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The impact of waiting times, physical therapy and length of hospital stay on the quality outcomes after total knee arthroplasty and total hip arthroplasty

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I hope you will enjoy reading this thesis.

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Abstract

Introduction Health insurance companies buy care for their members by making agreements with health care providers. The goal of health insurance companies is to represent the interest of their insured persons with regard to care. In the Netherlands the number of people with arthrosis is very large. Total knee and hip arthroplasty are two of the most common surgical procedures performed worldwide. Right now, there are differences between hospitals and patients with respect to the waiting time for total joint arthroplasty, the number of physical therapy sessions and the number of hospital days after total joint arthroplasty. These differences between hospitals can lead to different outcomes after total knee and hip arthroplasty.

Aim Investigate to what extent waiting time, physical therapy and length of hospital stay have an influence on the quality of care after total knee or hip arthroplasty.

Methods Data is derived from the declaration database of Company X. This research investigates the effect of four independent variables, namely waiting time, physical therapy – number of sessions, physical therapy – performed on day of surgery and length of hospital on the dependent variable quality of care. Quality of care is expressed in four outcome measures, namely readmission within 30 days, revision within two years, request for antibiotics and request for opioids. SmartPLS3 is used to perform analysis with the data. Three calculation methods were used, namely the Consistent Partial Least Squares (PLSc) Algorithm, the PLSc Bootstrapping method and the PLSc Multigroup Analysis. This is used to determine which variables had a significant influence on quality of care after total knee or hip arthroplasty.

Results The results of total knee arthroplasty show that the number of physical therapy sessions on the number of readmissions is found to be positive significant. Furthermore, physical therapy on the day of total knee arthroplasty on the number of readmissions is found to be negative significant. The results of total hip arthroplasty show that waiting time has a significant positive effect on the number of readmissions. The number of physical therapy sessions on the number of readmissions is also found to be positive significant. Physical therapy on the day of total hip arthroplasty on the number of readmissions was found to be negative significant. The length of hospital stay on the number of readmissions was also found to be positive significant. Lastly, the price agreement on the number of readmissions was found to be negative significant.

Discussion Both the analyses performed by patients undergoing total knee and hip arthroplasty show that the number of physical therapy sessions corrected for the number of days in the hospital leads to higher readmissions within 30 days. This suggest that too much physical therapy has a positive relationship with readmissions within 30 days, or it suggest that physical therapy influences a third aspect – such as the degree of damage or problems – which influences the number of readmissions. It is important for patients to immediately start with physical therapy on the day of surgery, since the findings show that physical therapy on the day of surgery leads to a significant lower chance of getting a readmission within 30 days after total knee or hip arthroplasty.

Recommendations Health insurance companies have no data about the extramural physical therapy that patients perform after their surgery. Including the number of physical therapy sessions after discharge from the hospital could lead to different outcomes in the number of readmissions, revisions and requests for opioids. Moreover, the outcomes would be more reliable when it was measured with data from every region in the Netherlands. This research only focused on the main regions of Company X. Future research should focus on finding significant relationships which have a higher influence than what is found in this research. This can be done by including more data from different regions and years.

Table of Content

Index of abbreviations

Zvw	Health Insurance Act (Zorgverzekeringswet)
NZa	Nederlandse Zorgautoriteit
P4P	Pay for Performance
KNGF	Koninklijk Nederlands Genootschap voor Fysiotherapie
FIM	Functional Independence Measure
HSMR	Hospital Standardized Mortality Ratio
PLSc	Consistent Partial Least Squares

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1. Introduction: The impact of physical therapy, waiting times and length of hospital stay on the quality of care after total knee or hip arthroplasty

Health insurance companies buy care for their members by making agreements with health care providers. Since 2006 the Health Insurance Act (‘Zorgverzekeringswet’, Zvw) is applicable in the Netherlands, whereby consumers, health care providers and health insurance companies make agreements with health care providers in a regulated market. These agreements are about the size, quality and price of the health care (Nederlandse Zorgautoriteit, 2019, p. 1). Health insurance companies are obligated to adhere to the Zvw, whereby the ‘Nederlandse Zorgautoriteit’ (NZa) is the regulator who verifies that the health insurance companies comply to these standards, rules and conditions (van de Ven et al., 2009, p. 19). This law is aimed at introducing regulated competition in health care. This is intended to achieve an efficient operating system that allows all inhabitants, regardless of age, health or income, access to good quality and affordable care (Nederlandse Zorgautoriteit, 2019, p. 1).

The goal of health insurance companies is to represent the interest of their insured persons with regard to care. By providing good quality of care for a low price, health insurance companies can keep their existing insured persons and try to win new possible clients. In the current healthcare system, health insurance companies should purchase the healthcare more efficiently. They can exert pressure through not purchasing care from certain healthcare providers and thus keep costs under control and improve quality of care (Halbersma & en Wolf, 2012, p. 13). In this way, health insurance companies do not contract specific healthcare provider which means that their clients do not use the healthcare of that healthcare provider. In literature, a contract between a health insurance company and a healthcare provider is an agreement where both of the parties commit themselves in advance to the performances to be delivered. The three most common contract theories are: the principal agent theory, the transaction cost theory and the property rights economics (Ruwaard, Douven, Struijs, & Polder, 2014, pp. 102-103). The principal agent theory describes a contract where a contractor (agent) performs a task for a client (principal). However, it is possible that the objectives of both parties are not necessarily consistent. Monitoring performance and Pay for Performance (P4P) can provide a solution to

keep the agent's objectives and behaviour in line with that of the principal. The transaction cost theory assumes that parties have an organizational form (free market, hybrid form or vertical integration) based on the lowest transaction cost. The property rights economics emphasizes the allocation of rights among players. The allocation of these rights affects the behaviour of the contracting parties and thus influences the results and the distribution of it.

The empirical literature on contracts and the implication of contract theories in practice is scarce. This has to do with the confidential nature of the contracts. It is often not possible for researches to access private contracts. It is known that health insurance companies make price agreements with healthcare providers every year, but only the average price agreements are published at the NZa. However, there is a great need for transparency about these price agreements according to the Patient Federation of the Netherlands. Moreover, health insurance companies are looking for more transparency with regard to the delivered quality of care by healthcare providers. Since health insurance companies only got insight in the healthcare activities that were declared, their data is limited. However, combining this data with their own vision can give valuable outcomes.

The Netherlands is the second best country related to quality and accessibility of care, according to the Euro Health Consumer Index 2018 (Health Consumer Powerhouse, 2018, p. 1). There are 32 health insurance companies in the Netherlands who try to buy high quality of care to deliver good and affordable care to their members. Quality of care is an important aspect that needs to be developed over time (Copnell et al., 2009, pp. 352-353). Therefore, reporting of health care quality has become increasingly important. Healthcare providers measure the quality of their care every year. The 'Inspectie Gezondheidszorg en Jeugd' and 'Zorginstituut Nederland' want to have insight in these numbers, to check whether healthcare providers meet the quality requirements. Several indicators are used to measure the quality of healthcare providers.

Health care expenditures are rising everywhere. The health care costs in 2015 were more than 85 billion euros in the Netherlands, which means 5.000 euros per inhabitant. Since health care is the largest expenditure within the government budget, this is the sector in which the most profit can be gained according to reducing costs (Volksgezondheid en zorg, 2019a, p. 1). To curb the unsustainable rise in health care expenses, health insurance companies are developing programs to incentivize healthcare providers to improve the value of care delivered to patients.

In the Netherlands the number of people with arthrosis is very large. In 2017 there were almost 1.4 million people diagnosed with arthrosis, from which 482.000 people were men and 902.200 people were women. Knee arthrosis is the most common type of arthrosis, almost 50.000 people were diagnosed with this disease in 2017. Hip arthrosis is also a common disease with more than 30.000 diagnosis in 2017 (Volksgezondheid en zorg, 2019b, p. 1). There are different treatments for knee and hip arthrosis. The first treatment consists of the combination between drugs and physical therapy. This will improve the flexibility of the knee. When this treatment is not enough and there is too much wear of the knee or hip, people can have a prosthesis in their knee or hip. This is called total knee or hip arthroplasty. Total knee and hip arthroplasty are elective surgeries performed in patients with severe end-stage arthritis of several types.

Total knee and hip arthroplasty are two of the most common surgical procedures performed worldwide (Molloy, Martin, Moschetti, & Jevsevar, 2017, p. 402). There are around 24.000 total knee arthroplasty admissions and 24.000 total hip arthroplasty admissions per year in the Netherlands (ZorgKaart Nederland, 2020, p. 1). The demand for total knee and hip arthroplasty is still increasing, due to a relatively high prevalence of degenerative arthritis of the knee and hip and the success of total knee and hip arthroplasty. This automatically leads to longer waiting times of these procedures. Although the waiting times are increasing, the average length of stay in the hospital is decreasing (Molloy et al., 2017, p. 403). This is due to advances in surgical techniques, anaesthesia and care pathways. In 1987, the mean length of hospital stay for total knee and hip arthroplasty was three weeks (Epstein, Read, & Hoefer, 1987, p. 994), which reduced to five days by the 2000s (Anastase, Florescu, Munteanu, Stoica, & Antonescu, 2013, p. 766). In 2016, the mean length of hospital stay for total knee arthroplasty and total hip arthroplasty decreased towards a mean of three or four days (Williams et al., 2017, p. 715). This is the same for the Netherlands, where the average length of stay after total knee arthroplasty is around three days (Meermans, Galvain, Wigham, Do Rego, & Schröer, 2020, p. 182).

Right now, there are differences between healthcare providers and patients with respect to the waiting time for total knee and hip arthroplasty, the number of physical therapy sessions per day and the number of hospital days after total knee and hip arthroplasty. These differences between healthcare providers can lead to different outcomes after total knee or hip arthroplasty. Since it

is important to know what the different outcomes of total knee or hip arthroplasty are when different guidelines are used, the aim of this study is to investigate to what extent waiting time, physical therapy and length of hospital stay have an influence on the quality of care. This will be investigated from the perspective of the health insurance companies. In this research, the following research question needs to be answered:

"What are the effects of waiting time, postoperative physical therapy and length of hospital stay on the quality of care for patients treated with total knee or hip arthroplasty?"

This study contributes to the literature by providing a clear definition of the concept quality of care, whereby there is focused on both input and output related aspects of care. This results in the best possible outcomes, since both the process and outcomes are evaluated. In previous studies a lot of different definitions were made for quality of care, but there is no definition that considers both input and output related aspects. In the studies of Schuster, McGlynn, and Brook (1998, p. 518), Donabedian (1980, p. 1) and Leebov and Clara Jean Ersoz (2003, p. 4) they provided a definition for quality of care where they only focused on the input related aspects of quality of care. Moreover, the studies of World Health Organization (1948, pp. 9-10), Mohammad Mosadeghrad (2013, p. 203), Lohr (1990, p. 21) and Øvretveit (2009, p. 4) provided a definition of quality of care where they only paid attention to the output related aspects of quality of care. Since this study considers both the input and output related aspects of quality of care, it provides a broader definition of quality of care. A second contribution to the literature is that this study looks from the perspective of the health insurance companies instead of the health care providers. Looking from the perspective of the health insurance companies results in other health insurance related outcomes for quality of care, since previous literature used other databases mostly coming from other sources than health insurance companies. In the study of DeJong et al. (2011, p. 1832) they also investigated the effects of postoperative physical therapy after total knee arthroplasty, but they studied this effect with data coming from rehabilitation centres. Since patients have to stay a couple of days in the hospital after total knee arthroplasty, this kind of physical therapy did not start right after the total knee arthroplasty.

2. Theoretical framework: The definition of quality of care and guidelines regarding waiting times, physical therapy and length of hospital stay which influences the quality outcomes after total knee or hip arthroplasty

2.1 Quality of health care: a broad and dynamic concept

Quality is a dynamic concept and can have different meaning for different people (Harrist, Thompson, & Norris, 2007, p. 306). This means that there are many definitions of quality used both in relation to health care and health systems. The World Health Organization made one working definition of quality of care, based on several definitions in the literature. They call quality of care "the extent to which health care services provided to individuals and patient populations improve desired health outcomes. To achieve this, health care must be safe, effective, timely, efficient, equitable and people-centred." (World Health Organization, 2006, pp. 9-10). This means that a health system should seek to make improvements in these six dimensions of quality. The dimension *safe* stands for delivering care which minimizes the risk and harm to service users. *Effective* stands for providing services based on evidence-based guidelines and scientific knowledge. It should result in improved health outcomes for both individuals and communities based on their needs. The dimension *timely* means reducing delays in providing and receiving health care. It should be geographically reasonable and should be provided in a setting where skills and resources are appropriate to the medical need of patients. *Efficient* means delivering health care in a manner that maximizes resource use and avoid waste. The dimension *equitable* means delivering care which does not vary in quality because of personal characteristics, such as gender, ethnicity and socioeconomic. *People centred* stands for providing care that considers the preferences and aspirations of individual service users and the cultures of their communities. status, race and geographical location (World Health Organization, 2006, pp. 9-10).

Donabedian defined quality of health care as "the application of medical science and technology in a manner that maximizes its benefit to health without correspondingly increasing the risk" (Donabedian, 1980, p. 1). According to the Donabedian model, health care quality can be evaluated in terms of structure, process and outcome. Structure stands for the characteristics of the health care setting, such as hospital buildings, staff and equipment. Process is about the

clinical processes performed in the health care setting. It denotes the transactions between patients and health care providers throughout the delivery of health care, such as services, diagnostics or treatments. Outcome is the ultimate health status of the patient following a given set of interventions. This model suggests that improvement in the structure of care should lead to improvements in the clinical process, which then should improve the quality of care (Moore, Lavoie, Bourgeois, & Lapointe, 2015, p. 1168).

A more comprehensive view of quality comes from Mohammad Mosadeghrad (2013, p. 215), who defines quality of health care as "consistently delighting the patient by providing efficacious, effective and efficient healthcare services according to the latest clinical guidelines and standards, which meet the patient's needs and satisfies providers". This definition takes into account various healthcare stakeholder perceptions and expectations (Mohammad Mosadeghrad, 2013, p. 203). It focuses mostly on the health care outcomes, whereby it is important to meet the needs of the patients. Moreover, Lohr (1990, p. 21) describes the quality of health care as "the degree to which healthcare services for individuals and population increases the likelihood of desired health outcomes and is consistent with the current professional knowledge". Furthermore, Øvretveit (2009, p. 4) defines the quality of health care as the "provision of care that exceeds patient expectations and achieves the highest possible clinical outcomes with the resources available". These three studies indicate that health care outcomes define the quality of care.

According to Schuster et al. (1998, p. 518), health care quality is about "providing patients with appropriate services in a technically competent manner, with good communication, shared decision making and cultural sensitivity". In this definition the health care services must meet the professional standards, but it focuses on the shared decision making whereby good quality of care can be accomplished when the patient is involved in the decision making. For Leebov and Clara Jean Ersoz (2003, p. 4) health care quality is more focused on the ethical side, and they argue that quality of health care means "doing the right things right and making continuous improvements, obtaining the best possible clinical outcome, satisfying all customers, retaining talented staff and maintaining sound financial performance".

Author	Definition quality of health care	Input or output
World Health Organization (1948, pp. 9-10)	The extent to which health care services provided to individuals and patient populations improve desired health outcomes. Health care must be safe, effective, timely, efficient, equitable and people-centred	Output focused
Mohammad Mosadeghrad (2013, p. 203)	Providing efficacious, effective and efficient healthcare services according to the latest clinical guidelines and standards, which meet the patient's needs and satisfies providers	Output focused
Lohr (1990, p. 21)	The degree to which healthcare services for individuals and population increases the likelihood of desired health outcomes and is consistent with the current professional knowledge	Output focused
Øvretveit (2009, p. 4)	Provision of care that exceeds patient expectations and achieves the highest possible clinical outcomes with the resources available	Output focused
Schuster et al. (1998, p. 518)	Providing patients with appropriate services in a technically competent manner, with good communication, shared decision making and cultural sensitivity	Input focused
Donabedian (1980, p. 1)	The application of medical science and technology in a manner that maximizes its benefit to health without correspondingly increasing the risk	Input focused
Leebov and Clara Jean Ersoz (2003, p. 4)	Doing the right things right and making continuous improvements, obtaining the best possible clinical outcome, satisfying all customers, retaining talented staff and maintaining sound financial performance	Input related

Table 1: Overview definitions quality of health care

Table 1 provides an overview of all different viewpoints of quality of health care described in this section. It makes a distinction between input and output focused viewpoints. Both input and output focused viewpoints are important for formulating a definition of quality of health care. Therefore, the definition of quality of health care used in this thesis is an aggregation of the definitions of World Health Organization (2006, pp. 9-10) and Donabedian (1980, p. 1). To get the best possible outcomes, it is important to look at both structure, process and outcome. Therefore, the definition of quality of health care is formulated as followed:

"Providing safe, effective, timely, efficient, equitable and people-centred care by focusing on the structure, process and outcome of care."

The six dimensions created by World Health Organization (1948, pp. 9-10) and the structure, process and outcome of care devised by Donabedian (1980, p. 1) are all broad concepts. It is impossible to study all these concepts at once, since they are all too comprehensive. The concepts safe, equitable and people-centred care are concepts that are more related to healthcare providers instead of health insurance companies. Healthcare providers perform the surgeries and have more influence on the safety, equity and people-centred care. Moreover, healthcare providers are responsible for the structure and process of care they provide. They are responsible for the outcomes after total knee or hip arthroplasty, but this information is also known at the health insurance company. Since this thesis focuses on the vision of the health insurance companies, only the concepts effective, timely and efficient care will be discussed whereby not the structure and process of care, but only the outcomes will be evaluated.

2.2 Quality of care is expressed in number of readmissions, revisions, requests for antibiotics and requests for opioids after total knee or hip arthroplasty

For patients undergoing total knee or hip arthroplasty, it is important that the total arthroplasty relieves pain and help them live a more active life, whereby the quality of life is experienced as high. Arthroplasty is associated with significant improvement in the function, quality of life and pain of patients (Kane, Saleh, Wilt, & Bershadsky, 2005, p. 1723). However, there is variation in the arthroplasties that are offered, including a wide range of joint implants with different designs, materials and fixation methods to bone. This variability in treatments can result in different outcomes, such as function, pain, complications, survival and the chance for a revision surgery (National Institute For Health And Care Excellence, 2018, p. 1). It is deemed to be a safe procedure, but there are associated risks.

Around 10% of the patients are less satisfied with the outcome of the arthroplasty (Medical Advisory Secretariat, 2005, p. 10). When undergoing total knee arthroplasty or total hip arthroplasty, there is a chance that the wound will be infected. There are on average 0.49% of people getting an infection after total knee arthroplasty and 0.78% of people getting an infection after total hip arthroplasty in the Netherlands (Ziekenhuischeck, 2019, p. 1). Infections are caused by bacteria, which can enter the body through the wounds from the total knee or hip

arthroplasty. These infections can occur in the wound or deep around the artificial knee or hip. Since wound infection can lead to increased pain or stiffness, swelling, warmth and redness around the wound, wound drainage, fatigue, fevers, chills and night sweats, it has an effect on the quality of care. It can be developed during the patient's stay in the hospital, or after the patient is discharged from the hospital. It is important that the infection is caught early. When only the skin and soft tissues around the artificial knee or hip are infected, and the infection has not spread deep into the artificial knee or hip, then the doctor can prescribe intravenous or oral antibiotics. This treatment has a high success rate when caught early. Infections that go beyond the superficial tissues and get deep into the artificial knee or hip almost always require surgical treatment (OrthoInfo, 2018, p. 1).

Acute postoperative pain after total knee arthroplasty or total hip arthroplasty is common (Stomberg & Öman, 2006, p. 454). A knee or hip replacement can begin to wear or loosen after surgery. This is the most common problem in the long-term and can cause pain in the knee or hip. The problem of acute postoperative pain after total knee or hip arthroplasty is relevant for two reasons. The first reason is that total knee and hip arthroplasty are commonly performed elective surgical procedures in the Netherlands (ZorgKaart Nederland, 2020, p. 1), which is predicted to increase over the coming years (Otten, van Roermund, & Picavet, 2010, p. 1). This result in the fact that the problem of acute postoperative pain will continue to escalate when there is no appropriate pain management implemented. The second reason is that total knee and hip arthroplasty is mostly performed to alleviate chronic knee or hip pain, where in some cases a number of patients continue to experience chronic pain after surgery (Wylde, Dieppe, Hewlett, & Learmonth, 2007, p. 418). This means that the surgery has failed for these patients. Since acute postoperative pain is a risk factor for chronic pain after total knee and hip arthroplasty, a reduction in this acute postoperative pain severity could reduce the number of patients who did not achieve long-term benefit from the surgery (Nikolajsen, Brandsborg, Lucht, Jensen, & Kehlet, 2006, p. 497). To treat patients with post-operative pain, doctors can prescribe drugs such as opioids (Nederlandse Orthopaedische Vereniging, 2014, p. 226).

When there are complications after total knee and hip arthroplasty, it might happen that a patient needs to be readmitted to the hospital or even needs a revision. In the Netherlands, 1.39% of the

patients needed a revision after total knee arthroplasty and 2.03% of the patients needed a revision after total hip arthroplasty (Ziekenhuischeck, 2019, p. 1). Looking from a clinical perspective, a revision after total knee arthroplasty is a complex procedure which is associated with extended hospitalization, higher complication rates, unsatisfactory functional outcomes and shorter survival (Ritter et al., 1996, p. 137). A revision due to infection costs twice as much as aseptic revision. The risk for having a revision after total knee and hip arthroplasty is especially pronounced in the younger patients, who are more physically active and more subject to multiple revision surgeries over a lifetime (Bhandari, Smith, Miller, & Block, 2012, p. 92). When looking at the economic consequences of revision surgery after total knee and hip arthroplasty, the costs of a revision can be very costly. Each total knee arthroplasty is associated with a price ranging between €7.399,00 and €17.362,00, whereby a length of stay of five days and the use of hospital resources are included (Zorgkaart Nederland, 2015, p. 1).

As discussed above, complications can occur after total knee and hip arthroplasty. Looking from the perspective of the health insurance companies, only patients who reported these complications and needed healthcare related activities from their healthcare provider are known at the health insurance companies. Therefore, only patients who were readmitted to the hospital or needed a revision are known. However, health insurance companies do not know what the reason for this readmission or revision was. Health insurance companies have insight in the number of requests for drugs since these prescriptions are declared by the health insurance companies. This give health insurance companies insight in the drug consumption after the procedure. A request for antibiotics can suggest that the patient got a wound infection after the total knee or hip arthroplasty, but this is an assumption and it might be possible that the antibiotics were prescribed from something different not related to the total knee or hip arthroplasty. Moreover, a request for opioids can suggest that the patient experienced more pain than average. The abovementioned reasons make that this research only can focus on the readmissions, revisions and requests for antibiotics and opioids, since these are the available outcome measures that are known at the health insurance companies. Table 2 provides an overview of all possible outcome measures and in what way this outcome variable can be measured with the available data coming from declaration databases of health insurance

companies. When health insurance companies have no access to this data, the outcome measure is not included in this research.

Outcome variables	Measurement level	Included/Excluded
Function	Not possible to measure for health insurance companies	Excluded
Pain	Number of requests for opioids	Included
Complications	Number of readmissions	Included
Survival rate	Not possible to measure for health insurance companies	Excluded
Revision	Number of revisions	Included
Wound infection	Number of requests for antibiotics	Included

Table 2: Outcome variables after total knee or hip arthroplasty

2.3 The independent variables waiting time, physical therapy and length of hospital stay are important from the perspective of the health insurance company, when looking at the quality of care after total knee and hip arthroplasty

In the Netherlands there are different quality marks to indicate what quality is and how quality is measured. For the treatment of patients with knee or hip arthrosis, there is a quality standard available. This standard is described in the guideline for total knee and hip arthroplasty created by ZorgInstituut Nederland (ZorgInstituut Nederland, 2019b, p. 1). This standard distinguishes the care path in three different phases, namely the perioperative phase, the total knee or hip arthroplasty and the postoperative phase. This thesis will focus on the perioperative and postoperative phase.

2.3.1 Waiting times

In the Netherlands there is a new arrangement regarding waiting times in medical specialist care since August 2018. This arrangement formulates the definition of waiting time for treatment as "the time (in days) between the order moment and the execution of the treatment, characterized by the corresponding care activities" (Nederlandse Zorgautoriteit, 2018, p. 1). It is obligated that every healthcare provider publishes the list of waiting times for diagnostics, policlinic and treatment on their website for each location. This regulation aims to make waiting times for elective medical specialist care transparent and comparable for patients.

Having people wait for orthopaedic surgery such as total knee or hip arthroplasty is common in a number of health systems. There are several studies conducted that investigated the relationship between waiting times for total knee and hip arthroplasty and quality of care. In the article of Fielden et al. (2005, p. 994) they aimed to determine the health costs of waiting for total hip arthroplasty. They compared the preoperative and postoperative health status with the WOMAC index. The study state that the scores diminished on the physical function dimension, with no improvement in the dimensions of stiffness and pain when patients were waiting for total hip arthroplasty. This finding indicate deterioration in health status while waiting for total hip arthroplasty. Moreover, in the article of Ostendorf et al. (2004, p. 302) they determined the effect of waiting times for total hip arthroplasty in terms of loss in quality adjusted life years. Besides, they studied the effect of waiting times and preoperative function scores on postoperative outcome scores. They found a considerable loss of quality adjusted life years occurred by postponing surgery. They did not find a direct effect of waiting time on postoperative outcomes. However, patients who were in a later phase of arthrosis did not improve to the level achieved by patients with a better preoperative function. Although the above articles suggest that a long waiting time have a negative effect on the quality of care, the article of K. Kelly, Voaklander, Johnston, Newman, and Suarez-Almazor (2001, p. 351) found minimal amounts of change in pain and physical function occurred for total knee and hip arthroplasty patients while they waited.

2.3.2 Physical therapy

For the physical therapy there is a special guideline, named “the KNGF guideline for arthrosis of the knee or hip” (Koninklijk Nederlands Genootschap voor Fysiotherapie, 2018, p. 1). Physical therapy can be used in a conservative way, which is a non-surgical treatment. The implication of physical therapy offer symptom relief, have limited side effects and alter disease progression (Crawford, Miller, & Block, 2013, p. 5). However, there are some disadvantages regarding physical therapy as conservative treatment. It can be variably effective when it is frequently performed, but the effects may not last long when the exercises are not regularly performed (Jamtvedt et al., 2008, p. 131). When conservative treatments have failed to provide pain relief, or the patient is developing limitation of their activity, then total knee or hip

arthroplasty is considered. In the guideline is stated that it is important that physical therapy is offered in both the perioperative as postoperative phase when the patient has an increased risk of delayed recovery (Koninklijk Nederlands Genootschap voor Fysiotherapie, 2018, p. 12). In other words, doctors should provide more physical activities that patients can perform independently when there is no increased risk of delayed recovery. The recommended length of time in which physical therapy is provided should be between eight and twelve weeks, whereby patients should be stimulated to continue physical therapy independently after this period (Koninklijk Nederlands Genootschap voor Fysiotherapie, 2018, p. 13).

There is no widely agreement in the effects of physical therapy on the quality of care after total knee arthroplasty or total hip arthroplasty. In the article of DeJong et al. (2011, p. 1832) they examined the relation between physical therapy activities and the Functional Independence Measure (FIM), which measures function, in patients undergoing total knee arthroplasty. They found that three physical therapy activities (assessment time, bed mobility and transfers) were negatively associated with discharge motor FIM outcome. This means that there is no evidence that physical therapy has a positive influence on the function of the patient. Moreover, in the article of Artz et al. (2015, p. 16) they performed a systematic review and meta-analysis to evaluate the effectiveness of post-discharge physical therapy exercises in patients undergoing total knee arthroplasty. Their results show that physical therapy and exercises lead to short-term improvements in patients' physical function. However, they did not identify that the delivery of physical therapy services offers minimal long-term benefits for patients after total knee arthroplasty. They suggest that further research need to be done to identify the long-term benefits of total knee arthroplasty. Moreover, when looking at the effects of the intensity of physical therapy after total knee arthroplasty and the number of readmissions, the article of Moses et al. (2018, p. 943) found no difference in 90-day readmission rates between a non-intensive cohort and an intensive cohort.

Although some scholars state that physical therapy has a negative influence on quality or do not provide benefits in the long-term, there are also some scholars that state that offering physical therapy has a positive effect on the rehabilitation of patients undergoing total knee or hip arthroplasty. In the article of Pua et al. (2017, p. 462) they conducted a prospective cohort study

in which they investigate the association between rehabilitation attendance and physical function following discharge after total knee arthroplasty. They found that rehabilitation attendance post total knee arthroplasty is associated with an increase in self-reported physical function. Moreover, in the article of Freburger (2000, p. 448) they examined the relationship between physical therapy utilization and outcomes of care for patients following total hip arthroplasty. They state that physical therapy intervention was directly related to a total cost of care that was less than expected and to an increased probability of discharge home.

2.3.3 Length of hospital stay

Regarding the length of hospital stay after total knee or hip arthroplasty, there is a shift ongoing from inpatient to outpatient procedures. Inpatient procedures are performed in the hospital and require an overnight stay. Outpatient procedures can be performed within a day, whereby the patient can be discharged the same day as surgery (Crawford, Li, Sprague, & Bhandari, 2015, p. 116). Outpatient total knee and hip arthroplasty is made possible due to more efficient management pathways, improvements in surgical techniques and improved anesthesia and rehabilitation protocols (Bovonratwet et al., 2017, p. 1773). According to a financial analysis performed by Bertin (2005, p. 154), total hip arthroplasty performed in an outpatient setting performed for around 30% of 250.000 treatments would save $300 million in billing charges and $87 million in reimbursement. Although outpatient procedure protocols can lead to a decrease in costs, there are hidden costs from managing complications and readmissions (Hunt et al., 2009, p. 1074). This can be due to the fact that it is harder to monitor the recovery process, since patients do not stay in the hospital overnight (Crawford et al., 2015, p. 116). Detailed information on the safety of outpatient total knee arthroplasty and total hip arthroplasty in large samples is scarce.

In the literature there is no agreement whether outpatient arthroplasty is as safe as inpatient arthroplasty. A study performed by Gromov et al. (2019, p. 283) found that readmissions rates in patient discharged on the day of surgery may be similar to matched patients with at least one overnight stay in arthroplasty procedures. Besides, Aynardi, Post, Ong, Orozco, and Sukin (2014, pp. 253-254) found that there is no difference in complications or estimated blood loss between inpatient and outpatient total knee and hip arthroplasty. However, the article of

Bovonratwet et al. (2017, p. 1773) found that there was a higher rate of post discharge blood transfusions in the outpatient cohort. Moreover, in the article of Lovecchio, Alvi, Sahota, Beal, and Manning (2016, p. 197) is found that outpatient procedures had higher rates of medical complications.

Not every person is suitable for outpatient total knee or hip arthroplasty outpatient procedures. There are several factors that can increase the risk for readmissions, such as nausea, bleeding, urinary retention and pain (Courtney, Rozell, Melnic, & Lee, 2015, p. 1428). Besides, the risk of rehospitalization increases by older patients, patients with a history of heart failure and patients not receiving a femoral nerve block (Lovald et al., 2014, p. 2). Hospitals and surgeons need to be careful with respect to the safety impact of readmissions. However, there is no widely accepted screening metric that allows for safe outpatient arthroplasty procedures (Hoffmann et al., 2018, p. 1265). The optimal candidate for outpatient arthroplasty remains to be defined. This leads to much variation between healthcare providers regarding the number and characteristics of patients that are treated in an outpatient setting.

The article of Sibia et al. (2017, p. 53) investigated the relationship between a shorter length of stay at the hospital on the number of readmissions after joint arthroplasty. They found no difference between patients who stayed in the hospital for one day and patient who stayed in the hospital for two days with respect to the readmission rate. Moreover, in the article of Vorhies, Wang, Herndon, Maloney, and Huddleston (2011, pp. 120-121) they found no increase in the readmission rate when there was a reduction in length of stay after total hip arthroplasty. This means that there is no evidence found that outpatient total knee and hip arthroplasty lead to better outcomes than inpatient total knee and hip arthroplasty.

Since this study looks from the perspective of the health insurance company, it only focuses on waiting times, postoperative physical therapy in the hospital and length of hospital stay. These are the healthcare related activities that are declared at health insurance companies by different healthcare providers. Preoperative physical therapy and physical therapy after discharge from the hospital are not included in this research, since health insurance companies have no insight into this data.

3. Hypotheses and research model: Physical therapy and price agreements are hypothesised to have a positive effect on quality of care, and waiting times and length of stay are hypothesised to have a negative effect on quality of care

3.1 The relationship between waiting time and quality of care

As discussed in Chapter 2, the studies of Fielden et al. (2005, p. 994) and Ostendorf et al. (2004, p. 302) both found that waiting time have a negative effect on the quality of care after total knee and hip arthroplasty. However, the study of K. Kelly et al. (2001, p. 351) found no change in pain and physical function when patients need to wait longer for their total knee or hip arthroplasty. A reason why this article found no effect of waiting times on quality of care, can be that the health status of the patient has an influence on the waiting time. This is examined in the study of K. D. Kelly et al. (2000, p. 877), where they found that an increased body mass index and a decreased social function are determinants of waiting time.

The average waiting time for total knee arthroplasty and total hip arthroplasty is around seven weeks in the Netherlands (Volksgezondheid en zorg, 2016, p. 1). When patients need to wait longer for total knee or hip arthroplasty than the average of 7 weeks, this can have a negative effect on the outcomes of total knee or hip arthroplasty. According to the study of Ghomrawi et al. (2020, p. 468) waiting too long for total knee arthroplasty can cause limitations in the physical activity that in turn increase the risk of chronic disease and additional disability. When people need to wait too long for their total knee or hip arthroplasty, they cannot be as active as normal which can cause weight gain, depression or other health related problems. Moreover, Ghomrawi et al. (2020, p. 473) state that patients who undergo total knee or hip arthroplasty when their function is very deteriorated may improve quite a bit, but their improvement is still not to the average. Therefore, the first hypothesis is formulated as follows:

H1: A waiting time of more than the average of 7 weeks for total knee or hip arthroplasty has a negative effect on quality of care (increases H1a: the number of readmissions and H1b: the number of revisions)

According to Vergara, Bilbao, Gonzalez, Escobar, and Quintana (2011, p. 1416) patients with lower pain levels and better physical function have longer waiting times before they get total hip arthroplasty. This suggest that patients who are healthier should wait longer for surgery and should have better clinical outcomes. However, Vergara et al. (2011) also found that the suboptimal selection of patients for total hip arthroplasty have clinical consequences in function gain that affect the quality of the clinical care. Therefore, selecting patients not in the right way could lead to a worse quality of care after total hip arthroplasty.

H1c: *The presence of comorbidities of the patient waiting for total knee or hip arthroplasty moderates the negative effect of waiting time on the quality of care*

3.2 The relationship between postoperative physical therapy and quality of care

As discussed in Chapter 2, the article of DeJong et al. (2011, p. 1832) found a negative relationship between physical therapy and quality of care, but focused primarily on physical therapy without concurrently considering the interventions that physical therapists used when patients participated in physical therapy activities. This research focuses on inpatient physical therapy sessions only, whereby patients perform a number of activities that correspond to the guidelines (Koninklijk Nederlands Genootschap voor Fysiotherapie, 2018, pp. 11-12). The article of Artz et al. (2015, p. 16) has proven that it has a positive influence on the rehabilitation in the short term, but misses the evidence that this will also be positive in the long-term. However, the articles of Pua et al. (2017, p. 462) and Sarpong et al. (2019, p. 2931) provide a positive influence on the rehabilitation and are recently performed. Therefore, the second hypothesis is formulated as follows:

H2: Postoperative physical therapy in the hospital after total knee or hip arthroplasty lead to a higher quality of care (reduces H2a: the number of readmissions, H2b: the number of revisions and H2c: the number of requests for opioids)

Besides, in the article of Sarpong et al. (2019, p. 2931) they evaluate the effect of same-day physical therapy on in hospital functional outcomes and opioid consumption. They found that the cohort who started physical therapy on the day of surgery had a significantly shorter length

of stay, were more discharged home and consumed significantly fewer opiates than the cohort who received physical therapy on the first postoperative day. Moreover, in the study of Warwick et al. (2019, p. 4) they found that patients who did not received physical therapy immediately after total joint arthroplasty, had a higher 30-day readmission rate compared to patients who did receive physical therapy immediately after total knee arthroplasty. This study suggests that early physical therapy may help reduce 30-day readmissions. Therefore, the third hypothesis is formulated as follows:

H3: Physical therapy on the day of total knee arthroplasty or total hip arthroplasty has a positive effect on quality of care (reduces H3a: the number of readmissions, H3b: the number of revisions and H3c: the number of requests for opioids)

3.3 The relationship between length of hospital stay and quality of care

As discussed in Chapter 2, the studies of Sibia et al. (2017, p. 53) and Vorhies et al. (2011, pp. 120-121) found no evidence that outpatient total knee arthroplasty and total hip arthroplasty leads to better outcomes than inpatient total knee arthroplasty and total hip arthroplasty. However, these studies focused on the difference between inpatient and outpatient total knee or hip arthroplasty. In the article of Meermans et al. (2020, p. 184) they found that the average length of stay in the Netherlands after total joint arthroplasty is around three days. When patients need to stay longer in the hospital than 3 days, this can be due to patient-related risk factors. The study of Zhang et al. (2018, p. 3) examined factors that were significantly associated with prolonged length of hospital stay after total knee arthroplasty. They found that prolonged length of hospital stay was positively associated with an increased visual analogue scale pain score. This suggest that patients with a longer hospital stay had more pain after total knee arthroplasty and needed more opioids to manage the pain. According to the study of Piuzzi et al. (2019, p. 1093) a longer length of hospital stay than three days was predicted by an older age, higher Body Mass Index, higher Charlson Comorbidity Index and female sex. These patient-related risk factors increase the length of stay after total joint arthroplasty due to a higher chance of having complications. Therefore, the fourth hypothesis is formulated as follows:

H4: A length of hospital stay of more than three days after total knee or hip arthroplasty has a negative effect on quality care (increases H4a: the number of readmissions, H4b: the number of revisions, H4c: the number of requests for antibiotics and H4d: the number of requests for opioids)

3.4 The relationship between price agreements and quality of care

As mentioned earlier, total knee arthroplasty and total hip arthroplasty are very successful and common performed orthopaedic surgical procedures, which leads to pain relief and demonstrate consistently good or even excellent functional outcomes (Kane et al., 2005, p. 1723). However, there is a variability in both the quality and price agreements of these procedures, which results in a wide difference in their value. According to Porter, value is defined by outcomes divided by costs (Value-Based Health Care Center Europe, 2010, p. 1). One concept of Value-Based Healthcare is P4P in healthcare. P4P comprises payment models that attach financial incentives or disincentives to provider performance. This can support healthcare providers to metric-driven outcomes, proven best practices and patient satisfaction, thus aligning payment with value and quality. When hospitals have a low readmission rate they can have a better price agreement with the health insurance company than when their readmission rates are higher (NEJM Catalyst, 2018, p. 1). Therefore, higher price agreements between the healthcare provider and health insurance company can support a better performance of the healthcare provider.

Since there is no transparency in literature about price agreements of total knee arthroplasty and total hip arthroplasty, the average price agreement of one of the biggest health insurance companies in the Netherlands with all healthcare providers in the Netherlands is considered as the average price agreement for this hypothesis. Therefore, the fifth hypothesis is formulated as follows:

H5: A price agreement between the health insurance company and a healthcare provider that is higher than the average price agreement of €X for total knee arthroplasty and €X for total hip arthroplasty has a positive effect on the quality of care (decreases H5a: the number of readmissions)

3.5 Control variables

Previous literature state that some extraneous factors can influence the risk of having complications after total knee or hip arthroplasty. In the article of Falvey et al. (2016, p. 1126) they found that these risk factors include access to care, age, medical complexity, comorbidities, length of hospital stay and impaired physical function. The access to care is well arranged in the Netherlands. Patients can visit the general practitioner with complaints and will receive a referral to a hospital when necessary. Therefore, this factor is not included in this research.

Comorbidities of the patient have an influence on the quality of care after total knee or hip arthroplasty. In the article of Hoyer et al. (2014, p. 277) they state that functional status near the time of discharge is strongly associated with readmissions. In a study performed by J. A. Singh, Inacio, Namba, and Paxton (2015, pp. 721-723) they found that rheumatoid arthritis is a risk-factor for 90-day readmission after total knee arthroplasty or total hip arthroplasty. Besides, the study of Saucedo et al. (2014, p. 256) found an increased likelihood of readmission with coronary artery disease. Moreover, McGee et al. (2018, p. 6) found that 31.6% of patients with a readmission had a coronary artery disease, compared to 6.5% of patients without a coronary artery disease. Since comorbidities can have an influence on the functional status after total knee arthroplasty or total hip arthroplasty, it is important to consider them when analyzing quality of care (Marques, Cruz, Rego, & da Silva, 2016, p. 15).

The age of the patient is important when undergoing total knee or hip arthroplasty. The article of Yu et al. (2019, p. 96) found adjusted rates of risk when a patient is over 80-85 years. The article of Paula, Cunha, Leite, Pinheiro, and Valente (2016, p. 5) found that the risk of readmission was higher for individuals more than 79 years old. Moreover, the article of Malkani et al. (2017, p. 2878) found that 21% elderly patients were readmitted after total hip arthroplasty compared to 12% of the younger group. Reasons why elderly patients have a higher risk for readmissions, is that they are at increased risk of dislocation, venous thromboembolism, complications and mortality (Malkani et al., 2017, p. 2878). Bayliss et al. (2017, pp. 1427-1428) found that the lifetime risk of requiring a revision surgery in patients who had total knee arthroplasty over the age of 70 was around 5%. For those who had total knee arthroplasty and were younger than 70 years, the lifetime risk of requiring a revision increased for younger

patients, up to 35% for men in their early 50s. Kuo, Raji, Chen, Hasan, and Goodwin (2016, pp. 4-5) state that elderly patients are more likely to develop persistent opioid use after surgery. Besides, the study of Hamina et al. (2017, p. 252) found that an age above 80 years is a risk factor for excessive opioid use. Moreover, the study of Sun, Darnall, Baker, and Mackey (2016, pp. 1290-1292) identified that the point at which age became a risk factor for excessive opioid use was over 50 years. However, other studies have shown that a younger age has been associated with postoperative opioid overuse. The study of Clarke, Soneji, Ko, Yun, and Wijeysundera (2014, p. 3) found that opioid use 90 days after surgery was higher in the younger age group.

With respect to gender, the article of Singh, Kwoh, Richardson, Chen, and Ibrahim (2013, p. 1098) found that the odds of 30-day readmission were significantly higher for men compared to women. Moreover, Schröder et al. (2016, p. 1803) studied the relationship between gender and use of antibiotics. They found that women were 27% more likely than men to receive an antibiotic prescription in their lifetimes. In an article from Aghdassi, Schröder, and Gastmeier (2019, p. 3) they studied the gender-related risk factors for surgical site infections. They found that the incidence rate ratio and the adjusted odds ratio for surgical site infections were significantly higher for male patients. Moreover, the study of Hamina et al. (2017, p. 252) found that women have a higher risk for opioid use than men. However, the study of Sun et al. (2016, pp. 1290-1292) state that opioid use has been reported more in male patients after total knee arthroplasty. This study found that women use more opioids than men.

Quality of care is different among all healthcare providers in the Netherlands. Some hospitals are really focused on specific medical specialties, whereas academic hospitals mostly have to deal with the most complex patients. There are different quality marks available that give insight in the quality healthcare providers perform. One of these quality criteria is the death rate. The death rate can be expressed in the Hospital Standardized Mortality Ratio (HSMR). The HSMR is an outcome measure that indicates whether there are more or less patients who died in the hospital than expected, based on the patient profile. A ratio of 100 suggests that the percentage of deceased patients is exactly as expected. Factors such as age, severity of the condition, additional conditions and urgency of admission are considered, since these factors play a role in

the chance of survival (DHD: Zorg voor Data, 2020). Therefore, the HSMR tells something about the quality a hospital delivers and could have an influence on the outcomes after total knee or hip arthroplasty. Length of hospital stay is also an important control variable, since patients who stay longer in the hospital will have more inpatient physical therapy. This might influence the chance of getting a readmission (Dossett & Chesser, 2017, p. 40). Therefore, when looking at inpatient physical therapy, it is important to keep in mind the length of hospital stay.

Taking in consideration the above-mentioned literature about risk factors for total knee arthroplasty and total hip arthroplasty, the variables comorbidities, hospital HSMR, age and gender will be included as control variables in the research model. The variable physical therapy will be corrected for length of hospital stay. Based on the previously established hypotheses and control variables, the following research model was derived. Figure 1 gives an overview of this research model.

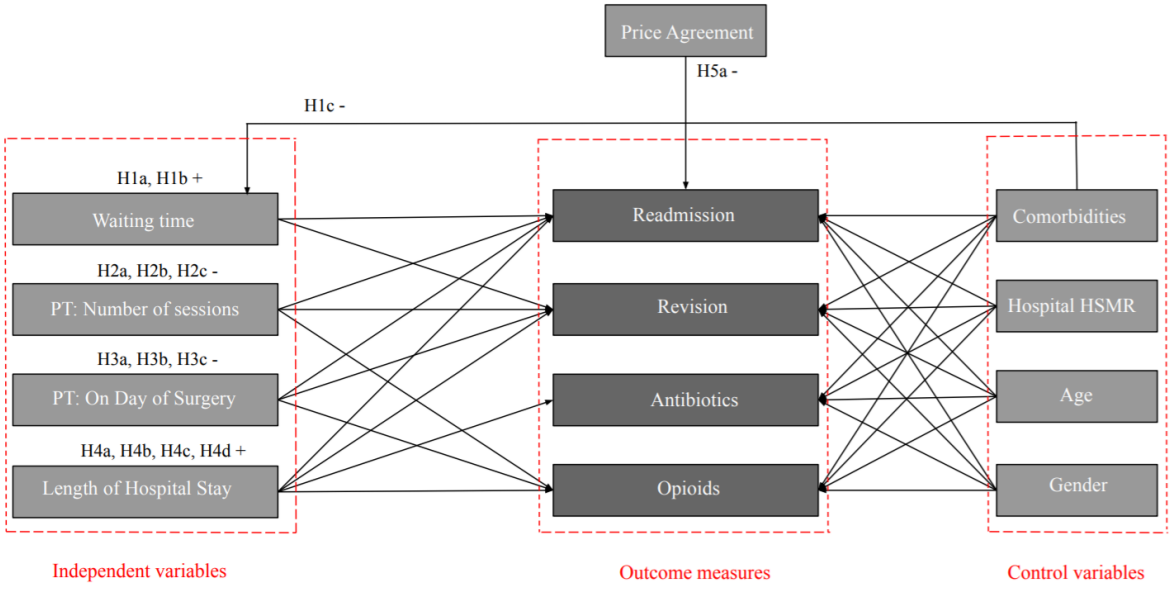

Figure 1: Research model

The section that follows will present the methods to be used to find support for the previously derived hypotheses.

4. Methods: PLS path modelling using SmartPLS3 to determine variables that influence quality of care after total knee and hip arthroplasty

4.1 About Company X

Company X is a health insurance company located in the Netherlands. It is the fourth biggest health insurance company (De Nederlandsche Bank, 2017, p. 1). Their market share is mostly located in the north and east of the Netherlands. Together with their members, health care providers, patient associations and other partners, Company X is committed to maintain the accessibility and affordability of care. They achieve this by supporting projects and research that improve the quality of health care. This support makes the movement possible towards a new organization of care (Company X, 2019, p. 1).

4.2 Study design

To study the hypotheses provided in Chapter 3, data is derived from the declaration database of Company X. This declaration database contained sensitive information on patient level. Person X (database analyst Company X) created a data query in Microsoft SQL Server Management Studio, which only include data that is relevant for this research. It included demographical data, data related to performed care activities and corresponding price agreements. This database can deliver clear healthcare insights and smart processes, which enables effective and efficient decision-making and implementation within the healthcare market.

This research investigated the effect of four independent variables, namely (1) waiting time, (2) physical therapy – number of sessions, (3) physical therapy – on day of surgery and (4) length of hospital stay on the dependent variable quality of care. Quality of care is expressed in four outcome measures, namely (1) readmission within 30 days, (2) revision within two years, (3) request for antibiotics and (4) request for opioids. These variables were investigated for both total knee and hip arthroplasty. Besides the independent variables and outcome measures, the data query contained anonymized demographical data, whereby the patient number was changed into a random number. The variables price agreement, comorbidities (cardiovascular disease, diabetes, respiratory disorder and rheumatoid arthritis), HSMR score, age and gender were included as control variables.

To determine the cut-off values of readmission and revision, the reference guide from International Consortium for Health Outcomes Measurement (2017, p. 28) was used. This report state that readmissions should be measured 30 days after total knee or hip arthroplasty and revision should be measured on a continuous base. Since there is data available up to and including 2018, the number of revisions was measured two years after total knee or hip arthroplasty. For the postoperative pain management there is a guideline available, which advices that opioids should be prescribed at their lowest dose and for the shortest duration necessary to control symptoms (Lespasio, Guarino, Sodhi, & Mont, 2019, p. 1). There is already a misuse epidemic in the United States and also in the Netherlands the past years showed signals of an increase in the prescription of opioids such as oxycodone, morphine and fentanyl (van Amsterdam & van den Brink, 2015, p. 9). Opioids are prescribed directly after total knee and hip arthroplasty. The "Nederlands Instituut voor Onderzoek van de Gezondheidszorg" found that the median duration for an opioid prescription is 30 days (Weesie, 2016, p. 25). Since the risk is too high that opioids are prescribed for something else than pain management more than 30 days after total knee or hip arthroplasty, this study used a cut-off value of 30 days after total knee or hip arthroplasty. There is no clear guideline available that states in which timeframe antibiotics should be prescribed after total knee or hip arthroplasty. This is dependent on the time the infection is detected. It is important to not use a cut-off value that is too far away from the total knee or hip arthroplasty, since this request for antibiotics can be for something else than wound infection. In comparable studies they mostly included patients getting wound infection up to and including 30 days after total knee or hip arthroplasty, so this study used a cut-off value of 30 days after total knee or hip arthroplasty (Feng et al., 2017, p. 2552; Naqvi et al., 2017, p. 377; Santeon, 2018, p. 14).

Table 3 and table 4 give an overview of the variables discussed above with corresponding description. It also provides an overview of the measurement levels.

Variable	Description	Measurement	Range and Coding
Waiting time	The number of days between diagnosis and total knee/hip arthroplasty	Dichotomous	0 (less than 49 days between diagnosis and surgery) or 1 (more than 49 days between diagnosis and surgery)
Physical therapy – Number of sessions corrected for length of hospital stay	The number of individual sessions of regular physical therapy performed in the hospital divided by the length of hospital stay	Continuous	0 – 4 sessions of individual sessions of regular physical therapy in the hospital per day
Physical Therapy – On surgery date	Whether the patient received physical therapy on the day of surgery	Dichotomous	0 (no physical therapy on day of surgery) or 1 (physical therapy on day of surgery)
Length of hospital stay	The number of nursing days in the hospital after total knee/hip arthroplasty	Dichotomous	0 (less than 3 days in hospital after surgery) or 1 (more than 3 days in hospital after surgery)
Price agreement	The price that healthcare provides receive from the health insurance company when performing a total knee or hip arthroplasty	Dichotomous	0 (the price agreement is below the average price agreement) or 1 (the price agreement is above the average price agreement)
Comorbidities	Whether the patient has comorbidities in the field of cardiovascular disease, diabetes, respiratory disorders and/or rheumatoid arthritis in 2016 or 2017	Dichotomous	0 (no comorbidities in 2016/2017) or 1 (there were comorbidities in 2016/2017)
HSMR score	Whether the patient had a total knee/hip arthroplasty in a hospital below or above 100 HSMR	Dichotomous	0 (HSMR is below 100) or 1 (HSMR is above 100)
Age	The age of the patient	Continuous	17 – 96 years old
Gender	The gender of the patient	Dichotomous	0 (man) or 1 (woman)

Table 3: Overview of the independent variables used in this research

Outcome measure	Description	Measurement	Range and Coding
Readmission within 30 days	Whether there are complications as a result of total knee/hip arthroplasty within 30 days after surgery, whereby the needs to be admitted to the hospital	Dichotomous	0 (no readmission) or 1 (readmission <30 days) (International Consortium for Health Outcomes Measurement, 2017, p. 28)
Revision within two years	Whether the patient needs surgery due to complications or whether the knee or hip protheses needs to be removed and re-implanted	Dichotomous	0 (no revision) or 1 (revision <2 years) (International Consortium for Health Outcomes Measurement, 2017, p. 28)

Prescription for antibiotics within 30 days	Whether the patient requested a prescription for antibiotics	Dichotomous	0 (no request for antibiotics) or 1 (request for antibiotics <30 days) (Feng et al., 2017, p. 2552) (Naqvi et al., 2017, p. 377)
Prescription for opioids within 30 days	Whether the patient requested a prescription for opioids	Dichotomous	0 (no request for opioids) or 1 (request for opioids <30 days) (Weesie, 2016, p. 25)

Table 4: Overview of the outcome measures of the dependent variable quality of care

The data query contained data derived from 2017, except for the data related to comorbidities. This data is derived from the period 2016-2017. The reason for this chosen timeframe is that in this research, only comorbidities before total knee or hip arthroplasty were relevant. Since all total knee and hip arthroplasties in 2017 were investigated, comorbidities should be present in 2016. Otherwise there is a chance that the patient does not suffer from the comorbidity anymore.

To determine which comorbidities should be included, a mini interview was conducted with Person Y and Person Z. Person Y is a medical advisor at Company X, specialized in cardiology and Person Z is a medical advisor at Company X, specialized in primary care. During this interview, Person Y and Person Z gave advice which comorbidities are relevant regarding total knee and hip arthroplasty. Person Y and Person Z both agreed that cardiovascular diseases, diabetes, respiratory disorders and rheumatism are relevant comorbidities which can influence quality of care. Besides, they gave advice which types of antibiotics and opioids are prescribed for wound infection and pain relief after total knee and hip arthroplasty. Appendix 1 shows the notes which are made during this interview.

Table 5 provides characteristics of the variables and the distribution of the groups. The data contained 7.543 arthroplasty cases in total, from which 3.818 cases were total knee arthroplasties and 3.725 cases were total hip arthroplasties.

Independent variables	Mean	St. Dev	Distribution of groups	
			0	1
Waiting Time	50.4	29.8	50.2%	49.8%
Physical Therapy – Number of sessions	0.7	0.6	-	-
Physical Therapy – On day of surgery	-	-	48.2%	51.8%
Length of Hospital Stay	3.8	2.1	58.5%	41.5%
Price agreement	-	-	43.0%	57.0%
Cardiovascular disease	-	-	86.1%	13.9%
Diabetes	-	-	97.5%	2.5%
Respiratory Disorders	-	-	96.7%	3.3%
Rheumatoid Arthritis	-	-	98.0%	2.0%
HSMR score	88.0	31.7	64.1%	35.9%
Age	68.2	9.8	-	-
Gender	-	-	34.9%	65.1%
Dependent variables	**Mean**	**St. Dev**	**Distribution of groups**	
			0	1
Readmissions	-	-	97.5%	2.5%
Revisions	-	-	97.7%	2.3%
Request for opioids	-	-	43.4%	56.6%
Request for antibiotics	-	-	97.0%	3.0%

Table 5: Characteristics of the independent and dependent variables

There were in total 89 different hospitals included who performed total knee and hip arthroplasty surgeries. However, only twelve hospitals performed more than 100 total knee or hip arthroplasties in 2018. Table 6 and 7 gives an overview of the twelve hospitals with the number of performed total knee and hip arthroplasties and corresponding price agreement. Moreover, the table give insight in the percentage infections and the percentage revisions. The number of treated patients in all other hospitals can be found in appendix 2.

Hospital	Number of knee patients	Percentage readmissions	Percentage revisions	Price Agreement knee
Restricted				

Table 6: Number of patients per hospital with price agreement for total knee arthroplasty

Hospital	Number of hip patients	Percentage readmissions	Percentage revisions	Price Agreement hip
Restricted				

Table 7: Number of patients per hospital with price agreement for total hip arthroplasty

4.3 Data analysis

The data query is written in Microsoft SQL Server Management Studio 2014. This is done by Person X, database analysist at Company X. After that, the data was transferred to Microsoft Excel 2016 to organize the data and convert it into the right measurement levels. Thereafter, the data was transferred to SmartPLS3 to perform analyses. SmartPLS3 is a tool for latent variable modelling. Three calculation methods were used, namely the Consistent Partial Least Squares (PLSc) Algorithm, the PLSc Bootstrapping method and the PLSc Multigroup Analysis. This is used to determine which variables have an influence on quality of care.

Considering the quality criteria of the independent variables, convergence reliability tests reveal that Cronbach's alpha scores are all 1.0, which is above the threshold of 0.7. All variables score 1.0 on the Composite Reliability test, which is above the threshold of 0.7. Moreover, Average Variance Extracted values are all 1.0. Discriminant Validity is also supported, since Variance Inflation Factors is below 4 and all values for the Heterotrait-Monotrait ratio below 0.85. Table 8 and table 9 give an overview of the latent variable correlations.

Data was then transferred to SmartPLS3 in order to run structural equation models. The following section will present the results from the analyses conducted with the data.

	1	2	3	4	5	6	7	8	9	10	11	12
1 Waiting Time	1											
2 PT: Number of Sessions	.02	1										
3 PT: On Day of Surgery	.04**	.60**	1									
4 Length of Hospital Stay	-.04*	-.04*	-.12**	1								
5 Price Agreement	.05**	.28**	.23**	-.02	1							
6 Cardiovascular Disease	-.01	.05**	-.01	.06**	.02	1						
7 Diabetes	.00	-.01	.00	.05**	-.01	.03	1					
8 Respiratory Disorders	-.01	.01	.00	.04**	-.02	.02	.03	1				
9 Rheumatoid Arthritis	-.02	.00	-.01	.02	.02	.02	.00	.03	1			
10 Hospital HSMR	.05**	.08**	.18**	.04**	.02	-.02	.04*	-.03	.01	1		
11 Age	-.03	.03	.01	.13**	-.03	.17**	.01	.00	-.02	.02	1	
12 Gender	-.02	.02	.01	.10**	-.02	-.06**	.01	-.01	.04**	.00	.04*	1

Table 8: Latent variable correlations for total knee arthroplasty

** = significant at α<0.01
* = significant at α<0.05

	1	2	3	4	5	6	7	8	9	10	11	12
1 Waiting Time	1											
2 PT: Number of Sessions	-.02	1										
3 PT: On Day of Surgery	.02	.57**	1									
4 Length of Hospital Stay	-.02	-.02	-.04*	1								
5 Price Agreement	.01	.30**	.31**	.09**	1							
6 Cardiovascular Disease	.00	.02	-.01	.08**	.01	1						
7 Diabetes	-.01	-.01	-.01	.05**	-.05**	.06**	1					
8 Respiratory Disorders	.01	.03	-.01	.06**	.03	.02	.01	1				
9 Rheumatoid Arthritis	-.03	.00	-.01	.02	.01	-.03	.01	.03	1			
10 Hospital HSMR	.02	.11**	.20**	.10**	.09**	.00	-.00	.03	.01	1		
11 Age	-.01	.03	.01	.16**	-.01	.18**	-.02	.00	-.01	.03*	1	
12 Gender	.02	-.01	.01	.09**	.00	-.05**	-.04*	.01	.00	-.04*	.14**	1

Table 9: Latent variable correlations for total hip arthroplasty

** = significant at α<0.01
* = significant at α<0.05

5. Results: Variables of physical therapy as major influences on the quality of care after total knee arthroplasty and total hip arthroplasty

5.1 Influences on the quality of care after total knee arthroplasty

Results of the first model, which measured differences in readmission within 30 days, revision within 2 years, request for antibiotics within 30 days and request for opioids within 30 days after total knee arthroplasty, showed significant influences of one control variable on the number of revisions, two control variables on the number of requests for antibiotics and two control variables on request for opioids. The variable revision within 2 years was significantly influenced by age (β = -0.062; t-value = 3.398; f^2 = 0.004; α = 0.001). The variable request for antibiotics was significantly influenced by gender (β = -0.033; t-value = 2.088; f^2 = 0.001; α = 0.037) and respiratory disorders (β = 0.052; t-value = 2.055; f^2 = 0.003; α = 0.040). The variable request for opioids was significantly influenced by age (β = -0.056; t-value = 3.237; f^2 = 0.003; α = 0.001) and gender (β = 0.063; t-value = 4.250; f^2 = 0.004; α = 0.000).

The results show no support for the hypothesis concerning the influence of waiting time on quality of care (H1), length of hospital stay on quality of care (H4) and price agreements on quality of care (H5) after total knee arthroplasty. Furthermore, the results show no support for the hypothesis concerning the number of physical therapy sessions on quality of care after total knee arthroplasty (H2). However, the hypothesized negative effect of number of physical therapy sessions on the number of readmissions (H2a) is found to be positive significant (β = 0.157; t-value = 2.797; f^2 = 0.015; α = 0.005). This means that people with a higher number of physical therapy sessions in the hospital after total knee arthroplasty, has a significantly higher chance of having a readmission within 30 days. The hypothesized negative effect of physical therapy on the day of total knee arthroplasty on the number of readmissions (H3a) is supported by the results of the analyses (β = -0.127; t-value = 4.131; f^2 = 0.010; α = 0.000). However, there are no significant effects found between physical therapy on the day of surgery on the number of revisions and the number of requests for opioids (H3b, H3c). The results are depicted in figure 2 and appendix 3. Additionally, the next section will present results of the other model to provide accompanying insights into the influences on quality of care after total hip arthroplasty.

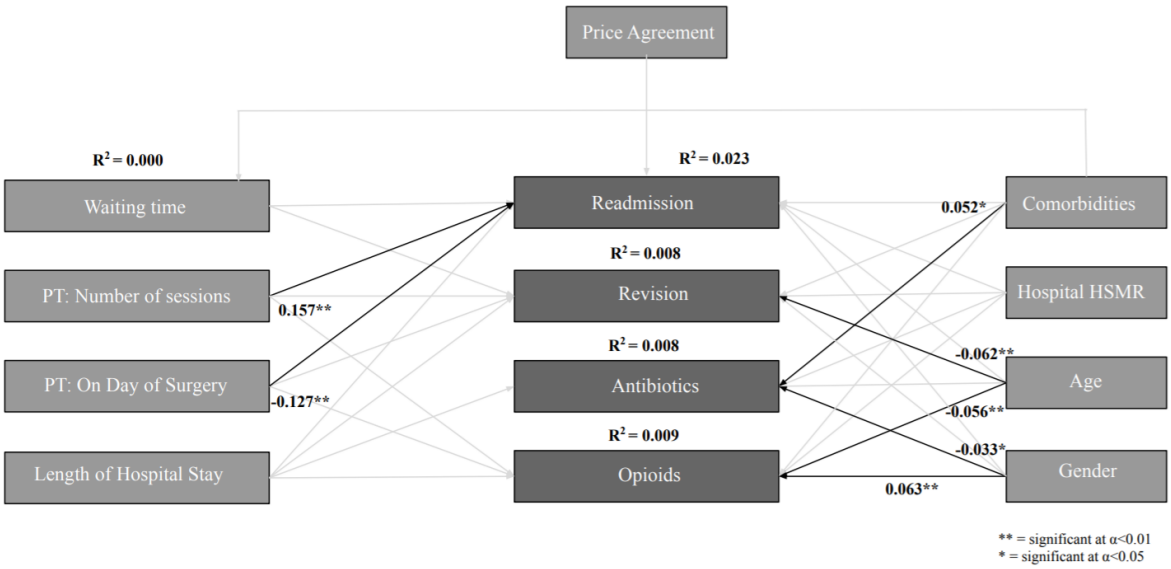

Figure 2: Research Model with β-values and significances total knee arthroplasty

5.2 Influences on the quality of care after total hip arthroplasty

Results of the second model, which measured differences in readmission within 30 days, revisions within 2 years, request for antibiotics within 30 days and request for opioids within 30 days after total hip arthroplasty, showed significant influences of three control variables on the number of readmissions, one control variable on the number of revisions and one control variable on the number of requests for opioids. The variable readmissions within 30 days was significantly influenced by age ($\beta = 0.039$; t-value = 2.582; $f^2 = 0.002$; $\alpha = 0.010$), cardiovascular disease ($\beta = 0.079$; t-value = 3.637; $f^2 = 0.006$; $\alpha = 0.000$) and gender ($\beta = -0.043$; t-value = 2.472; $f^2 = 0.002$; $\alpha = 0.014$). The variable number of revisions was significantly influenced by age ($\beta = 0.031$; t-value = 2.085; $f^2 = 0.001$; $\alpha = 0.038$). The variable request for opioids was significantly influenced by age ($\beta = -0.035$; t-value = 2.062; $f^2 = 0.001$; $\alpha = 0.040$).

The results showed support for one hypothesis concerning the influence of waiting time on the number of readmissions after total hip arthroplasty (H1a). Waiting time has a significant positive effect on the number of readmissions ($\beta = 0.042$; t-value = 2.662; $f^2 = 0.002$; $\alpha = 0.008$). The results show no support for the hypotheses concerning the influence of waiting time on the number of revisions after total hip arthroplasty (H1b). Furthermore, the results show no support

for the hypotheses concerning the influence of the number of physical therapy sessions on quality of care (H2). However, the hypothesized negative effect of number of physical therapy sessions on the number of readmissions (H2a) is found to be positive significant (β = 0.247; t-value = 5.856; f^2 = 0.042; α = 0.000). This means that people with a higher number of physical therapy sessions in the hospital after total hip arthroplasty, has a significantly higher chance of having a readmission within 30 days. The hypothesized negative effect of physical therapy on the day of total hip arthroplasty on the number of readmissions (H3a) was supported by the results of the analyses (β = -0.174; t-value = 7.178; f^2 = 0.020; α = 0.000). This means that the chance of getting a readmission is lower when the patient received a physical therapy session on the day of surgery. There was no significant effect found between physical therapy on the day of surgery on the number of revisions (H3b) and the number of requests for opioids (H3c). Furthermore, the hypothesised effect of length of hospital stay after total hip arthroplasty on the number of readmissions (H4a) was found to be positive significant (β = 0.034; t-value = 1.990; f^2 = 0.001; α = 0.047). This means that patients who had a longer stay at the hospital after total hip arthroplasty, had a higher chance of getting a readmission within 30 days. Last, the hypothesized positive effect of price agreement on the number of readmissions (H5a) was found to be negative significant (β = -0.058; t-value = 3.774; f^2 = 0.003; α = 0.000). The results are depicted in figure 3 and appendix 4.

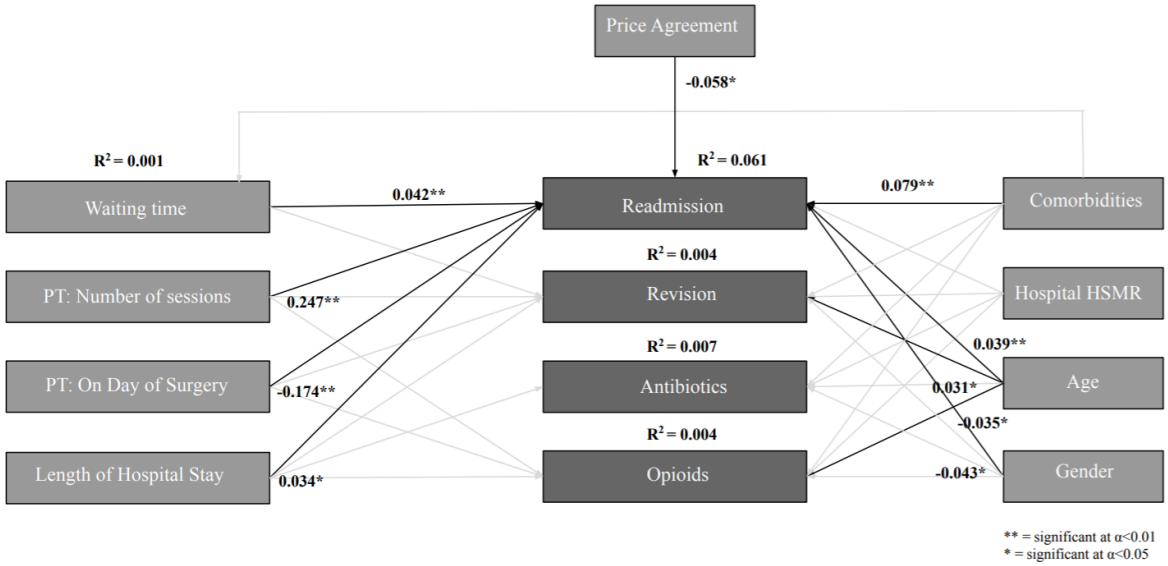

Figure 3: Research Model with β-values and significances total hip arthroplasty

5.3 Multigroup Analysis to compare two groups: difference between the two groups with respect to physical therapy on day of surgery on the number of readmissions

To analyse the difference between the total knee arthroplasty patients and total hip arthroplasty patients, a multigroup analysis is performed. Appendix 5 and figure 4 shows these β-values with corresponding t-statistic and p-value. Table 10 provides the legend with information how to interpret figure 4. There is a significant difference between the total knee arthroplasty group and the total hip arthroplasty group according to three control variables. There is a negative significant difference between the two groups in the effect of cardiovascular disease on the number of requests for antibiotics (β = -0.056; t-value = 2.190; f^2 = 0.000 α = 0.029) and in the effect of gender on number of requests for opioids (β = -0.053; t-value = 2.396; f^2 = 0.001 α = 0.017) and a positive significant difference in the effect of age on the number of revisions (β = 0.092; t-value = 3.730; f^2 = 0.000 α = 0.000).

Relationship	B-value Hip	B-value Knee	B-value Difference (hip-knee)
Comorbidities - Antibiotics	-0.020	0.036	-0.056*
Age - Revision	0.030**	-0.062*	0.092*
Gender - Opioids	0.010	0.063*	-0.053*

Table 10: Legend for multigroup analysis

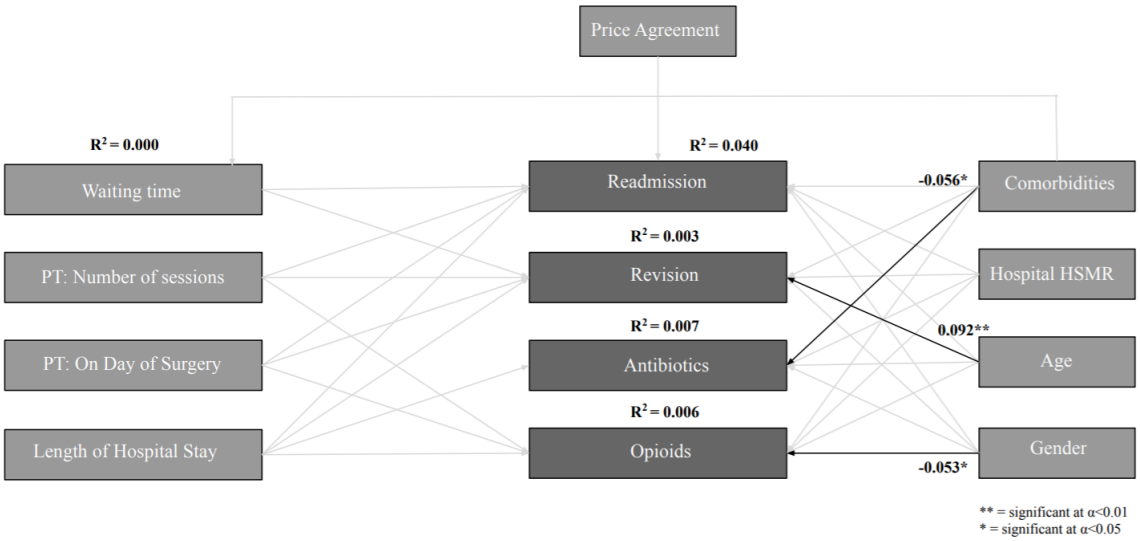

Figure 4: Research Model with β-values and significances multigroup analysis

6. Discussion of the results about quality of care after total knee arthroplasty and total hip arthroplasty

This chapter provides a summary about the main findings of both the analyses of total knee and hip arthroplasty and discusses all significant and non-significant relations that are hypothesized in chapter 3. These relations are discussed per independent variable. Then the significant relations between the control variables and quality of care will be discussed. Lastly the recommendations for future research will be presented and the limitations will be discussed.

6.1 Relationship between waiting time and number of readmissions and revisions

This study found that there is a positive significant relationship between waiting time and number of readmissions after total hip arthroplasty. In the literature is found that patients' health status deteriorate while waiting for total hip arthroplasty (Fielden et al., 2005, p. 994) and that a considerable loss of quality adjusted life years is found, which is occurred by postponing surgery (Ostendorf et al., 2004, p. 302). This is in line with the finding that waiting time have a positive effect on the number of readmissions.

There is no significant relationship found between waiting time and the number of readmissions and revisions after total knee arthroplasty and the number of revisions after total hip arthroplasty. This is in line with the study of K. Kelly et al. (2001, p. 351) who found minimal amounts of change in pain and physical function occurred for total knee arthroplasty and total hip arthroplasty patients while they waited. This supports the insignificant relations found in this research. Reasons for the fact that some findings suggest no relationship between waiting time and quality of care can be that not every health aspect of the patient is considered. This research only focused on cardiovascular disease, diabetes, pulmonary disorders and rheumatoid arthritis. Since the study of K. D. Kelly et al. (2000, p. 877) found that an increased body mass index and a decreased social function are also determinants of waiting time, more comorbidities should be taken into consideration in future research. This could make the relationship between waiting times and number of readmissions and revisions after total knee arthroplasty and the number of revisions after total hip arthroplasty significant, since more aspects are taken into

consideration which might be relevant for the outcomes after arthroplasty. However, this is an assumption and should be investigated in future research.

6.2 Relationship between the number of physical therapy sessions and the number of readmissions, revisions and opioids

This study found that for both total knee arthroplasty as total hip arthroplasty, there is a positive significant influence of the number of physical therapy sessions on the number of readmissions. This is not in line with the article of Pua et al. (2017, p. 462) who found that postoperative physical therapy is associated with an increase in self-reported physical function. Moreover, the article of Freburger (2000, p. 448) state that physical therapy lead to an increased probability of discharge home. However, a reason for the positive significant relationship that has been found in this research, is that the given strain on the patient from too much exertion can lead to negative outcomes of the surgery. This could lead to complications which causes more readmissions. The article of Moses et al. (2018, p. 943) found no difference in 90-day readmission rates between a non-intensive cohort and an intensive cohort. A reason for this can be that the article of Moses measured readmissions 90 days after surgery and this research only focused on readmissions within 30 days. This is in line with the article of Artz et al. (2015, p. 16) who found no long-term benefits for patients after total knee arthroplasty. There is also no significant relationship found between number of physical therapy sessions and number of revisions and number of requests for opioids. This is in line with the study of DeJong et al. (2011, p. 1832) who found no evidence that physical therapy has a positive influence on the function of the patient.

6.3 Relationship between physical therapy on the day of surgery and the number of readmissions, revisions and opioids

This study found that for both total knee and hip arthroplasty there is a negative significant influence of physical therapy on the day of surgery on the number of readmissions. This is in line with the article of Warwick et al. (2019, p. 4), who found that patients who did not received physical therapy immediately after total joint arthroplasty, had a higher 30-day readmission rate compared to patients who did receive physical therapy immediately after total knee arthroplasty. Moreover, the study of Sarpong et al. (2019, p. 2931) found that people were more discharged

home when they had physical therapy on the day of surgery. This confirms the results of this study, which shows that patient who receive physical therapy on the day of surgery have a lower chance of getting a readmission within 30 days. There is no significant relationship found between physical therapy on the day of surgery on the number of revisions and requests for opioids. A reason for this can be that physical therapy has no influence on having a knee or hip infection, which is one of the reasons for having a revision surgery. Therefore, it seems logical that physical therapy does not influence the chance of having a revision surgery. When looking at the opioid consumption, it seems logical that people with physical therapy on the day of surgery does not need more or less opioids than patients who did not receive physical therapy on day of surgery, since almost every patient receive inpatient physical therapy and need opioids for postoperative pain. This is in line with the insignificant relationships found. Since physical therapy on the day of surgery lead to less readmissions and has no negative influence on the chance of having a revision and does not lead to more opioid use, it should be recommended for every patient to start physical therapy on the day of surgery.

6.4 Relationship between length of hospital stay and the number of readmissions, revisions, antibiotics and opioids

This study found that for total knee arthroplasty there is no significant relationship between length of hospital stay on the number of readmissions, revisions, antibiotics and opioids. When looking at total hip arthroplasty, there is only one positive significant relationship found between length of hospital stay and number of readmissions. The studies of Gromov et al. (2019, p. 283) and Aynardi et al. (2014, pp. 253-254) did not find higher readmissions rates or differences in complications between patients that were discharged on the day of surgery or had an overnight stay. A reason for this difference in outcome can be that this research made a distinguishing between a length of hospital stay of less than three days or more than three days, were the above-mentioned studies looked at patients who were discharged at the day of surgery or required an overnight stay. Something that is important to take into consideration is that when patients need to stay longer in the hospital than the average patient, this can be an indicator that the patient is more complicated than the average patient. Since not every comorbidity is considered, this might have an influence on the length of stay of patients after total knee or hip arthroplasty.

6.5 Relationship between price agreements and the number of readmissions

This study found for total knee arthroplasty no significant relationship between price agreements and number of readmissions. However, there is a negative significant relationship in total hip arthroplasty between price agreements and the number of readmissions. This means that when the price agreements between the health insurance company and the healthcare provider is higher than average, the number of readmissions are lower. A reason for the difference between total knee arthroplasty and total hip arthroplasty can be that for total knee arthroplasties the price agreements are higher compared to total hip arthroplasties. This is supported by the literature about P4P models, in which healthcare providers get more money when their performance is higher. To further investigate the impact of price agreements on quality of care, literature about P4P should be analysed. Studies where they comply to this P4P model should be compared with studies where they used contracts between health insurance companies and health care providers with no P4P model, but a fixed agreed amount of money. This can give insight in the role of price agreements on the quality of care.

6.6 Control variables

This study found for total knee arthroplasty positive significant relationships between respiratory disorders and antibiotics and gender and opioids and negative significant relationships between age and revisions, age and opioids and gender and antibiotics. Moreover, for total hip arthroplasty there are positive significant relationships found between cardiovascular disease and readmissions, age and readmissions, age and revisions and age and opioids and negative significant relationships between age and opioids and gender and readmissions. The findings in this research show that patients who are older have less revisions than younger patients after total knee arthroplasty. However, it is remarkable that in total knee arthroplasty age has a negative influence on the number of revisions and that in total hip arthroplasty there is a positive influence of age on the number of revisions. A reason for this can be that people who are older do not always want another surgery when they have complaints, since they are too old for another knee or hip prothesis or do not want to have surgery again since they have a higher chance of getting a complication (Fang, Noiseux, Linson, & Cram, 2015, p. 173). For them the balance between potential risk and benefit can be totally different

compared to younger patients. Since the risks and rehabilitation phase of total knee and hip arthroplasty are not the same, it might have an influence on their choice for having a revision. Moreover, older patients are physically less active than younger people. This can be a reason why they need less opioids, since they experience less pain. Gender can have an influence on antibiotics, since men have a higher change of getting an infection after total knee arthroplasty, and therefore got a prescription for antibiotics. There is a difference in health seeking behavior between men and women. Women have a higher pain sensitivity and risk for clinical pain than men. Therefore, it makes sense that women requested more often opioids than men did after total hip arthroplasty.

6.7 Recommendations

Both the analyses performed by patients undergoing total knee and hip arthroplasty show that the number of physical therapy sessions corrected for the number of days in the hospital lead to higher readmissions rates within 30 days. This suggest that too much physical therapy has a positive relationship with readmissions within 30 days, or it suggest that physical therapy influences a third aspect – such as the degree of damage or problems – which influences the number of readmissions. This should be investigated in future research. However, it is important for patients to immediately start with physical therapy on the day of surgery. According to the findings, this will lead to less readmissions within 30 days after total knee arthroplasty and total hip arthroplasty.

The findings with respect to total knee arthroplasty did not show any relationships between waiting times and length of hospital stay on the quality of care. However, when looking at the total hip arthroplasty analysis, longer waiting times and a longer length of stay lead to higher readmission rates within 30 days. It should be looked further into the effect of waiting times and length of hospital stay on quality of care, since it could be the case that a too long waiting time or too long hospital stay leads to more readmissions within 30 days. However, when patients need to stay longer in the hospital than average this can suggest that they have more comorbidities or complications, which also increases the chance of having a readmission within 30 days.

Moreover, there should be investigated whether performance-based contracts have an influence on the price agreement and quality of care after total knee or hip arthroplasty. Since performance-based contracts are not yet used in the Netherlands, future research should focus on the relationship between price agreements and the quality of care after total knee or hip arthroplasty when there are performance-based contracts between health insurance companies and healthcare providers. This should then be implemented in the Dutch healthcare system, where health insurance companies should communicate with other health insurance companies to only contract healthcare providers according to the P4P principle. This could provide the literature with new findings.

6.8 Limitations and future research

There are some limitations in this study that can be opportunities for future research. In this research, only intramural physical therapy is analysed. Health insurance companies have no data about extramural physical therapy that patients performed after their hospital stay. Including the number of physical therapy sessions after discharge from the hospital could lead to different outcomes in the number of readmissions, revisions and requests for opioids. Therefore, performing the same analyses with data from healthcare providers could lead to other insights. Another limitation is that there was only data available from the health insurance company Company X. Since Company X has most of its insured persons living in the north and east side of the Netherlands, it might be possible that the region of the insured persons had an influence on the results. The outcomes would be more reliable when it was measured with data coming from each region in the Netherlands. The total sample size of the research was high enough (>3500 cases) but most of the hospitals performed less than 100 surgeries. To say more about all healthcare providers in the Netherlands, data from a longer study period should be included. The last limitation of this research is that the beta-values and f^2-values are very small. There are some significant relationships found, but the effect sizes are very small. Future research should focus on finding significant relationships which have a higher influence than what is found in this research. This can be done by including more data from different regions and years.

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Appendix 1: Notes mini-interview

With respect to total knee and hip arthroplasty not all comorbidities are relevant.

Every disease has a different code for diagnosis. It is important to check if you not have the same disease more than once in the research, since some diseases can have multiple diagnosis codes per specialism. It is important to figure out which code(s) are associated with which disease.

Cardiovascular diseases, diabetes, respiratory disorders and rheumatism are relevant comorbidities which should be included in the comorbidities.

There are a lot of different cardiovascular diseases. These are arrhythmias, angina pectoris, heart failure, valvular heart disease, heart attack, transient ischaemic attack (TIA), stroke, aneurysm, hypertension and increased cholesterol. All these diseases are relevant with respect to cardiovascular diseases. There are more diseases, but these are the most common ones.

With respect to respiratory disorders, there are three important diseases which should be included. These are chronic obstructive pulmonary disease (COPD), asthma and bronchitis.

Looking at rheumatism, it is important to include parts of the body that are not related to the hip or knee when the patient needs surgery for that. The types of rheumatism that should be included are shoulder belt / upper arm arthritis, elbow/forearm arthritis, hand/wrist arthritis and ankle/foot arthritis.

Relevant ATC-codes for antibiotics and pain killers after total knee/hip arthroplasty:

Antibiotic	ATC-code
Beta lactam antibiotics, penicillin’s	J01C

Pain killer	ATC-code
Opioids: This group comprises strong analgesics of the opiate type and analgesics with similar structure or action.	N02A

Appendix 2: Number of patients with total knee or hip arthroplasty

Restricted

Appendix 3: Results total knee arthroplasty

Independent variable --> Dependent variable	β value	t Statistics	p Value	f Square
Age -> Antibiotics	0.009	0.525	0.600	0.000
Age -> Opioids	**-0.056**	**3.237**	**0.001**	**0.003**
Age -> Readmission	0.015	1.050	0.294	0.000
Age -> Revision	**-0.062**	**3.398**	**0.001**	**0.004**
Cardiovascular Disease -> Antibiotics	0.036	1.664	0.097	0.001
Cardiovascular Disease -> Opioids	-0.001	0.080	0.936	0.000
Cardiovascular Disease -> Readmission	0.027	1.402	0.162	0.001
Cardiovascular Disease -> Revision	-0.019	1.474	0.141	0.000
Cardiovascular Disease -> Waiting Time	-0.011	0.668	0.504	0.000
Price Agreement -> Readmission	-0.016	0.882	0.378	0.000
Diabetes -> Antibiotics	0.031	1.297	0.195	0.001
Diabetes -> Opioids	0.028	1.311	0.191	0.001
Diabetes -> Readmission	0.012	0.598	0.550	0.000
Diabetes -> Revision	0.035	1.473	0.141	0.001
Diabetes -> Waiting Time	-0.002	0.093	0.926	0.000
Gender -> Antibiotics	**-0.033**	**2.088**	**0.037**	**0.001**
Gender -> Opioids	**0.063**	**4.250**	**0.000**	**0.004**
Gender -> Readmission	-0.021	1.325	0.186	0.000
Gender -> Revision	-0.021	1.296	0.196	0.000
HSMR -> Antibiotics	-0.012	0.711	0.477	0.000
HSMR -> Opioids	0.005	0.304	0.761	0.000
HSMR -> Readmission	0.020	1.115	0.265	0.000
HSMR -> Revision	-0.005	0.284	0.776	0.000
Length of Stay -> Antibiotics	0.025	1.549	0.122	0.001
Length of Stay -> Opioids	0.032	1.942	0.053	0.001
Length of Stay -> Readmission	0.015	0.865	0.387	0.000
Length of Stay -> Revision	0.005	0.299	0.765	0.000
PT: Number of sessions -> Opioids	0.019	0.875	0.382	0.000
PT: Number of sessions -> Readmission	**0.157**	**2.797**	**0.005**	**0.015**
PT: Number of sessions -> Revision	0.054	1.766	0.078	0.002
PT: On Surgery Date -> Opioids	-0.002	0.105	0.917	0.000
PT: On Surgery Date -> Readmission	**-0.127**	**4.131**	**0.000**	**0.010**
PT: On Surgery Date -> Revision	-0.027	1.134	0.257	0.000
Respiratory Disorders -> Antibiotics	**0.052**	**2.055**	**0.040**	**0.003**
Respiratory Disorders -> Opioids	0.002	0.115	0.908	0.000
Respiratory Disorders -> Readmission	0.015	0.711	0.477	0.000
Respiratory Disorders -> Revision	0.006	0.340	0.734	0.000
Respiratory Disorders -> Waiting Time	-0.008	0.522	0.602	0.000
Rheumatoid Arthritis -> Antibiotics	0.009	0.446	0.656	0.000
Rheumatoid Arthritis -> Opioids	0.001	0.029	0.977	0.000
Rheumatoid Arthritis -> Readmission	0.060	1.877	0.061	0.004
Rheumatoid Arthritis -> Revision	-0.003	0.188	0.851	0.000
Rheumatoid Arthritis -> Waiting Time	-0.015	0.936	0.350	0.000
Waiting Time -> Readmission	0.000	0.018	0.986	0.000
Waiting Time -> Revision	-0.023	1.410	0.159	0.001

Appendix 4: Results total hip arthroplasty

Independent variable --> Dependent variable	β value	t Statistics	p Value	f Square
Age -> Antibiotics	0.026	1.681	0.093	0.001
Age -> Opioids	**-0.035**	**2.062**	**0.040**	**0.001**
Age -> Readmission	**0.039**	**2.582**	**0.010**	**0.002**
Age -> Revision	**0.031**	**2.085**	**0.038**	**0.001**
Cardiovascular Disease -> Antibiotics	-0.020	1.284	0.200	0.000
Cardiovascular Disease -> Opioids	-0.009	0.623	0.533	0.000
Cardiovascular Disease -> Readmission	**0.079**	**3.637**	**0.000**	**0.006**
Cardiovascular Disease -> Revision	-0.009	0.544	0.587	0.000
Cardiovascular Disease -> Waiting Time	-0.004	0.204	0.839	0.000
Price Agreement -> Readmission	**-0.058**	**3.774**	**0.000**	**0.003**
Diabetes -> Antibiotics	0.048	1.837	0.067	0.002
Diabetes -> Opioids	0.019	1.119	0.264	0.000
Diabetes -> Readmission	0.045	1.728	0.085	0.002
Diabetes -> Revision	0.005	0.261	0.794	0.000
Diabetes -> Waiting Time	-0.011	0.686	0.493	0.000
Gender -> Antibiotics	-0.029	1.679	0.094	0.001
Gender -> Opioids	0.010	0.579	0.563	0.000
Gender -> Readmission	**-0.043**	**2.472**	**0.014**	**0.002**
Gender -> Revision	-0.004	0.245	0.807	0.000
HSMR -> Antibiotics	-0.026	1.602	0.110	0.001
HSMR -> Opioids	0.001	0.039	0.969	0.000
HSMR -> Readmission	0.017	0.982	0.326	0.000
HSMR -> Revision	0.002	0.122	0.903	0.000
Length of Stay -> Antibiotics	0.031	1.792	0.074	0.001
Length of Stay -> Opioids	0.011	0.633	0.527	0.000
Length of Stay -> Readmission	**0.034**	**1.990**	**0.047**	**0.001**
Length of Stay -> Revision	0.007	0.415	0.678	0.000
PT: Number of sessions -> Opioids	-0.010	0.463	0.644	0.000
PT: Number of sessions -> Readmission	**0.247**	**5.856**	**0.000**	**0.042**
PT: Number of sessions -> Revision	0.037	1.160	0.247	0.001
PT: On Surgery Date -> Opioids	0.037	1.801	0.072	0.001
PT: On Surgery Date -> Readmission	**-0.174**	**7.178**	**0.000**	**0.020**
PT: On Surgery Date -> Revision	0.015	0.646	0.519	0.000
Respiratory Disorders -> Antibiotics	0.044	1.774	0.077	0.002
Respiratory Disorders -> Opioids	0.025	1.324	0.186	0.001
Respiratory Disorders -> Readmission	-0.004	0.196	0.845	0.000
Respiratory Disorders -> Revision	0.014	0.654	0.514	0.000
Respiratory Disorders -> Waiting Time	0.009	0.544	0.587	0.000
Rheumatoid Arthritis -> Antibiotics	-0.006	0.385	0.700	0.000
Rheumatoid Arthritis -> Opioids	-0.002	0.120	0.905	0.000
Rheumatoid Arthritis -> Readmission	0.011	0.601	0.548	0.000
Rheumatoid Arthritis -> Revision	0.008	0.411	0.681	0.000
Rheumatoid Arthritis -> Waiting Time	-0.031	1.959	0.051	0.001
Waiting Time -> Readmission	**0.042**	**2.662**	**0.008**	**0.002**
Waiting Time -> Revision	-0.021	1.287	0.199	0.000

Appendix 5: Results multigroup analysis

Independent variable --> Dependent variable	β value	t Statistics	p Value	f Square
Age -> Antibiotics	0.017	0.755	0.450	0.000
Age -> Opioids	0.021	0.878	0.380	0.002
Age -> Readmission	0.025	1.254	0.210	0.001
Age -> Revision	**0.092**	**3.730**	**0.000**	**0.000**
Cardiovascular Disease -> Antibiotics	**-0.056**	**2.190**	**0.029**	**0.000**
Cardiovascular Disease -> Opioids	-0.008	0.361	0.718	0.000
Cardiovascular Disease -> Readmission	0.052	1.733	0.083	0.003
Cardiovascular Disease -> Revision	0.010	0.489	0.625	0.000
Cardiovascular Disease -> Waiting Time	0.005	0.214	0.830	0.000
Price Agreement -> Readmission	-0.041	1724	0.085	0.002
Diabetes -> Antibiotics	0.017	0.485	0.628	0.002
Diabetes -> Opioids	-0.009	0.331	0.741	0.001
Diabetes -> Readmission	0.032	0.974	0.330	0.001
Diabetes -> Revision	-0.030	0.982	0.326	0.000
Diabetes -> Waiting Time	0.027	1194	0.232	0.000
Gender -> Antibiotics	0.004	0.170	0.865	0.001
Gender -> Opioids	**-0.053**	**2.396**	**0.017**	**0.001**
Gender -> Readmission	-0.021	0.873	0.383	0.001
Gender -> Revision	0.017	0.723	0.469	0.000
HSMR -> Antibiotics	-0.014	0.614	0.539	0.000
HSMR -> Opioids	-0.005	0.188	0.851	0.000
HSMR -> Readmission	-0.003	0.118	0.906	0.000
HSMR -> Revision	0.008	0.323	0.747	0.000
Length of Stay -> Antibiotics	0.007	0.278	0.781	0.001
Length of Stay -> Opioids	-0.021	0.901	0.368	0.001
Length of Stay -> Readmission	0.019	0.762	0.446	0.000
Length of Stay -> Revision	0.001	0.039	0.969	0.000
PT: Number of sessions -> Opioids	-0.029	0.918	0.359	0.000
PT: Number of sessions -> Readmission	0.088	1.265	0.206	0.029
PT: Number of sessions -> Revision	-0.016	0.381	0.703	0.001
PT: On Surgery Date -> Opioids	0.039	1281	0.200	0.000
PT: On Surgery Date -> Readmission	-0.046	1.189	0.234	0.016
PT: On Surgery Date -> Revision	0.043	1.243	0.214	0.000
Respiratory Disorders -> Antibiotics	-0.008	0.243	0.808	0.002
Respiratory Disorders -> Opioids	0.024	1002	0.317	0.000
Respiratory Disorders -> Readmission	-0.019	0.673	0.501	0.000
Respiratory Disorders -> Revision	0.008	0.287	0.774	0.000
Respiratory Disorders -> Waiting Time	0.028	1284	0.199	0.000
Rheumatoid Arthritis -> Antibiotics	-0.015	0.615	0.538	0.000
Rheumatoid Arthritis -> Opioids	-0.002	0.102	0.919	0.000
Rheumatoid Arthritis -> Readmission	-0.050	1.382	0.167	0.001
Rheumatoid Arthritis -> Revision	0.012	0.468	0.640	0.000
Rheumatoid Arthritis -> Waiting Time	0.013	0.487	0.626	0.000
Waiting Time -> Readmission	0.004	0.190	0.849	0.000
Waiting Time -> Revision	-0.006	0.206	0.837	0.000