hospital in which surgery is performed. Then based on the probability of being operated in an inpatient or outpatient setting in the assigned hospitals the patient is either inpatient or outpatient. Based on the patient type and hospital each patient gets then care activities assigned for each procedure. Some of these care activities are assigned to them based on a distribution as section 4.4 describes. Care activities that almost always occur once or not at all are assigned based on the probability of occurring in the assigned hospital. Each patient also gets the corresponding costs of their DBC assigned as an attribute.

Some of the assigned attributes are conditional on attributes that are assigned earlier to the patient. All care activities are dependent on the patient type and hospital. The age of a patient is dependent on their sex. Criteria differ for each procedure but are often dependent on the sex and age attributes.

For all of the above described attributes we use common random numbers for each procedure to control the randomness in the simulation. Law et al. (2005) describes that otherwise the effect of changing one factor may be confounded with other changes.

## 5.3 List of Assumptions

Multiple assumptions have been made for the simulation, which are as follows:

- Simulated patients are considered equal to the patients found in studies which we used to add patient characteristics.
- All patients simulated can be shifted to an outpatient setting when they fit the criteria for shifting of a procedure.
- Patient characteristics do not differ between the baseline and experimental set-up due to the use of common random numbers.
- A patient is only being treated for the selected procedure. Multiple assigned DBC’s at the same time are not possible.

## 5.4 Input

As the model is altered for each procedure the input not always the same. The following list contains the input needed for every procedure and describes the differences in input for the different procedures.

- The agreed prices of the corresponding DBC's between Menzis and each hospital.
- Distribution of age of the patients.
- Distribution of length of stay of the inpatient group.
- Distribution for each other care activity that can have a proper fitted distribution (i.e. number of physiotherapy sessions or number of radiologic screenings).
- Probabilities of receiving a care activity in one of the hospitals.
- Additional patient characteristics needed to determine whether a patient can shifted to an inpatient setting according to the literature (i.e. BMI, ASA classification).

## 5.5 Output

The model delivers the following output:

- Number of patients shifted from an outpatient setting to an inpatient setting (per year).
- Potential mean savings per year of treating patients in an outpatient setting instead of an inpatient setting for each hospital.

## 5.6 Uncertainty

Uncertainty analysis can serve two main purposes: assess confidence in a chosen course of action and ascertain the value of collecting additional information to better inform the decision (Briggs et al., 2012). Briggs describes different types of uncertainty, which are sometimes confused in literature. There is stochastic uncertainty which describes the random variability in outcomes between identical patients. Individuals facing the same probabilities and outcomes will experience the effects of a intervention differently. Increasing the number of patients being simulated will decrease the stochastic uncertainty. Next tot that there is parameter uncertainty which is the uncertainty in the estimation of parameters. Probabilities that govern outcomes are themselves uncertain because they are estimated quantities. By conducting a sensitivity analysis one can see the effect an used independent variable has on the output. The variability between patients that can be attributed to the characteristics of the patient is called heterogeneity. And there is the structural uncertainty, which describes the assumptions inherent in the decision model.

This sector describes the four types of uncertainty and shows the corresponding analyses

### 5.6.1 Stochastic uncertainty and number of simulated patients

In order to deal with the stochastic uncertainty in the savings per patient one can increase the number of simulated patients. The outcome is the mean of the difference in costs between the baseline and the experimental set-up for each patient. For each procedure the stochastic uncertainty should be as low as possible. In simulation studies a significance level of 95% is often used, as this level of significance level may not yield in the best results for this study we will try to increase the significance level while taking into account the computation time. The chosen number of patients is then used for the further analyses. Appendix B shows the calculation for the 95% confidence interval and significance level.

#### 5.6.1.1 Percutaneous Coronary Intervention

Figure 7 shows the mean savings per patient for performing PCI in an outpatient setting and the corresponding confidence interval of 95% for an increasing number of simulated patients. At around 2000 simulated patients the curve becomes relatively stable. Simulating this number of patients corresponds to a significance level of α = 0.051. In order to reduce the significance level as much as possible while accounting for the computing time we will simulate 5000 patients (approximately computation time of 20 minutes) which corresponds to a significance level of α = 0.035. Simulating 5000 patients corresponds with simulating the inflow of patients for the four selected hospitals for 1.93 years.

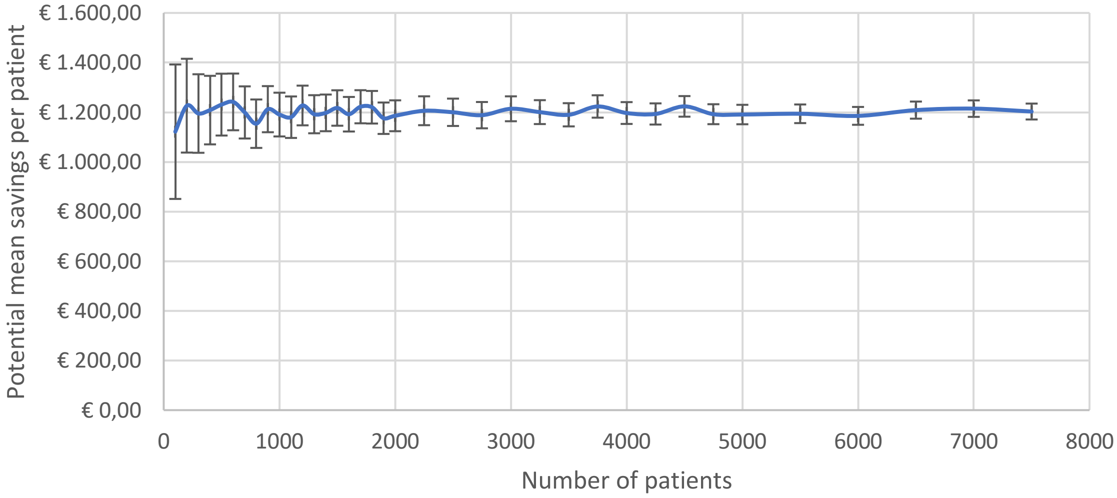


*Figure 7: potential mean savings per patient (95% CI shown with error bars) for PCI procedure versus number of patients*

#### 5.6.1.2 Total Knee Arthroplasty

Figure 8 shows the potential mean savings per patient for performing TKA in an outpatient setting and the corresponding confidence interval of 95% for an increasing number of simulated patients. As one can see at around 1000 patients the curve becomes relatively stable. Simulating this number of patients corresponds to a significance level of α = 0.042. In order to reduce the significance level as much as possible while accounting for the computing time we will simulate 5000 patients which corresponds to a significance level of α = 0.022. Simulating 5000 patients corresponds with simulating the inflow of patients for the four selected hospitals for 4.91 years.

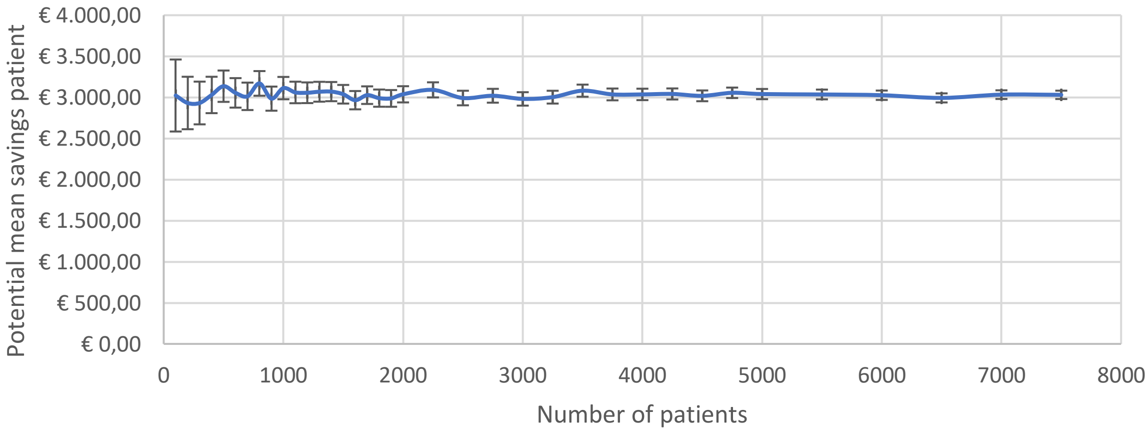


*Figure 8: potential mean savings per patient (95% CI shown with error bars) for TKA procedure versus number of patients*

#### 5.6.1.3 Total Hip Arthroplasty

Figure 9 shows the potential mean savings per patient for performing THA in an outpatient setting and the corresponding confidence interval of 95% for an increasing number of simulated patients. At around 2000 simulated patients the curve becomes relatively stable. Simulating this number of patients corresponds to a significance level of α = 0.031. In order to reduce the significance level as much as possible while accounting for the computing time we will simulate 5000 patients which corresponds to a significance level of α = 0.021. Simulating 5000 patients corresponds with simulating the inflow of patients for the four selected hospitals for 4.28 years.

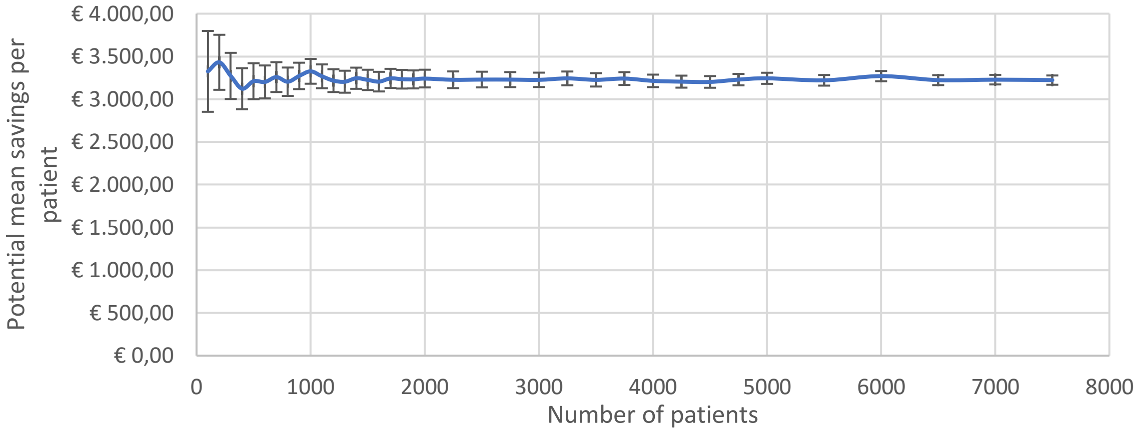


*Figure 9: potential mean savings per patient (95% CI shown with error bars) for THA procedure versus number of patients*

#### 5.6.1.4 Implantation of pacemaker

Figure 10 shows the mean savings per patient for the implantation of a pacemaker in an outpatient setting and the corresponding confidence interval of 95% for an increasing number of simulated patients. Around 3000 simulated patients the curve becomes relatively stable. Simulating this number of patients corresponds to a significance level of α = 0.09. This level of significance is not yet deemed fit for this study we therefore simulate an increasing number of patients till a significance level of α = 0.05 is found. This level is found when we simulate 12,500 patients. Simulating 12,500 patients corresponds with simulating the inflow of patients for the four selected hospitals for 19.81 years.

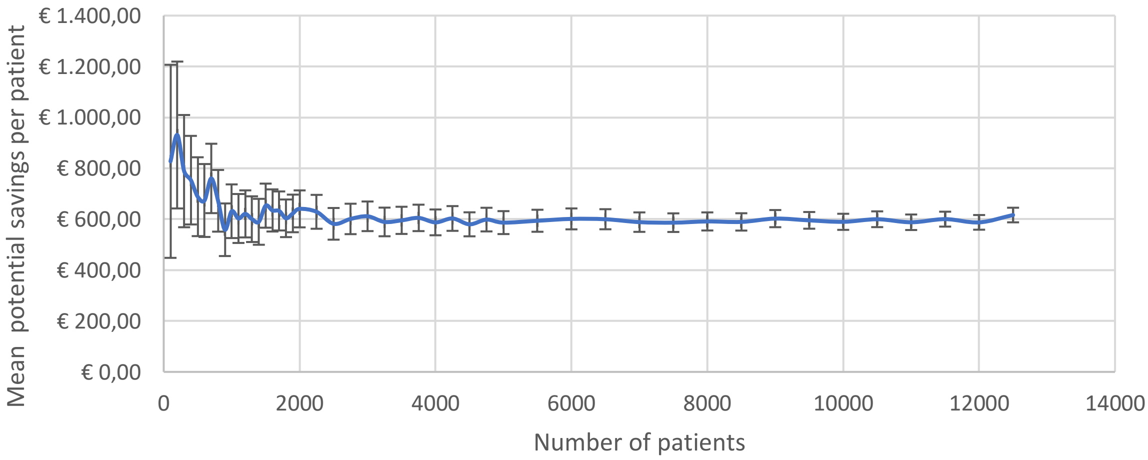


*Figure 10: potential mean savings per patient (95% CI shown with error bars) for pacemaker implantation procedure versus number of patients*

#### 5.6.1.5 Cholecystectomy

Figure 11 shows the mean savings per patient for performing cholecystectomy in an outpatient setting and the corresponding confidence interval of 95% for an increasing number of simulated patients. Around 1500 simulated patients the curve becomes relatively stable. Simulating this number of patients corresponds to a significance level of α = 0.048. We want to improve this level of significance while holding the computation time into account and therefore choose to simulate 5000 patients, which leads to a significance level of α = 0.028. Simulating 5000 patients corresponds with simulating the inflow of patients for the four selected hospitals for 4,54 years.

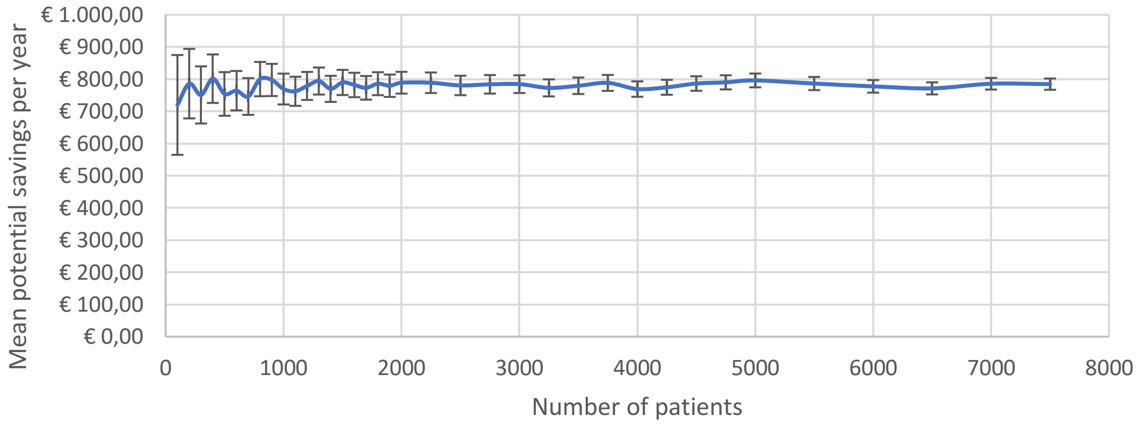


*Figure 11: potential mean savings per patient (95% CI shown with error bars) for cholecystectomy procedure versus number of patients*

### 5.6.2 Parameter uncertainty

According to Briggs et al. (2012) all decision models have parameters that need to be estimated. One method to represent parameter uncertainty is via probabilistic sensitivity analysis (PSA). In PSA multiple sets of parameter values are sampled to vary all parameters simultaneously. Due to the different procedures this study is evaluating and the different scenarios we want to investigate PSA is not performed for each parameter. PSA requires a lot of computation time and is therefore not suitable.

Parameter uncertainty can also be represented via deterministic sensitivity analysis (DSA). To test the sensitivity of the variables used in the simulation DSA varies parameters manually. In DSA parameters values are varied manually to test the sensitivity of the results of the simulation to specific parameters or sets of parameters. This sensitivity analysis is performed for all procedures by the one-factor-at-a-time (OFAT) method. Not all inputs are used in this sensitivity analysis due to the scope of this study. In sector 5.9.1 we describe the used parameters for the different sensitivity analyses performed for each procedure.

### 5.6.3 Heterogeneity

When variability can be explained by patients' characteristics (i.e. age- and sex-specific mortality) it is called heterogeneity (Briggs et al., 2012). It can be relevant to identify different subgroups, but since there is not enough data available to make a proper cost-effectiveness analyses this is not considered in this study.

### 5.6.4 Structural uncertainty

A decision-analytic model is characterised by assumptions reflected in its structure but not formally expressed numerically. All choices regarding this study's methodology involve structural uncertainty. In this study however, the structural uncertainty is not considered.

## 5.7 Verification

During programming the Monte Carlo simulation was constantly debugged in order to verify that the simulation behaves as expected and represents as described. At each new step patient level attributes were traced in order to make sure that the new step did not lead to false behaviour.

## 5.8 Validation

In order to continuously validate this simulation study, the simulation design was often discussed with a data specialist within Menzis. In addition to that the used criteria were discussed with medical specialists working for Menzis to ensure that the criteria can correspond with reality.

## 5.9 Experimental design

This study is conducted in order to provide insight for Menzis in the financial effects of shifting patients from an inpatient setting to an outpatient setting. The literature study in chapter 2 showed that for the five selected procedures conducting the procedure in an outpatient setting is safe and feasible. In sector 5.2 we described the baseline and in sector 4.4 we showed how we match the available literature with the patient characteristics in order to move patients safely from an inpatient to an outpatient setting.

In order to find if uncertainty in input values leads to uncertainty in output values we conduct a sensitivity analysis. For this sensitivity analysis we use the commonly used one-factor-at-a-time (OFAT). Next to that we perform a scenario analysis for all procedures to show how the financial effects will be affected by shifting patients from an inpatient to an outpatient setting stepwise.

### 5.9.1 Sensitivity analysis

Due to the fact that each procedure has different inputs the sensitivity analyses for each procedure will differ. The sensitivity analysis is however conducted in the same way. For each independent variable selected we will use a range of 4 steps to show the sensitivity. This range represents the percentual change of the criteria thresholds used or a percentual change in the probability of having a certain characteristic. Due to the large number of analysis to perform we only analyse 4 steps per variable. Table 11 to 15 show for each procedure the factor which will be varied with the corresponding range and step size.

*Table 11: OFAT sensitivity analysis factors for percutaneous coronary intervention*

| Factor | Range | Step size |
|---|---|---|
| Age criteria | -20% till +20% | 10% |
| Angina Class II or higher | -20% till +20% | 10% |

Patients undergoing a PCI and have a angina class of II or higher are excluded from being in the outpatient group. Therefore we perform a sensitivity analysis for the probability of being in class II or higher.

*Table 12: OFAT sensitivity analysis factors for total hip arthroplasty*

| Factor | Range | Step size |
|---|---|---|
| Age criteria | -20% till +20% | 10% |
| BMI criteria | -20% till +20% | 10% |
| Having 3 or more comorbidities | -20% till +20% | 10% |

*Table 13: OFAT sensitivity analysis factors for total knee arthroplasty*

| Factor | Range | Step size |
|---|---|---|
| Age | -20% till +20% | 10% |
| BMI | -20% till +20% | 10% |
| Having 3 or more comorbidities | -20% till +20% | 10% |

For both the total hip and total knee arthroplasty we assigned possible comorbidities to each simulated patient. In order to not conduct a sensitivity analysis for all these comorbidities we varied the chance of having 3 or more comorbidities. The criteria threshold of having 3 or more comorbidities and thus being excluded from being shifted to the outpatient group remains the same.

*Table 14: OFAT sensitivity analysis factors for implantation of pacemaker*

| Factor | Range | Step size |
|---|---|---|
| Age criteria | -20% till +20% | 10% |
| Pacemaker dependent | -20% till +20% | 10% |

Patients receiving a pacemaker implant and who are pacemaker dependent are not shifted to an outpatient setting in this study. We therefore perform a sensitivity analysis for the probability of being pacemaker dependent as this probability is adopted from literature.

*Table 15: OFAT sensitivity analysis factors for cholecystectomy*

| Factor | Range | Step size |
|---|---|---|
| Age criteria | -20% till +20% | 10% |
| Laparoscopic surgery | -20% till +20% | 10% |
| ASA score I or II | -20% till +20% | 10% |
| Elective | -20% till +20% | 10% |

Both the ASA score criteria and whether the patient undergoes cholecystectomy as an elective patient is a criteria are adopted from literature. We therefore chose to perform a sensitivity analysis for the criteria threshold of having a ASA score I/II or lower and the criteria threshold of being an elective patient. In addition we determined, based on the 2016 and 2017 data available of performed cholecystectomies in the four selected hospitals in the Netherlands, whether these procedures were laparoscopic performed or not. We conducted a sensitivity analysis for the probability of having laparoscopic surgery.

### 5.9.2 Scenario analysis

Menzis wants to use the data containing the care activities for different patients in order to perform analyses which show hospitals how they can reduce costs for different procedures. In order to provide more insight in the effect independent variables and care activities have on the potential savings of hospital for the selected procedures we conduct a scenario analysis. In the experimental set-up we do not shift patients based on the care activities assigned to a patient. In this scenario analysis we use the care activities in addition to the already used independent variables to show for example how the length of stay of a patient can be used to identify a first step a hospital can take to shift patients from an inpatient to an outpatient setting. The scenario analysis also helps determining the effect some care activities have on the potential savings of a hospital. For each procedure multiple scenarios have been simulated. The following paragraphs show for each procedure a table with the care activities used as additional criteria for whether a patient is being shifted to an inpatient setting or not.

**Percutaneous Coronary Intervention**

Table 16 shows the six scenarios of performing a PCI procedure which are analysed in order to show how care activities can help to determine which patients can be shifted first from an inpatient to an outpatient setting.

*Table 16: overview of scenario analysis PCI*

| Indicator | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 |
|---|---|---|---|---|---|---|
| **Length of Stay** | 1 night | 1 or 2 nights | 1 or 2 nights | 1 or 2 nights | 1 or 2 nights | 1, 2 or 3 nights |
| **Acute PCI** | Excluded | Excluded | Excluded | Excluded | Included | Included |
| **Age** | < 65 years | < 80 years | < 80 years | < 80 years | < 80 years | < 80 years |
| **Multiple branch PCI** | Excluded | Excluded | Excluded | Included | Included | Included |

The length of stay is the first factor as this is often pre-determined. The length of stay is commonly only extended when complications occur. The data available does not show whether complications have occurred and therefore does not show the complete picture. However patients with a short length of stay often are in good health and therefore the length of stay is used as an indicator. The next indicator is whether the patient undergoing a PCI procedure was an acute patient, an acute PCI can be an indicator for a more complex surgery. Therefore, in the first scenarios patients undergoing an acute PCI are not shifted to an outpatient setting. The age of patients is the next indicator being used. Younger patients are more suitable for undergoing PCI in an outpatient setting as they are often better in shape. 80 years is the age criteria being used by the found literature. The last indicator being used is whether patients received a multiple branch PCI. A multiple branch PCI is a more complicated surgery and therefore can be an indicator for performing the PCI procedure in an inpatient setting.

**Total Knee Arthroplasty**

The different scenarios as analysed for the TKA procedure are shown in table 17. Next to the length of stay and the age of patients we performed scenarios based on the anaesthesia type the patient received during surgery. It is common that patients undergoing TKA under general anaesthesia stay at least for one night at the hospital. We therefore analysed some scenarios in which these patients were not shifted to an outpatient setting. Patients undergoing TKA under epidural anaesthesia are always taken into account.

*Table 17: overview of scenario analysis TKA*

| Indicator | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 |
|---|---|---|---|---|---|---|
| **Length of Stay** | 1 night | 1 or 2 nights | 1, 2 or 3 nights | 1 night | 1 or 2 nights | 1, 2 or 3 nights |
| **Age** | < 65 years | < 65 years | < 65 years | < 80 years | < 80 years | < 80 years |
| **Epidural anaesthesia** | Included | Included | Included | Included | Included | Included |
| **General anaesthesia** | Excluded | Excluded | Included | Included | Included | Excluded |

**Total Hip Arthroplasty**

For the THA procedure we used the same scenarios as described at the TKA procedure. The scenarios analysed for the THA are shown in table 18.

*Table 18: overview of scenario analysis THA*

| Indicator | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 |
|---|---|---|---|---|---|---|
| **Length of Stay** | 1 night | 1 or 2 nights | 1, 2 or 3 nights | 1 night | 1 or 2 nights | 1, 2 or 3 nights |
| **Age** | < 65 years | < 65 years | < 65 years | < 80 years | < 80 years | < 80 years |
| **Epidural anaesthesia** | Included | Included | Included | Included | Included | Included |
| **General anaesthesia** | Excluded | Excluded | Excluded | Included | Included | Excluded |

**Implantation of pacemaker**

*Table 19: overview of scenario analysis pacemaker*

| Indicator | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 |
|---|---|---|---|---|---|
| **Length of Stay** | 1 night | 1 or 2 nights | 1, 2 or 3 nights | 1 night | 1 or 2 nights |
| **Age** | < 80 years | < 80 years | < 80 years | < 80 years | < 80 years |
| **Emergency A&E** | Excluded | Excluded | Excluded | Included | Included |

As patients who are receiving a pacemaker are often quite old we did not alter the age inclusion criteria being used in the found literature. We did however vary the length of stay indicator and whether the patients had emergency contact on the first aid department. Having emergency contact on the first aid department automatically means that it is not an elective surgery. It therefore may be an indicator to exclude the patient from undergoing surgery in an outpatient setting. Table 19 shows the scenarios analysed for the implantation of a pacemaker.

**Cholecystectomy**

Most cholecystectomy procedures are indicated based on ultrasound diagnostics. When a patients undergoes a CT scan this can be an indication for the severity of the gallbladder problems. We therefore used, next to the length of stay and age of patients, the CT of the abdomen as an indicator. Table 20 shows the scenarios analysed for the cholecystectomy procedure.

*Table 20: overview of scenario analysis cholecystectomy*

| Indicator | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 |
|---|---|---|---|---|---|---|
| **Length of Stay** | 1 night | 1 or 2 nights | 1, 2 or 3 nights | 1 night | 1 or 2 nights | 1, 2 or 3 nights |
| **Age** | < 70 years | < 70 years | < 70 years | < 80 years | < 80 years | < 80 years |
| **CT abdomen** | Excluded | Excluded | Included | Excluded | Excluded | Included |

## 5.10 Conclusion

In this chapter we constructed a Monte Carlo simulation based on the study design described in chapter 5. The simulation assigns, based on probabilities or distributions, different attributes for each simulated patient. The simulation shows the potential mean saving per year for each selected hospital. These attributes comprehend patient characteristics, but also care activities. We discussed multiple sensitivity analyses to show how changing the criteria for independent variables will affect the results. We also described different scenarios for each procedure to show how care activities can affect the results of the experimental set-up.

# 6 Results

This chapter shows the results that were obtained by performing the analysis described in chapter 5. We first describe the sensitivity analysis for all procedures in sector 6.1 Then, in sector 6.2, we show the results of the different scenario simulated.

## 6.1 Results of the Sensitivity Analyses

The shown figures in this sector show the relationship between a change in the number of patients being shifted to an outpatient setting when the criteria for this shift are changed, and the savings for each hospital simulated. These analyses are performed in order to show how the potential mean savings of a hospital change when the criteria for shifting a patient to an inpatient setting are changed. The savings of using the experimental set-up instead of the baseline is calculated for each patient. The total savings is subsequently calculated based on the number of patients simulated for each hospital. The figures also show the 95% confidence interval of the total savings for each hospital. In addition to that the figures show the number of patients shifted from an inpatient setting to an outpatient setting for each hospital.

### 6.1.1 Percutaneous Coronary Intervention

#### *6.1.1.1 Age of patients*

Figure 12 shows the relationship between a change in the age criteria and the potential mean savings per year for all hospitals when using the experimental set-up instead of the baseline. The 95% confidence interval is given by the black error bars.

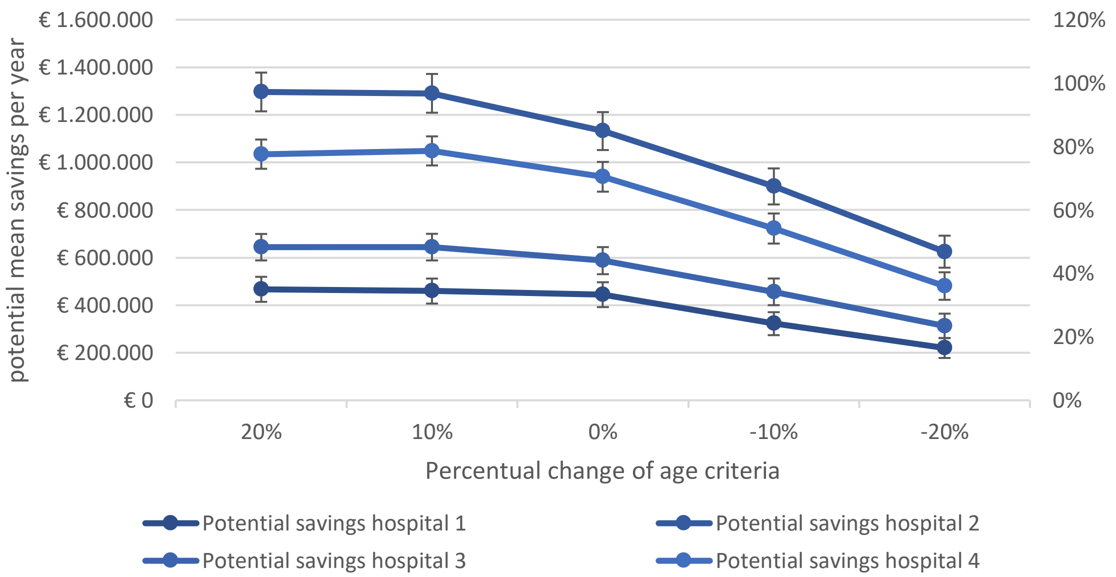


*Figure 12: sensitivity analysis age of patients PCI procedure*

We see that a decrease in the age criteria does lead to less savings. An increase in the age criteria does lead to a bit more savings as more patients meet the criteria and are therefore being shifted. Both a decrease as an increase do affect the total savings for each hospital. The increase in the age criteria does however has less effect because apparently almost all simulated patients which can be shifted to an inpatient setting are already shifted in the experimental simulation. An decrease in the age criteria does however affect the mean difference in costs greatly due to the declining number of patients that can be shifted.

### 6.1.2 Angina pectoris class of patients

In this analysis we excluded patients with a angina pectoris class of III or IV. Figure 13 shows the results of the sensitivity analysis of changing the probability that the patient is excluded based on their angina pectoris class.

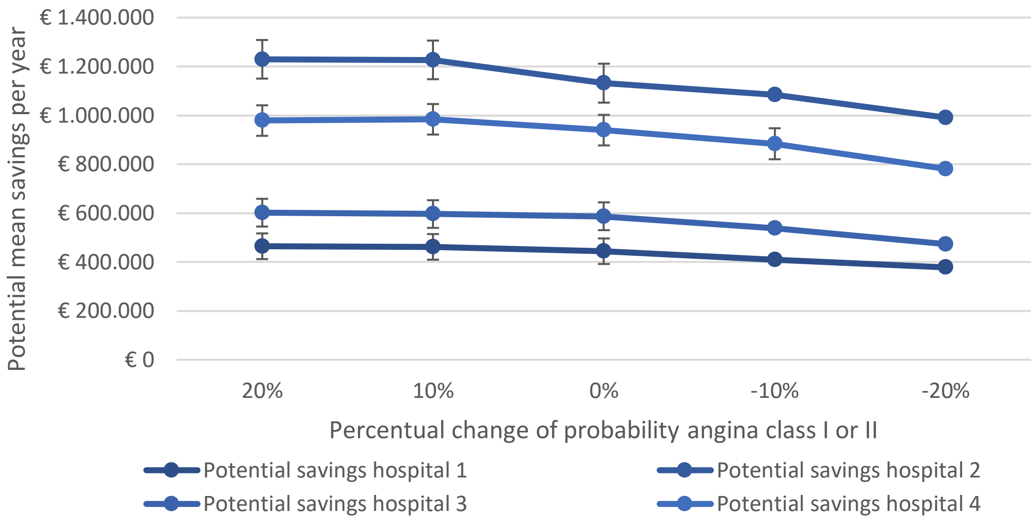


*Figure 13: sensitivity analysis angina pectoris classes PCI procedure*

Figure 13 shows us that increasing the probability that a simulated patient has angina pectoris class I or II and therefore is sent home the same day as surgery leads to more potential savings.

### 6.1.3 Total Knee Arthroplasty

#### *6.1.3.1 Age of patients*

Figure 14 shows the relationship between a change in the age criteria for the simulated patients and the potential mean savings per year of using the experimental set-up instead of the baseline. The 95% confidence interval is given by the black error bars.

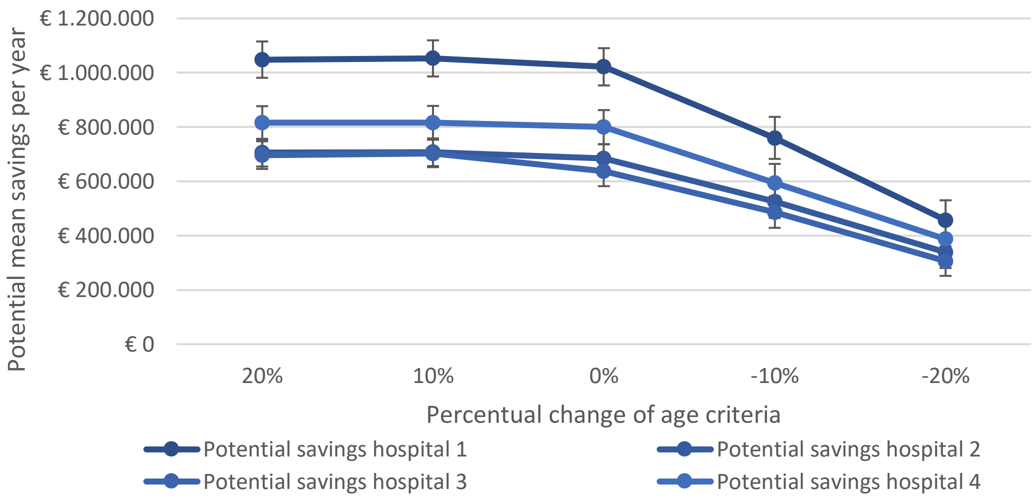


*Figure 14: sensitivity analysis for the TKA procedure of the age parameter*

We see that an increase in the criteria for the age of the patients does not lead to more potential savings. A decrease in the age criteria for patients does however lead to less savings. The increase in the age criteria does not affect the total savings of using the experimental set-up because apparently almost all simulated patients which can be shifted to an outpatient setting are already shifted in the experimental simulation. A decrease in the age criteria does however affect the total savings due to the declining number of patients that can be shifted. Less patients are therefore shifted from an inpatient setting to an outpatient setting.

#### *6.1.3.2 BMI of patients*

Figure 15 shows the relationship between a change in the BMI criteria for the simulated patients and total savings of using the experimental set-up instead of the baseline. The 95% confidence interval is given by the black error bars.

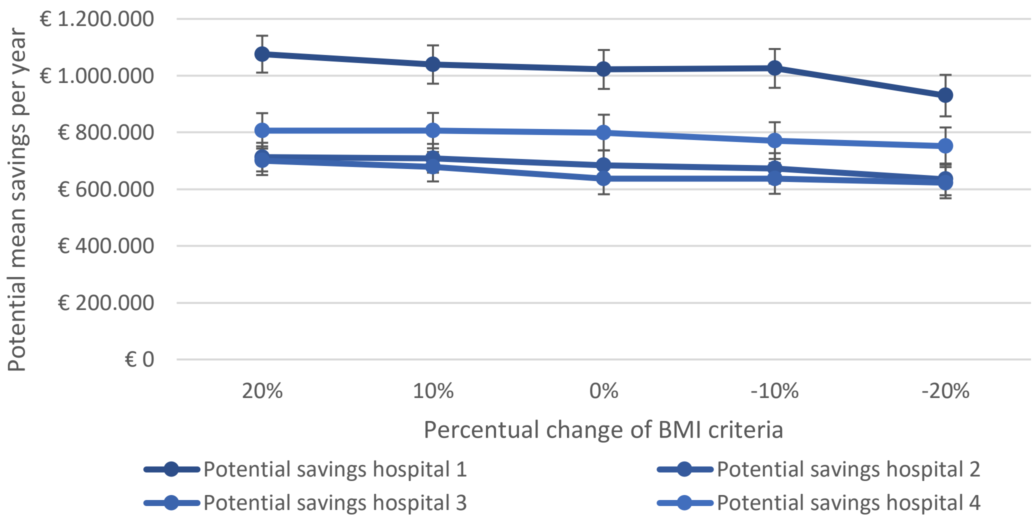


*Figure 15: sensitivity analysis for the TKA procedure of the BMI parameter*

The figure above shows a slight decrease in the potential mean savings per year for all hospitals when we decrease the BMI criteria.. This is due to the fact that a lower BMI criteria does lead to a decreased change of a patients being shifted to an outpatient setting in the experimental simulation.

#### *6.1.3.3 Comorbidities of patients*

Figure 16 shows the relationship between a chance of simulated patients having three or more comorbidities and the potential mean savings per year of using the experimental set-up instead of the baseline. The 95% confidence interval is given by the black error bars.

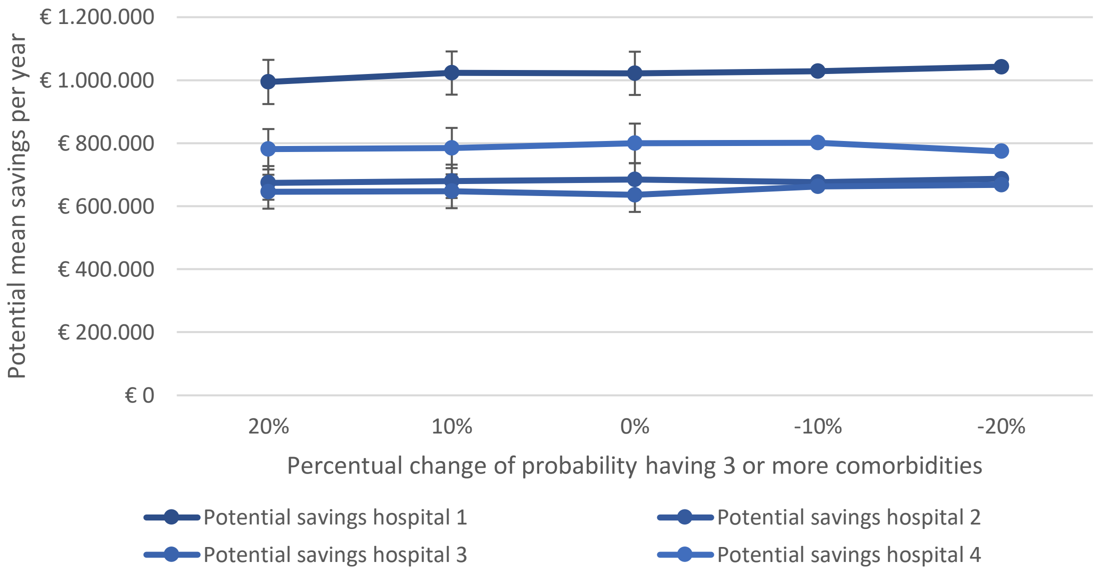


*Figure 16: sensitivity analysis for the TKA procedure of the number of comorbidities parameter*

There is no trend visible in the relationship between a decrease or increase in the chance of having three or more comorbidities and the total savings of shifting patients from an inpatient to an outpatient setting. Apparently the number of comorbidities is not a restricting factor for the experimental set-up

### 6.1.4 Total Hip Arthroplasty

#### *6.1.4.1 Age of patients*

Figure 17 shows the relationship between a change in the age criteria for the simulated and the potential mean savings per year using the experimental set-up instead of the baseline. The 95% confidence interval is given by the black error bars.

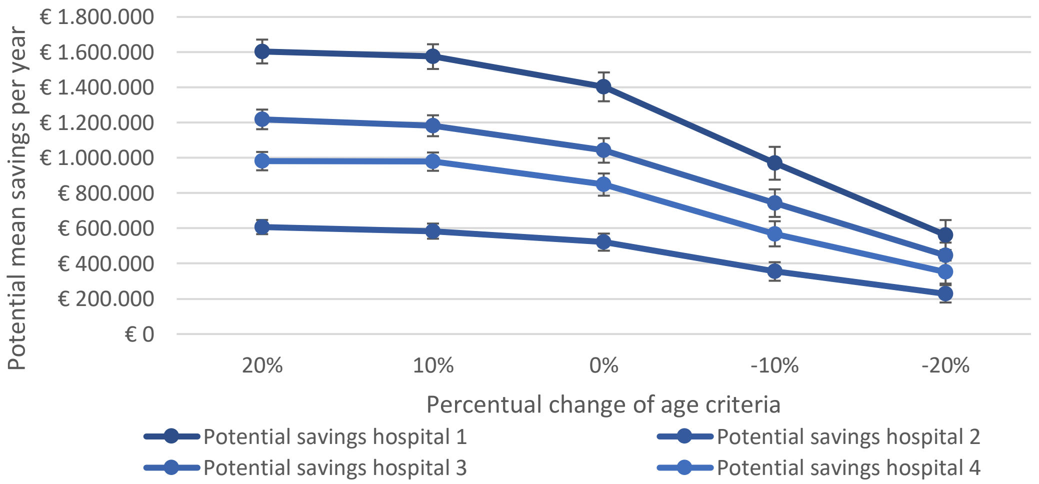


*Figure 17: sensitivity analysis for the THA procedure of the age parameter*

We see that an increase in the age criteria does lead to more savings. A decrease in the age criteria does lead to less savings. Both a decrease as an increase do affect the total savings for each hospital. The increase the age criteria does however has less effect because apparently almost all simulated patients which can be shifted to an outpatient setting are already shifted in the experimental simulation. A decrease in the age criteria does affect the mean difference in costs due to the declining number of patients that can be shifted.

#### *6.1.4.2 BMI of patients*

Figure 18 shows the relationship between a change in the BMI criteria and the potential mean savings each year of using the experimental set-up instead of the baseline. The 95% confidence interval is given by the black error bars.

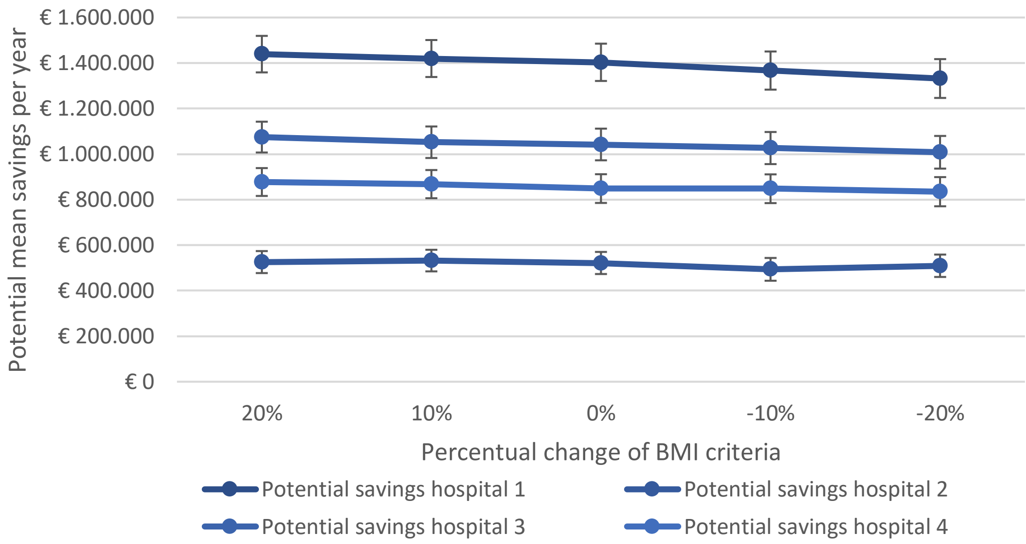


*Figure 18: sensitivity analysis for the THA procedure of the BMI parameter*

Figure 18 above shows an increase in in the potential mean savings per year when more patients are shifted from an inpatient to an outpatient setting for all hospitals due to an increased BMI criteria.

#### *6.1.4.3 Comorbidities of patients*

Figure 19 shows the relationship between a change of simulated patients having three or more comorbidities and the potential mean savings per year of using the experimental setup. The 95% confidence interval is given by the black error bars.

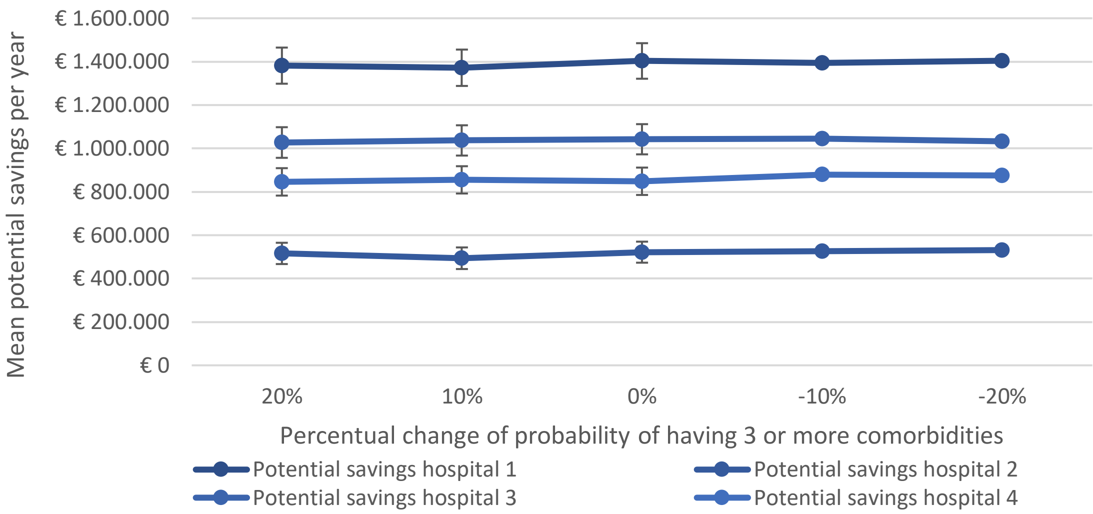


*Figure 19: sensitivity analysis for the THA procedure of the number of comorbidities parameter*

There is no trend visible in the relationship between a decrease or increase in the chance of having three or more comorbidities and the total savings of using the experimental set-up instead of the baseline. Apparently the number of comorbidities is not a restricting factor for the experimental set-up.

### 6.1.5 Implantation of pacemaker

#### *6.1.5.1 Age of patients*

Figure 20 shows the relationship between a change in the age criteria and the potential mean savings per year using the experimental set-up instead of the baseline. The 95% confidence interval is given by the black error bars.

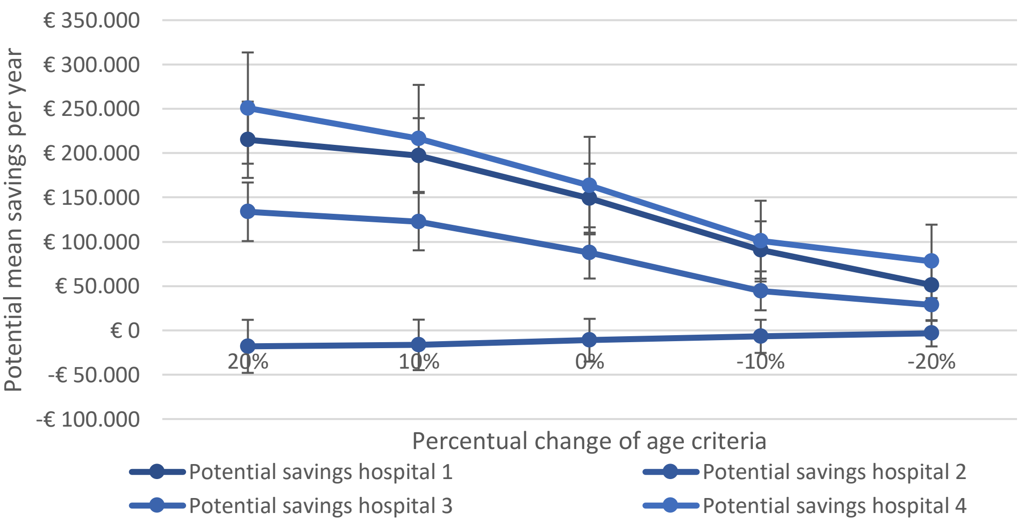


*Figure 20: sensitivity analysis for the implantation of a pacemaker procedure of age parameter*

Figure 20 shows that an increase in the age criteria does lead to more savings and a decrease leads to less savings for all hospitals expect hospital 2. Both a decrease as an increase do affect the total savings for each hospital. Hospital 2 yields negative results as the agreed price between Menzis and hospital 2 for the implantation of a pacemaker in an outpatient setting is higher than performing the same procedure in an inpatient setting.

#### 6.1.5.2 *Pacemaker dependency*

In this study we do not shift patients to an outpatient setting who are dependent of a pacemaker. Changing the probability as found in literature of being pacemaker dependent should lead to different savings. Figure 21 shows the result of the sensitivity analysis of patients being pacemaker dependent. The 95% confidence interval is given by the black error bars.

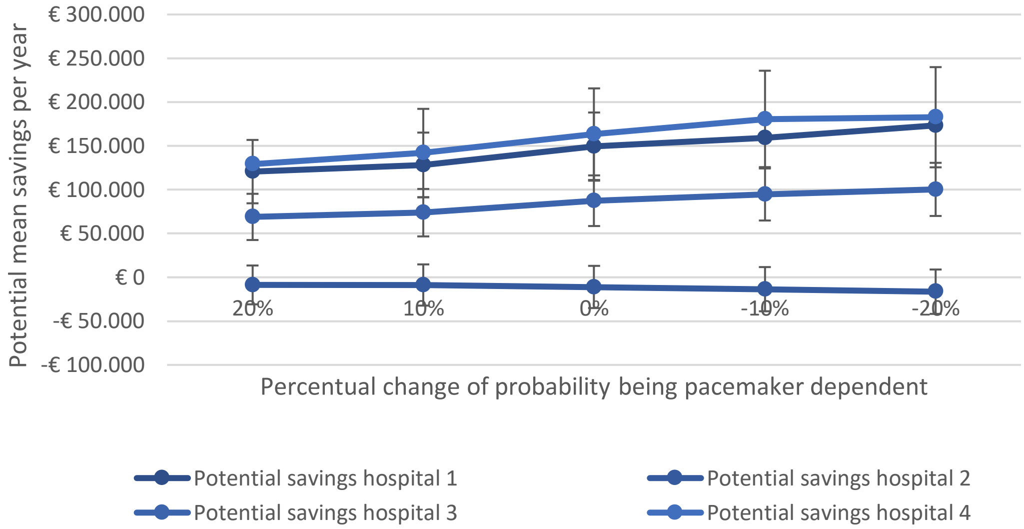


*Figure 21: sensitivity analysis for the implantation of a pacemaker procedure of pacemaker dependency parameter*

For hospitals 1, 2 and 3 we see in figure 21 that an increase in pacemaker dependency of patients leads to less savings. This corresponds with the expectations as less patients are shifted from an inpatient to an outpatient setting this leads to less savings.

### 6.1.6 Cholecystectomy

#### 6.1.6.1 *Age of patients*

Figure 22 shows the relationship between a change in the age criteria and the potential mean savings per year using the experimental set-up instead of the baseline for the cholecystectomy procedure. The 95% confidence interval is given by the black error bars.

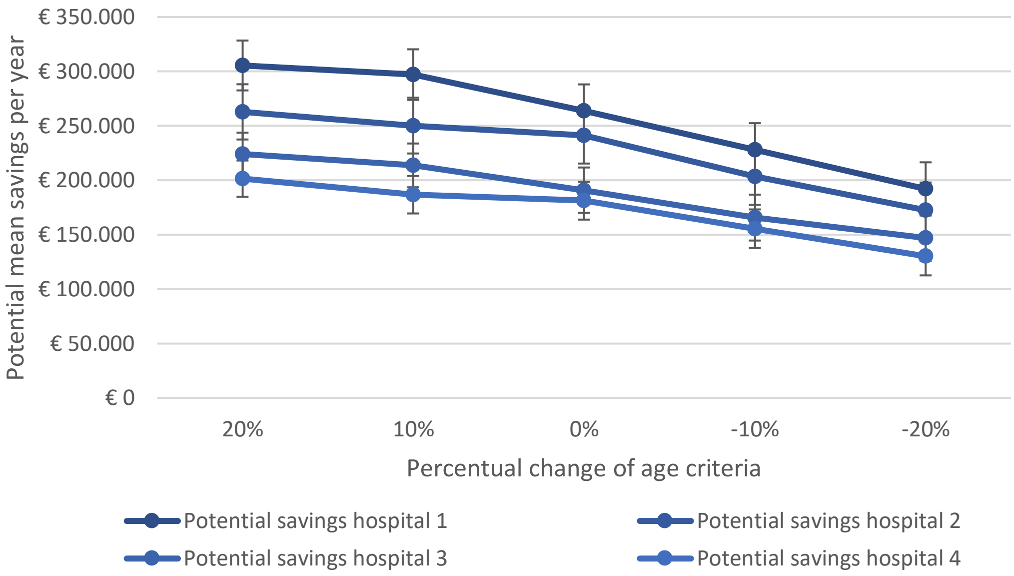


*Figure 22: sensitivity analysis for the cholecystectomy procedure of age parameter*

As in the other procedures we see that the results of the sensitivity analysis show that an increase in the age criteria does lead to more savings and a decrease leads to less savings for all hospitals. Both a decrease as an increase do affect the total savings for each hospital.

### 6.1.6.2 Laparoscopic surgery

In this study we determined the chance of having laparoscopic surgery on the historical data of 2016 and 2017 available at Menzis. When a patient does not receive the laparoscopic cholecystectomy the patient is not shifted to an outpatient setting. Therefore a change in the percentage of patients undergoing the laparoscopic should affect the total savings for each hospital. Figure 23 shows the relationship between this percentual change of patients undergoing laparoscopic surgery and the potential mean savings per year. The 95% confidence interval is given by the black error bars.

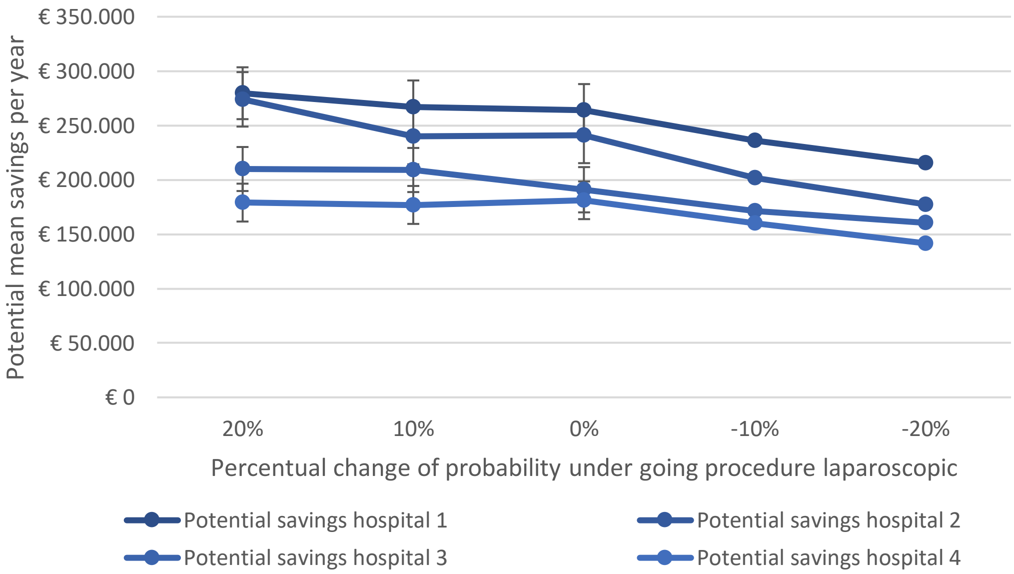


*Figure 23: sensitivity analysis for the cholecystectomy procedure of laparoscopic surgery parameter*

Figure 23 shows us that increasing the chance of patients having surgery laparoscopic leads to more savings for all hospitals.

#### 6.1.6.3 Elective surgery

Literature showed that having elective surgery or not is a criteria for being shifted to an outpatient setting. For the elective surgery we used a percentage found in literature (see sector 4.4.3.5). Increasing this percentage by conducting a sensitivity analysis leads to more savings for all hospitals as more patients will be shifted to an outpatient setting in the experimental set-up. A decrease leads to less savings as figure 24 shows.

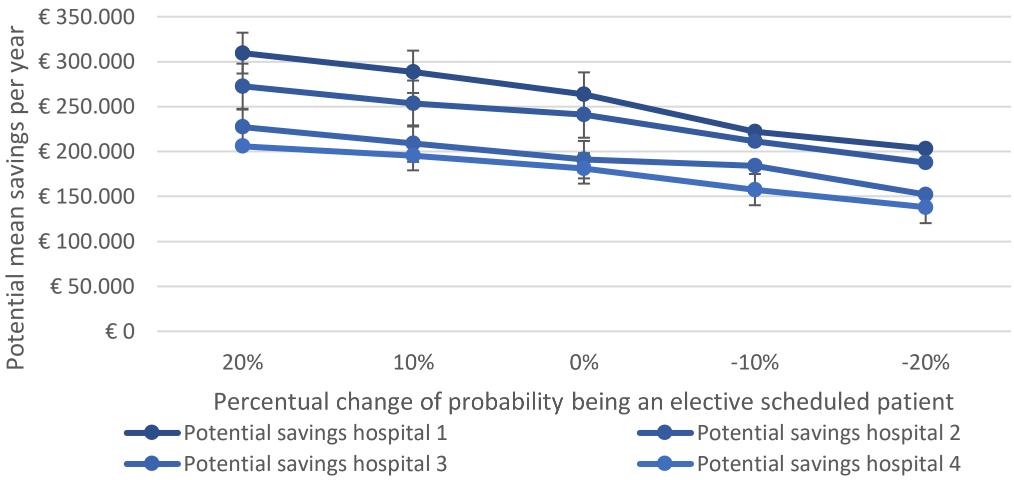


*Figure 24: sensitivity analysis for the cholecystectomy procedure of elective surgery parameter*

#### 6.1.6.4 ASA score of patients

For the ASA score of patients we also used probabilities found in literature (see sector 4.4.3.5). Figure 25 shows the relationship between a change in the probability of having an ASA score of I or II (and thus being shifted to an outpatient setting) and the potential mean savings per year when using the experimental set-up. Increasing the number of patients having a ASA score of I and II leads as expected to an increase in the total savings because more patients will be shifted to an outpatient setting in the experimental set-up.

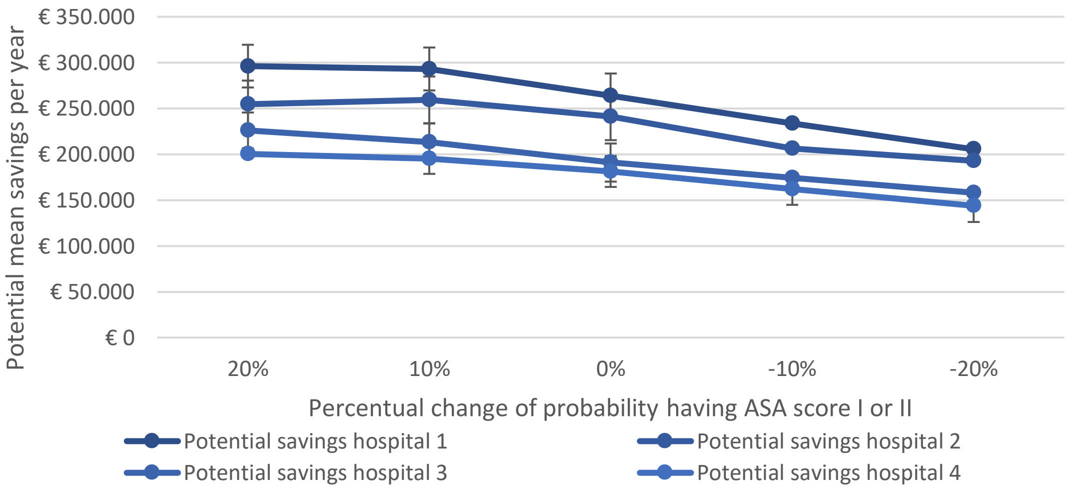


*Figure 25: sensitivity analysis for the cholecystectomy procedure of ASA score parameter*

## 6.2 Results of the Scenario Analyses

The following sectors show the results of the scenario analyses as described in sector 5.9.2. We show the percentage of patients that potentially can be shifted for each scenario and compare this with the criteria used for shifting patients to an outpatient setting used in the experimental set-up. In addition to that this sector shows the corresponding potential mean savings per year for each scenario. In this sector we will elaborate on the most striking differences between scenarios and/or the experimental set-up.

### 6.2.1 Percutaneous Coronary Intervention

Figure 26 and 27 show the results of the performed scenario analyses for the TKA procedure. The black error bars in figure 27 show the 95% CI. Scenario 1 till 4 for do not show a very large saving as these scenarios are very cautious. Scenario 4 excludes the patients undergoing an acute PCI procedure, scenario 5 differs by shifting these patients to an outpatient setting. This yields in a large additional potential savings per year and comes close to the savings achieved in the original experimental set-up.

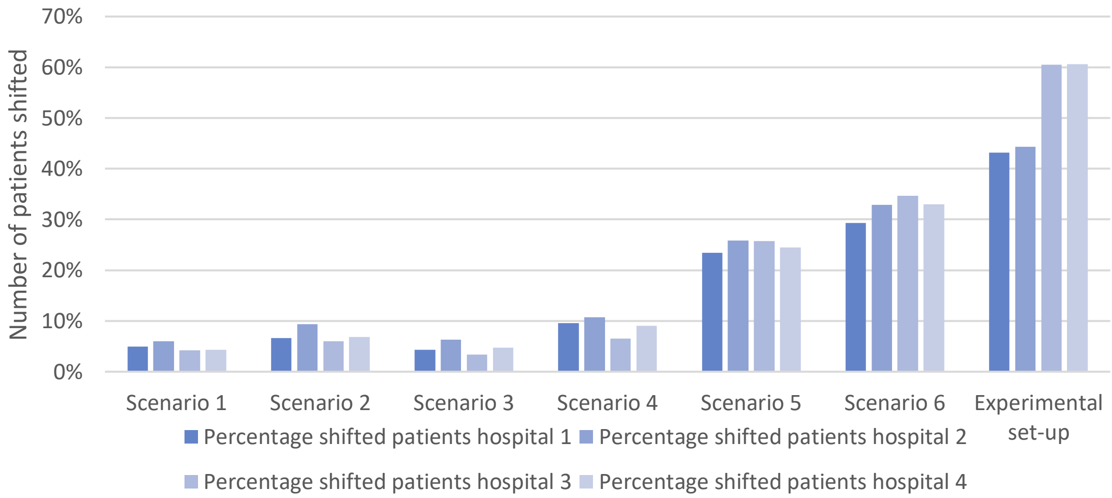


*Figure 26: percentage of patients moved from inpatient to outpatient setting for different scenarios for PCI procedure*

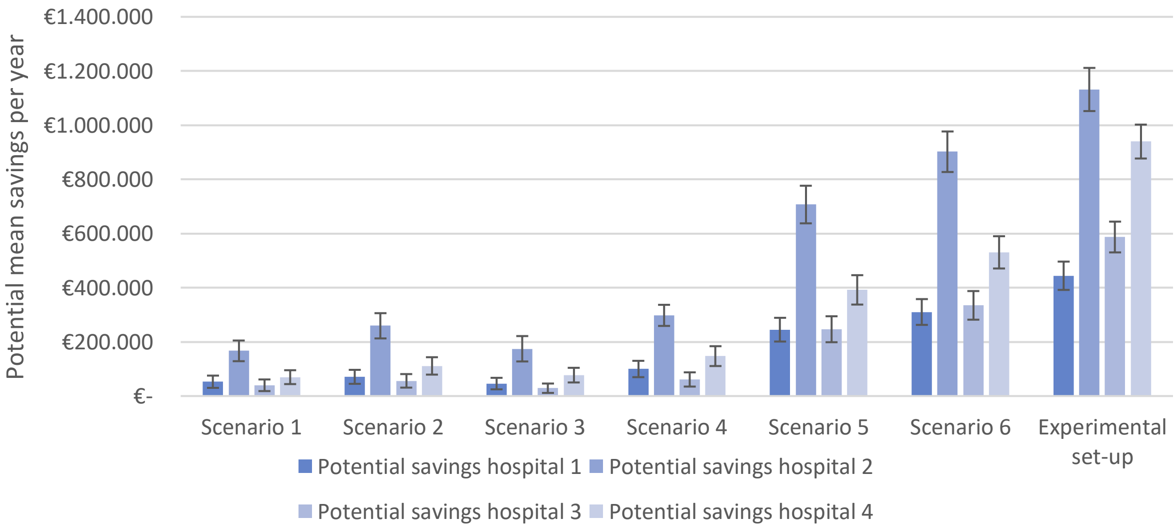


*Figure 27: potential mean savings per year per hospital for different scenarios for PCI procedure with 95% CI*

### 6.2.2 Total Knee Arthroplasty

Figure 28 and 29 show the results of the performed scenario analyses for the TKA procedure. The black error bars in figure 29 show the 95% confidence interval. The most striking is the absence of savings for hospital 3 and 4 in scenario 1, 2, 4 and 5. In these scenarios we do not shift patients to an outpatient setting who undergo the procedure under general anaesthesia, which is the preferred anaesthesia method for hospital 3 and 4 as they rarely conduct TKA surgeries with patients under epidural anaesthesia. Shifting patients with a longer LOS to an outpatient setting does not seem to affect the results greatly as scenario 1 versus 2 show (LOS ≤ 1 vs LOS ≤ 2).

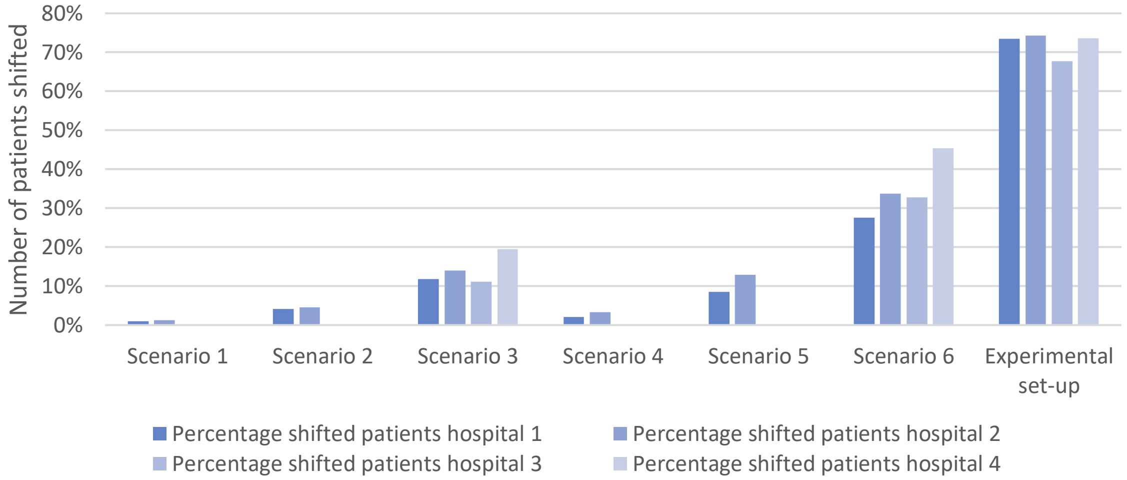


*Figure 28: percentage of patients moved from inpatient to outpatient setting for different scenarios for TKA procedure*

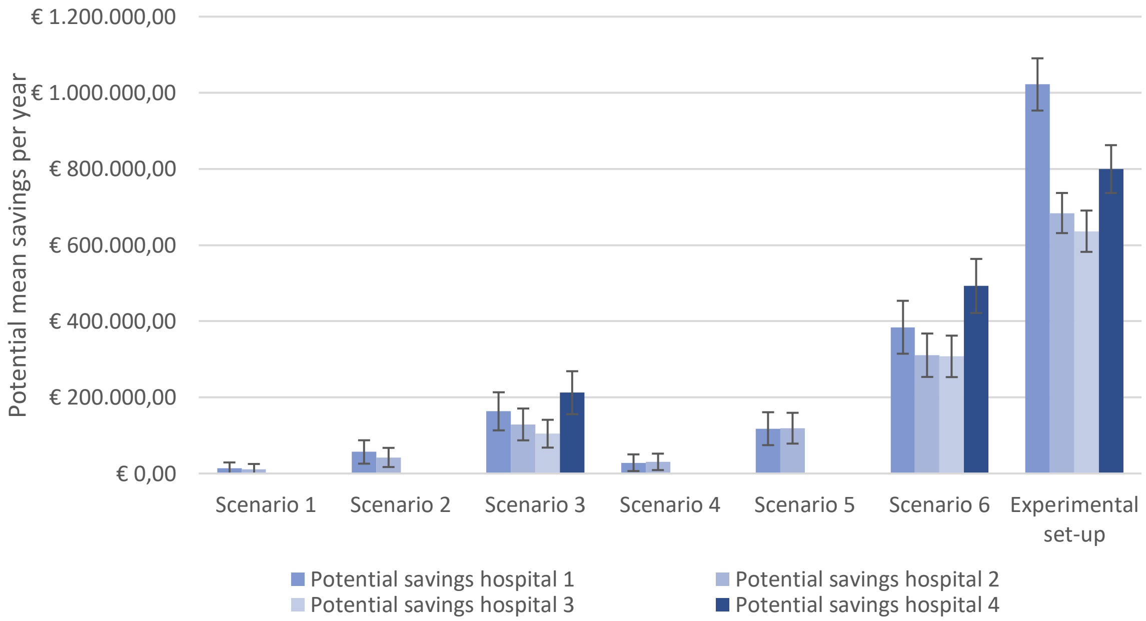


*Figure 29: potential mean savings per year per hospital for different scenarios for the TKA procedure with 95% CI*

### 6.2.3 Total Hip Arthroplasty

Figure 30 and 31 show the results of the performed scenario analyses for the THA procedure. The 95% CI of the potential mean savings per year is given by the black error bars shown in figure 31 Scenario 6 gives a great additional saving in comparison with scenario 5. In scenario 6, in addition to scenario 5, patients undergoing the surgery under general anaesthesia are shifted to an outpatient setting. Shifting patients with a longer LOS to an outpatient setting, which is varied in scenario 1, 2 and 3 does not seem to yield in great additional savings.

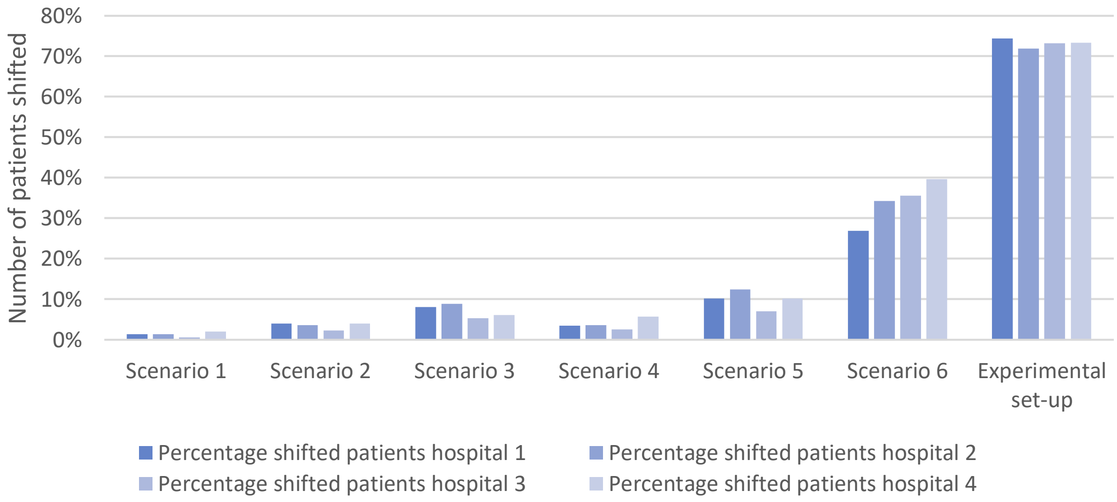


*Figure 30: percentage of patients moved from inpatient to outpatient setting for different scenarios for THA procedure*

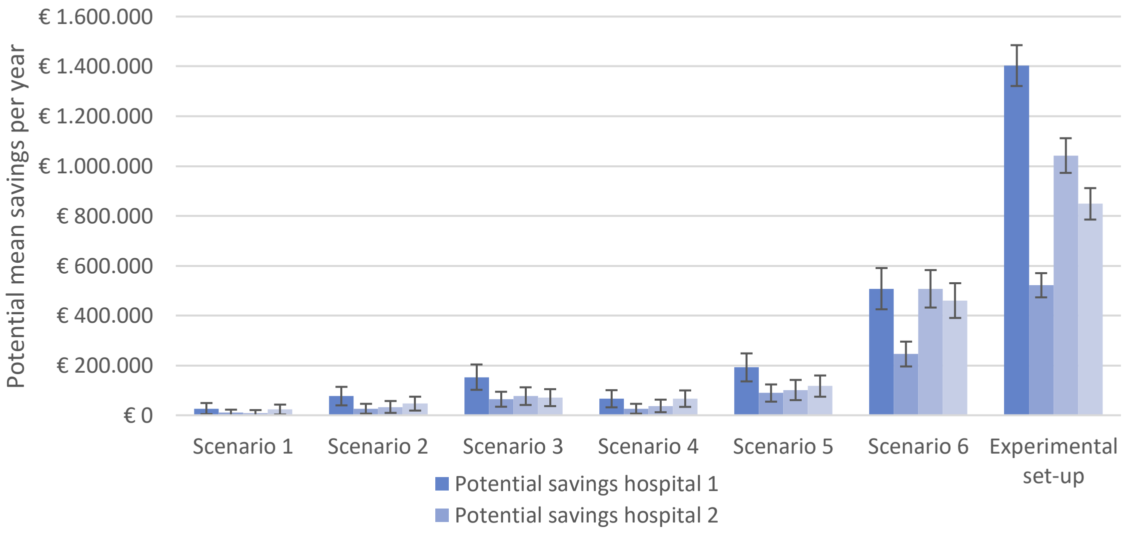


*Figure 31: potential mean savings per year per hospital for different scenarios for the THA procedure with 95% CI*

### 6.2.4 Implantation of pacemaker

Figure 32 and 33 show the results of the performed scenario analyses for the implantation of a pacemaker. Figure 33 also shows the 95% CI of the potential mean saving per year. We see the large confidence intervals of the potential mean savings per year for all scenarios and hospitals. This is probably due to the combination of a small amount of shifted patients from an inpatient to an outpatient setting and the fact that there are many different DBCs with various prices that are included in this analysis. Hospital 2 does not show any savings although patients are shifted. This is due the fact that Menzis has agreed on a higher price for one of the outpatient DBC than the corresponding inpatient DBC with hospital 2.

We notice that shifting patients to an outpatient setting who have had emergency contact on the first aid (scenario 1 vs 4, 2 vs 5, 3 vs 6) does yield in additional savings as more patients are being shifted. Moving patients with a longer LOS to an outpatient setting also shows its effects, as scenario 3 shows significantly more shifted patients than scenario 1 (LOS ≤ 3 vs LOS ≤ 1).

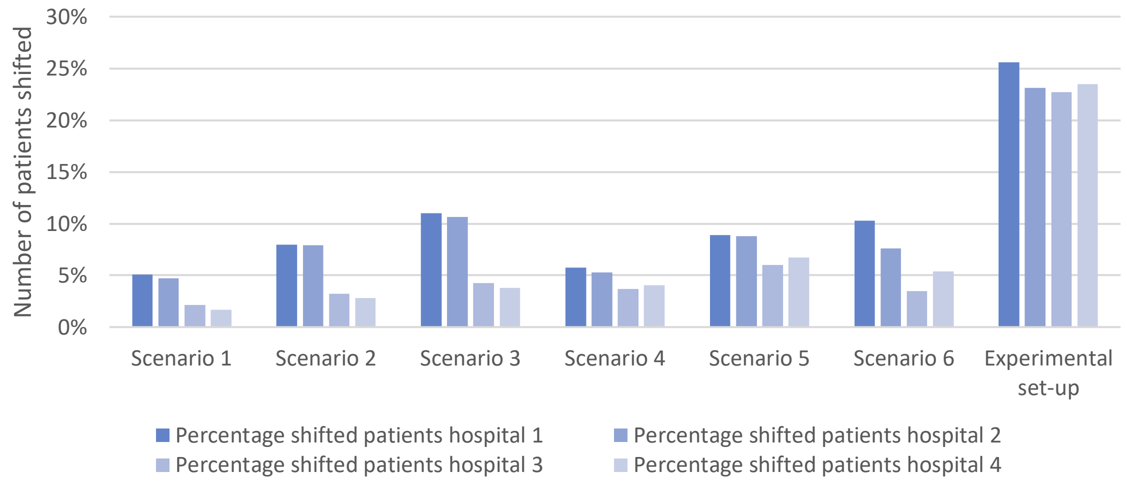


*Figure 32: percentage of patients moved from inpatient to outpatient setting for different scenarios for implantation of pacemaker procedure*

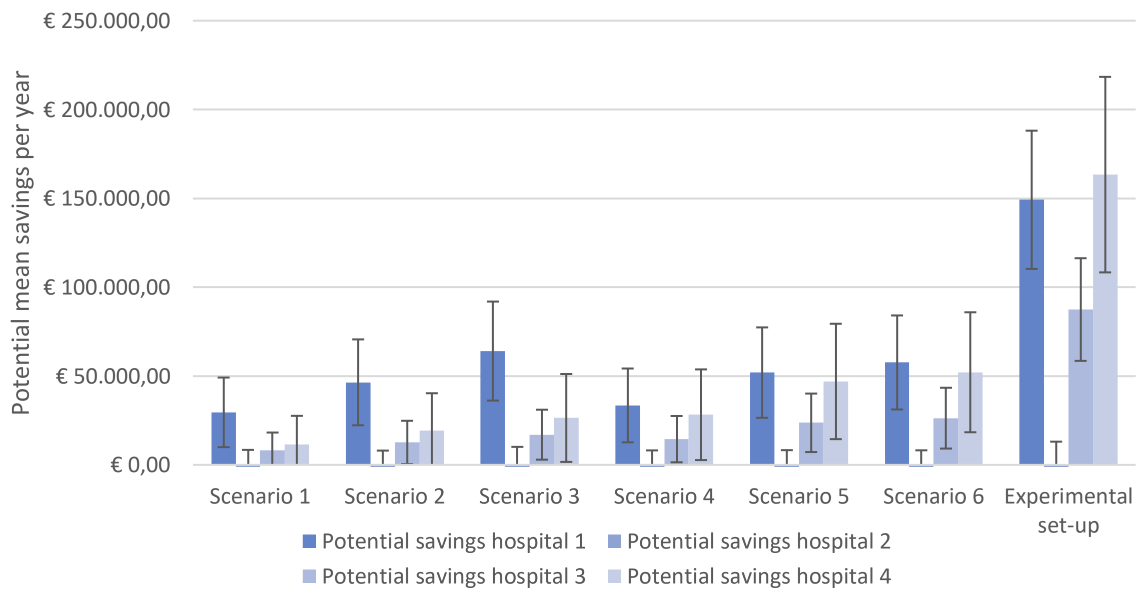


*Figure 33: potential mean savings per year per hospital for different scenarios for the implantation of pacemaker procedure with 95% CI*

### 6.2.5 Cholecystectomy

Figure 34 and 35 show the results of the performed scenario analyses for the TKA procedure. The 95% CI interval for the potential mean savings per year is shown by the black error bars in figure 35

Only scenario 1 does not yield in a big mean savings per year. Scenario 1 only shifts patients to an outpatient setting with  a LOS of 1 night, all other scenarios also shifted patients to an outpatient setting with a LOS of 2 or 3 nights. Moving more patients to an outpatient setting based on their age (70 years old in scenario 2 and 3 versus 80 years old in scenario 4, 5 and 6) and whether these patients have had a CT of the abdomen does yield in slightly larger savings.

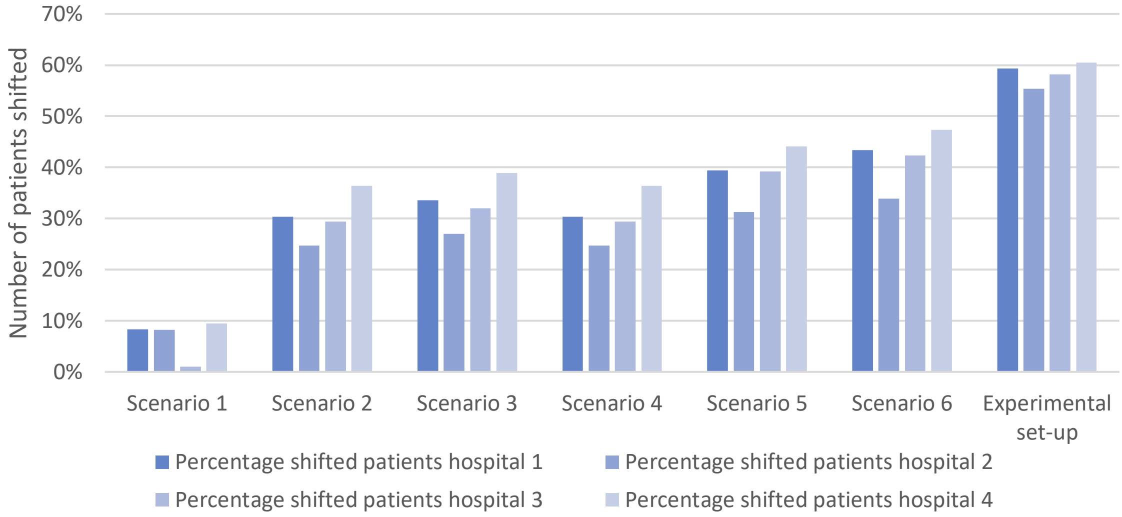


*Figure 34: percentage of patients moved from inpatient to outpatient setting for different scenarios for cholecystectomy procedure*

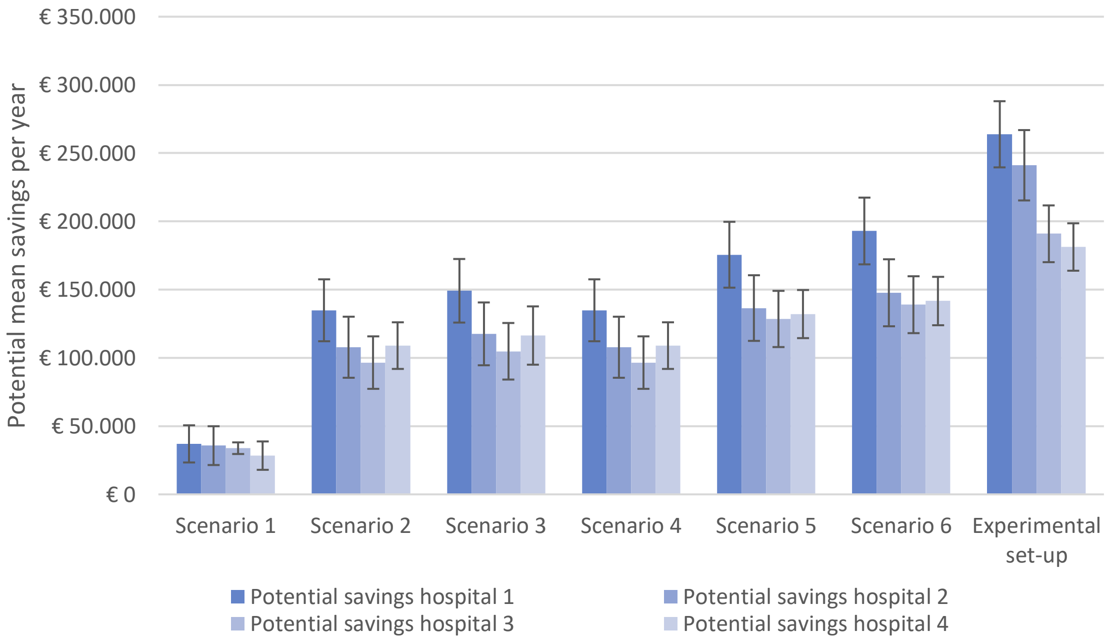


*Figure 35: potential mean savings per year per hospital for different scenarios for the cholecystectomy procedure with 95% CI*

## 6.3 Conclusion

In this chapter, the results of the OFAT method and the scenario analyse were given for each procedure. We will discuss the results per procedure

The sensitivity analysis of the PCI procedure showed that the changes in the criteria for the age of patients greatly affects the potentials savings. Whether a patients has a PCI class of II or lower does affect the results less. The scenario analysis showed that especially the acute PCI procedure does affect the shift in patients from an inpatient to an outpatient setting, the LOS of patients has far less effect.

Both the TKA as the THA procedure showed the greatest sensitivity for a shift in the age criteria of the patients. The number of comorbidities barely affect the results, apparently the number of comorbidities rarely exceeds three. For both procedures the scenario analysis showed that performing surgery with the anaesthesia method has a great impact on the potential savings. Not shifting patients which are undergoing the procedure under general anaesthesia to an outpatient setting leads to significant less savings.

The implantation of a pacemaker does not show for all hospitals the same trends as hospital 2 returns negative savings (thus additional costs). This is due to the fact that Menzis has agreed on a higher price for one of the outpatient DBC than the corresponding inpatient DBC. For the other hospitals we see that both the age criteria as patients being pacemaker dependent affects the results. We also note that the confidence interval for all results of the implantation of a pacemaker is quite large, this is due to the small amount of patients being shifted and the number of possible DBC codes.

The sensitivity analysis of the cholecystectomy procedure show that all independent variables affect the costs. The scenario analysis especially shows that shifting patients to an outpatient setting with a LOS of 1 barely yields in any savings. Currently most patients are staying 2 nights or longer. Shifting older patients to an outpatient setting and/or shifting patients undergoing a CT does not seem to affect the results greatly.

# 7 Discussion

In this study we investigated the financial effects of shifting patients from an inpatient setting to an outpatient setting for four different hospitals. These financial effects are analysed by performing a sensitivity analysis and a scenario analysis. In this chapter we will discuss the conclusions of this study. In addition to that we consider the limitations of the study and propose further directions for research for Menzis.

## 7.1 Conclusions

Based on the findings from literature and the data from the DBC information system we conclude that the percutaneous coronary intervention, total knee arthroplasty, total knee arthroplasty, implantation of a pacemaker and cholecystectomy are procedures which are currently often performed without discharging the patient the same day while literature shows that it is possible to discharge a patient the same day safely for patients meeting the criteria of the study.

In order to provide Menzis insight in how to use the data they have available on declared care activities we discussed multiple methods of health economic modelling. Although the current study is more of an analysis of data we conclude that performing a Monte Carlo simulation is suitable in order to draw for each simulated patient multiple attributes for patient characteristics and care activities in order to determine an expected cost reduction. The Monte Carlo simulation showed that shifting patients from an inpatient setting to an outpatient setting, considering inclusion and exclusion criteria of studies showing that the procedure is safe and feasible to be conducted in an outpatient setting, yields a saving for almost all considered hospitals for all procedures. The different scenarios, considering additional criteria by using the simulated care activities, showed that with the use of these care activities a more thorough picture can be given of the potential savings per year for each hospital.

The results show that the PCI, THA and TKA procedures are the most promising for shifting patients from an outpatient to an inpatient setting. These procedures all have a large potential mean savings per year. For both the THA and TKA procedure this is due to the very small amount of patients currently undergoing one of these procedures in an outpatient setting. The scenario analysis of these procedures showed that many patients currently undergo surgery under general anaesthesia.

The shifting of patients undergoing an implantation of a pacemaker from an inpatient to an outpatient setting does not yield in large potential savings. In fact, hospital 2 shows that it brings additional costs. This is expected due to the mentioned price agreements Menzis has with this hospital. In addition, the results of shifting patients undergoing an implantation of a pacemaker to an inpatient setting show large confidence intervals. This makes that this procedure is not yet the best procedure to explore further. The shift of patients undergoing cholecystectomy shows however quite a significant potential saving each year. Although the impact of cholecystectomy is relatively low the scenario analysis shows that it has quite some potential. However, based on the findings in the scenario analysis we conclude that quite a large group has a length of stay of at least two days. The length of stay may need to decrease first in order to come to the full potential of shifting patient from an inpatient to an outpatient setting.

## 7.2 Limitations

As this study is conducted as an explorative study to show Menzis the possibilities of using the data concerning declared care activities it has quite a few limitations. First of all the scope of this study is clinical care in hospitals. In order to be able to fully show the financial effects of discharging patients as the same day of surgery, costs regarding healthcare outside the hospitals should also be taken into account.

The reliability of this study is the next limitation. As this study considers only the data available at Menzis, data regarding patient characteristics is missing. These patient characteristics are partially included by the use of probabilities of having certain characteristics found in literature, but these patient characteristics found in literature do of course not match the patient data exactly. Due to the missing patient characteristics the inclusion or exclusion criteria found in literature cannot be exactly matched to the patients simulated. This probably has led to an optimistic shift of patients from an inpatient to an outpatient setting. With more patient characteristics the criteria for being shifted would be stricter, leading to less patients being shifted to an outpatient setting.

A next limitation of this study is the uncertainty about the quality of the data used. We used the data of all declared care activities of the selected hospitals. Whether this dataset is complete and does give a proper representation of the reality depends on the hospital personnel filling in the care activities correctly. Although hospitals strive for declaring the care activities as accurate as possible, as it also benefits them, it can occur that wrong care activities are declared. A care activity that is mistakenly declared does not automatically lead to a false DBC code. The grouper, which automatically collects the data activities and at the end of the care pathway of a patient assigns a DBC code, is however not flawless.

In this study we considered only the agreed prices of DBC codes between Menzis and hospitals in 2016. As one of the larger healthcare insurers in the Netherlands Menzis can support hospitals making a change in the length of stay in hospitals. One of the possibilities is to agree on different pricing for the in- and outpatient DBC codes. For example, reducing the gap between the price of an in-and outpatient DBC by increasing the price of an outpatient DBC can financially support the hospital to help a hospital make the changes needed to discharge more patients the same day as the surgery.

The output of the simulation leads to stochastic uncertainty. One could decrease the uncertainty of the output by increasing the number of simulated patients. Increasing the number of simulated patients will also affect the confidence intervals given in the sensitivity analysis. As this study considered multiple procedures and performed different sensitivity analyses the number of patients was not increased in order to not increase the running time of the simulation. For the parameter uncertainty we performed a deterministic sensitivity analysis. This method is also used in order to be able to deal with the running time of the simulation. In general, conducting a probabilistic sensitivity analysis quantifies the parameter uncertainty in a better way.

Care activities that occur frequently for a certain procedure were modelled by fitting a distribution. For the patients undergoing a procedure in an inpatient setting enough data was available. However, for some procedures the data available regarding performing procedures in an outpatient setting was limited as in some cases no patients underwent the procedure in an outpatient setting in the selected hospital. Therefore, for some care activities performed in an outpatient setting the distribution fitted for the inpatient setting was used. This may lead to inaccurate results as patients undergoing a procedure in an inpatient setting may have used other care activities than patients in an outpatient setting.

In this study we conducted a literature review for the selected procedures. We described that for each procedure multiple studies showed that it is safe and feasible to perform the procedure in an outpatient setting instead of an inpatient setting. For some procedures, larger clinical trials can give a decisive conclusion on the feasibility and safety. In addition to that, the majority of the studies described are not conducted in the Netherlands. The difference in the way a procedure is performed can lead to different outputs regarding the safety and feasibility of performing a procedure and the number of patients that can be discharged the same day as surgery.

This study does not validate the safety of conducting a procedure in an outpatient setting instead of an inpatient setting since the data to do this is not available. One could increase the validity of this study by including the records of complications and return rate patients to the hospitals with complications regarding their surgery. This is however not considered in this study as the data available at Menzis does not give enough information to determine whether the patient returns to a hospital due to complications regarding their surgery or if they return for something else.

## 7.3 Future research

By conducting this study we have showed the possibilities of using the data of declared care activities. The study shows the potential of moving patients from an inpatient to an outpatient setting by considering studies showing that it is feasible and safe to perform a certain procedure in an outpatient setting. However, as the limitations show there are quite a few obstacles still to take in order to be able to show a complete picture of the financial effects of moving patients from an inpatient to an outpatient setting. These obstacles can be overtaken by continuing this study by implementing new data sources.

A first step to consider in order to continue this research is further implementing the data available. This study already tried to find a connection between a patient undergoing a certain procedure and returning in a later stage for a new procedure related to the procedure they underwent at first, but couldn’t yet find a connection that always hold. This is due to the many reasons there are for the patient to return. Perhaps that there are relevant DBC’s and care activities for some procedures that can give a decisive connection between the return of the patient and their procedure they underwent at first.

Another data source available at Menzis is the chronical use of medicines by clients. The chronical use of medications by patients can give insight in possible chronical diseases of a patient. Using this data source leads to better patient characteristics and therefore less uncertainty on whether the patient should be shifted to an outpatient setting or not according to the criteria. For example, a patient using cardiac medications probably has a history of cardiac problems and therefore cannot be treated in an outpatient setting.

In order to show a complete picture of the financial effects of moving patients from an inpatient to an outpatient setting Menzis should cooperate with a hospital. A hospital has insight in all patient characteristics and therefore can give a decisive conclusion for each patient whether he or she is able to be treated in an outpatient setting. The hospital data also shows complications and revisits of a patient to the hospital with complaints regarding the performed surgery. This data itself leads to a better validation of modelling the financial effects of moving patients from an outpatient to an inpatient setting. In addition to that, only a hospital can give insight in their predicted costs for a care activity. Adding all the costs of the care activities of a hospital for performing a certain procedure to the study leads to a better overview of the financial effects moving patients from an inpatient to an outpatient setting has.

In order to implement time-dependent variables, such as the return of a patients with complications, and the costs of care activities the current simulation study should be expanded by using a discrete event simulation. A DES can simulate multiple pathways for a large number of patients when the costs of all care activities combined can differ due to time.

The constructed simulation is flexible and can be used for analysing different procedures or different care activities. In addition to that, the simulation can be expanded by adding new decisions. The current simulation has only two different pathways (inpatient and outpatient) for each procedure, there are no other moments where decisions have to be made that affect a patients pathway. The current simulation is built in order to be easily expanded. The current Monte Carlo simulation can be altered in order to model the shift of patients in a discrete event simulation.

## 7.4 Recommendations

Based on this study, we recommend the following for Menzis:

- Evaluate the used care activities and implement new care activities using this study's approach as other care activities can give other scenario results.
- Extend this study by performing the same analysis for different procedures with a significant impact.
- Cooperate with one or more hospitals in order to be able to include the costs of care activities in the study. Adding the costs of care activities leads to a more profound study since the costs of shifting patients from an inpatient to an outpatient setting are also considered.
- Implement time-dependent variables, like patients returning to the hospital with complications, in order to fully show the financial effects. In addition to that costs outside the hospitals should also be taken into consideration.
- The current scenario analysis can be updated when one cooperates with hospitals in order to provide better insight in which patients are suitable for procedure in an outpatient setting.

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# 9 Appendices

## 9.1 Appendix A: search strategies

In this appendix the search strategies are given by which we included studies regarding the five selected procedures in sector 2.3.The search strategies were both performed in Pubmed as Scopus on article titles and for studies performed after 2000.

For every procedure the following search queries were used. (((“Inpatient”) AND/OR (“Outpatient”)) OR (“same-day discharge”)) was combined with search terms for each procedure:

- ((“Percutaneous Coronary Intervention”) OR (“PCI”))
- ((“Total Hip Arthroplasty”) OR (“THA”))
- ((“Total Knee Arthroplasty”) OR (“TKA”))
- ((“Implantation”) AND (“Pacemaker”))
- ((“Cholecystectomy”) OR ((“gall bladder”)) AND (“remove”) OR (“removal”)))

After reading the titles and abstract of the found studies for the THA procedure four studies were included. For all other procedures three studies were included. In order to be included the studies should have conducted a systematic review, cohort study or randomised controlled trial.

## 9.2 Appendix B: confidence intervals

In this study we treat the output of the Monte Carlo simulation as independent and identically distributed (IID) random variables. This random variable is in this study the potential saving per patient for all patients simulated. For some patients there may be a saving as these patients are shifted from an inpatient to an outpatient setting and for some there may be no saving as these patients are not shifted due to the criteria. According to the central limit theorem, which says that if the number of simulated patients is "sufficiently large" the random variable will be approximately distribution as a standard normal random variable, we can estimate the mean of the whole output by taking the average of all outputs. By treating the output as the simulation as an IID variable we can thus determine the confidence interval half width. For this Monte Carlo simulation we use a significance level of α = 0.05, which is commonly used in simulation studies.

In order to estimate the significance level of the number of patients we first determine whether the confidence interval half width is sufficiently small in comparison with the relative error. We estimate the relative error by the following equations, since we estimate |μ| by x̄ we have to use the corrected target value.

*Equation 1 and 2: estimation of relative error and corrected target value*

$$\gamma = \frac{|\,\bar{x} - \mu\,|}{\bar{x}} \qquad\qquad \gamma' = \frac{\gamma}{1+\gamma}$$

We then can obtain the significance level for the number of patients by calculating the relative error using the following confidence interval half width equation.

*Equation 3: confidence interval half width compared to the mean*

$$\frac{t_{n-1,1-\propto/2}\sqrt{\frac{S^2(n)}{n}}}{\bar{x}} < \gamma'$$

## 9.3 Appendix C: Costs of used DBCs

In this appendix we describe the costs for the different DBC codes used. Table .. to .. show the costs for an inpatient setting. The Tables below show the costs for an outpatient setting. A "*" shows that no price agreements were found and that the national average cost, which can be found at the NZA, of that DBC is used

**Inpatient setting costs**

| PCI | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 14D079 | 7538 | 7301 | 7606 | 7435 |
| 14D081 | 6262 | 6779 | 6806 | 7657 |
| 14D083 | 5664 | 5769 | 5326 | 5511 |
| 14D085 | 5603 | 5093 | 5359 | 5359 |

| Total Hip Arthroplasty | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15B034 | 9434 | 8635 | 8578 | 9227 |
| 15D057 | 10809 | 10486 | 9978 | 10815 |

| Total Knee arthroplasty | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15B067 | 9725 | 9302 | 8939 | 10044 |

| Implantation of pacemaker | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15A749 | 12856 | 13723 | 9281 | 11289 |
| 15B780 | 5558 | 5517 | 4730 | 8535 |
| 15E743 | 10403 | 12500 | 8746 | 13478 |

| Cholecystectomy | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15A977 | 4007 | 4157 | 4091 | 4006 |

**Outpatient setting costs**

| PCI | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 14D078 | 4562 | 4545 | 3801 | 4562 |
| 14D080 | 6046 | 4464 | 5374 | 5374 |
| 14D082 | 3332 | 3677 | 3239 | 3360 |
| 14D084 | 3157 | 3162 | 3067 | 3114 |

| Total Hip Arthroplasty | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15B033 | 4825 | 4893 | 4200 | 4825* |
| 15D056 | 4825* | 4893 | 4200* | 4825* |

| Total Knee arthroplasty | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15B066 | 5248* | 5248* | 5248* | 5248 |

| Implantation of pacemaker | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15A748 | 9369 | 10147 | 9369* | 8455 |
| 15B779 | 1531 | 1881 | 1460 | 1704 |
| 15E744 | 6980 | 13500 | 5680 | 7281 |

| Cholecystectomy | Hospital 1 | Hospital 2 | Hospital 3 | Hospital 4 |
|---|---|---|---|---|
| 15A976 | 2597 | 2569 | 2696* | 2924 |