STOCKHOLM SCHOOL OF ECONOMICS
Department of Economics
659 Degree project in economics
Spring 2019

# Finding the Socioeconomic Gradient in Knee Arthroscopies: A Descriptive Study of the Horizontal Equity in the Swedish Orthopedic Sector

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**Abstract.**
Research on the graded association between socioeconomic status and healthcare access for non-fatal diseases has expanded in recent years. Since burdens from non-fatal diseases are increasing globally, and health expenditures represent a growing share of GDP in most developed countries, the phenomenon is worth studying through an economic lens. The purpose of this thesis is to investigate the horizontal equity in the Swedish orthopedic healthcare sector. We ask if there exists a socioeconomic gradient in the probability that a patient receives a knee arthroscopy, when diagnosed with a knee condition where an arthroscopy is a possible treatment. We develop a linear probability model with individual level register data on all patients (996,324) from the time period 2002-2016 that received a first-time knee diagnosis or a first-time knee arthroscopy in Sweden. Our results show a significant (p<0.01) positive association between socioeconomic status and the likelihood of receiving a knee arthroscopy. Whether the association is small or large is debatable. Future research could replicate our model to see whether a socioeconomic gradient exists for other conditions and treatments.

**Keywords:** socioeconomic gradient, equity, healthcare, healthcare access, orthopedic healthcare

**JEL:** I10, I14

Supervisors: Magnus Johannesson and Mårten Palme
Date submitted: 2019-05-13
Date examined: 2019-05-29
Discussant: Fredrik Persson
Examiner: Johanna Wallenius

# Acknowledgements

First and foremost, we want to thank our supervisors Magnus Johannesson and Mårten Palme for their excellent feedback. Furthermore, we also want to thank the researchers at Karolinska Institutet that are part of the project "To operate or not to operate: Socioeconomics and the invisible hand in orthopaedic decision making" and the members of the BONES project, Abdul Rashid Tony Qureshi, who assisted us with the data analysis, Alejandro Marcano, Lukas Berglund, Johanna Adami (Sophiahemmet University), Anne Garland, Li Felländer-Tsai and Martin Gerdin. We also want to thank Viking Waldén, Lovisa Rambjer, Elias Höckerfelt and Sigurd Log Røren for giving us useful and constructive feedback. Lastly, we want to give a special thanks to Nawar Al-Ebadi, for his invaluable input with Stata.

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# 1. Introduction

The famous quote by Boris Yeltsin "We don't appreciate what we have until it's gone" (referenced in Jeffers 2003, p. 60) can be applied to many aspects of life, not the least health. Oftentimes, we do not appreciate our health until we lose it. On an individual level, health is a precondition for a decent and meaningful life. On a societal level, health expenditures are increasing faster than GDP worldwide and are to a growing extent financed by domestic government sources rather than households (Xu et al. 2018). Therefore, health-related issues are of great economic importance.

Several studies have established the existence of a socioeconomic gradient in health, meaning that the relationship between health and socioeconomic status is graded–people that are well off are healthier than those that are less well off (Van Doorslaer et al. 1997; Adler and Ostrove 1999; Mackenbach et al. 2008;). A socioeconomic gradient exists both in healthcare consumption and healthcare access, where advantaged individuals are favored in the healthcare system in many developed countries (Van Doorslaer and Wagstaff 1992). This inequity in health and healthcare has wide-reaching consequences that transcend the medical arena. Many questions regarding the socioeconomic gradient persist. What are the mechanisms behind it? Do we observe a socioeconomic gradient for all conditions and injuries, even non-fatal ones?

Burdens from non-fatal diseases are increasing worldwide (James et al. 2018). These health burdens can have severe impacts both on an individual level by worsening quality of life, but also on an aggregate macroeconomic level by causing productivity loss among the working population. Therefore, it is of interest to research the socioeconomic gradient in non-fatal diseases, such as knee conditions that can be treated with an arthroscopy. A knee arthroscopy is an orthopedic surgical treatment that is used to treat common knee conditions that cause pain, joint stiffness and inactivity. There is so far little research on the presence of a socioeconomic gradient in the treatment of knee conditions in Sweden.

This thesis looks at data on knee arthroscopies between 2002–2016 in Sweden. It analyzes data on all patients with first-time diagnoses of knee conditions, as well as all first-time knee arthroscopies. Through a descriptive correlation study, we investigate whether patients with the same knee conditions, a proxy for the same need, have the same access to surgery irrespective of their socioeconomic status. We find a socioeconomic gradient in access to knee arthroscopies, which is an indicator of inequity in the Swedish orthopedic healthcare system. Other factors also have a positive association with the likelihood of receiving an arthroscopy. Therefore, more research is needed to assist policy-making in this area.

The thesis is structured as follows. A background explaining the studied surgical procedure, knee arthroscopies, introduces the topic. It is followed by a theory section where an economic perspective on health and previous research are introduced, as well as the notions socioeconomic status and equity. Afterwards our methodology is described, and the results are presented. The thesis ends with a discussion of the results and implications for future research and a conclusion.

# 2. Background

## 2.1 Knee Arthroscopy

Between 2002 and 2016, 989,072 patients were diagnosed with a knee condition for the first time in Sweden, where a potential treatment was a knee arthroscopy. All causes for different knee conditions are not fully known. Some can be due to sports related overuse or trauma, having work tasks that require heavy physical labor, or because of genetic factors. If a patient is diagnosed with a knee condition, it can negatively impact the ability to perform everyday life tasks. Around 35,000 knee arthroscopies are performed in Sweden each year, making it one of the most common surgical procedures (Stålman 2018). This can be compared to approximately 16,000 inguinal hernia operations a year (Swedish Hernia Register 2017), or 13,000 tonsil removal operations a year (Stalfors et al. 2011).

When performing a knee arthroscopy, a small incision is made in the patient's skin in order to reach the knee joint cavity. A fiberoptic video camera is placed inside the knee joint and then works as guidance to the surgeon during the procedure. The procedure itself normally lasts less than 60 minutes and does usually not require hospitalization for more than a day. The recovery time is often 1–2 weeks, but the duration of sick leave from work depends on how demanding the patient's working tasks are for the knee. It is common for some patients to receive several knee arthroscopies, if the knee condition is recurring (Vårdguiden 2016). A knee arthroscopy usually shortens recovery time for knee conditions and reduces pain and joint stiffness (Wilkerson 2016). The procedure is popular, much thanks to its ability to treat various types of knee conditions and since there is no need for large incisions.

## 2.2 Surgical Treatment vs Non-surgical Treatment

Surgical treatment for common knee conditions usually involves a knee arthroscopy or open surgery, while non-surgical treatment often involves physical therapy, rest, medications or injections (Wilkerson 2016). In spite of a knee arthroscopy being such a common orthopedic procedure, there is contradictory medical evidence of its efficiency (Sihvonen et al. 2013; Moseley 2002). Maffulli (2017) argues that in some cases the benefits of operative treatment over non-operative treatment cannot be scientifically established, and that operations are performed despite lack of solid evidence. It is up to the individual doctor treating the patient in question to determine whether the patient qualifies for surgical treatment. Meunier, Pozady and Tinghög (2017) examined this further by investigating whether orthopedic surgeons' attitudes to risk could affect the likelihood to operate. They found no significant association between risk-aversion and tendency to avoid surgery, but found that a "macho", or hazardous attitude had a positive significant association with the likelihood to operate. Nonetheless, a knee arthroscopy is beneficial both from the healthcare sector point of view and from the patient's perspective, as it can be performed quickly and without patients requiring a long hospitalization period.

# 3. Theory

## 3.1 An Economic Approach to Health

The field of health economics is large and can take several different approaches to health. The healthcare sector represents a large share of GDP, a trend that has been increasing for the last decades in most developed countries, including Sweden. In 1960 the Swedish share of GDP that accounted for healthcare expenditures was 4.7% (Folland, Goodman and Stano 2004), compared to 10.9% in 2017 (OECD 2019). With this in mind, the healthcare system is relevant to analyze through an economic lens, in order to see how the resources are allocated in this this large share of the GDP. This can be deemed as especially relevant, since healthcare expenditures to a growing extent are government sourced (Xu et al. 2018). Moreover, the output from the healthcare sector contributes to the national economy in both production and consumption aspects (Folland, Goodman and Stano 2004). Healthy people can work, earn and consume more, and differences in health among individuals can impact savings, supplied labor and productivity (Smith 1999).

## 3.2 Socioeconomic Status and Health

Mueller and Parcel (1981) proposed a definition of socioeconomic status, SES, as each family's or individual's relative position in a social, hierarchical, system where one's ranking is based on access to or control over wealth, status and power. Shavers (2007, p. 1013) relates this measurement to health and proposes a definition of SES as "an individual's or group's access to the basic resources required to achieve and maintain good health". Education is often viewed as the most basic component of socioeconomic status. According to Adler and Newman (2002), having a higher level of education can provide an individual with life skills and knowledge that can enable access to resources that promote health. Income is also a component of SES, as having a high income creates better possibilities to afford healthcare, and vice versa. Other factors can be also be included in the measurement of SES, like occupation, living area, age, gender or country of birth.

## 3.3 Equity in Healthcare

An important notion in the field of healthcare is equity. Policymakers in most developed countries agree that the notion of equity is important for policy-making in the healthcare system. In spite of this, what is specifically meant by equity is disputed. Culyer and Wagstaff (1993) present four definitions of equity in healthcare provision–equality of expenditure per capita, distribution according to need, equality of access and equality of health. The second definition, equity as the distribution of healthcare according to need, contains two aspects of equity–vertical and horizontal equity. Vertical equity implies that patients with different needs are treated differently. The more severe one's condition is, the more favorably one is treated. Horizontal equity means that patients with equal needs are treated the same way. This definition of horizontal equity will be applied in this thesis.

Policymakers in Sweden have agreed on striving for both horizontal and vertical equity in the healthcare sector. The healthcare law (SFS 2017:30) states that healthcare is to be provided on equal conditions to the entire population. According to a recent inquiry on equal access to healthcare in Sweden (SOU 2018:55), an equal healthcare system does not necessarily imply that each individual patient is treated the same. Instead, the healthcare system can be seen as unequal when there exist differences in treatment that cannot be explained by medical assessments.

## 3.4 The Socioeconomic Gradient in Health

A socioeconomic gradient in health implies that it is not only those in poverty suffer from poor health, but that the relationship between health and socioeconomic status is graded. Health increases along the entire socioeconomic scale (Adler and Ostrove 1999). Several studies have established this relationship and found a statistically significant association between health and socioeconomic status (Van Doorslaer et al. 1997; Mackenbach 2008).

Before the 1980's, most health research used socioeconomic status as a control variable, rather than looking at the relationship between several levels of socioeconomic status and health. In the mid 1980's the graded relationship between health and SES was discovered (Smith 1999). Some of the first empirical works in this area were the Whitehall studies, which started collecting data on British civil servants' mortality in 1967. These studies showed that mortality increased with lower employment grades (Marmot et al. 1991).

Previous research has shown that socioeconomic status has a weaker association with mortality from diseases where a diagnosis often follows from clear symptoms. Such conditions include for instance lung and pancreatic cancer (Adler and Ostrove 1999). With this in mind one can hypothesize the existence of a socioeconomic gradient for the treatment of knee conditions, as outcomes are not a matter of life and death, and symptoms are less clear.

Research on the socioeconomic gradient in health has difficulties with establishing its causal direction, as regressions of SES and health typically suffer from omitted variable bias. This is due to the fact that common measurements of SES, like income and education, often are correlated with variables that are hard to control for, such as living conditions, health information (Gerdtham 1997) or trust in the healthcare system (SOU 2018:55). In spite of this, research has tried to establish the causal direction of the gradient through innovative methods. Cesarini et al. (2016) investigated a wealth shock's potential causal impact on health in the form of a lottery win. They found its impact to be limited on winners', as well as their children's, health. Their study is an indicator of the complicated relationship between SES and health.

Angell (1993) proposes that socioeconomic status is not a determinant of health itself, but that it rather serves as a proxy for other determinants. Three mechanisms through which SES could be associated with health are environmental exposure, health behavior and healthcare. Individuals with lower SES are more likely to be exposed to worse physical environments than those with higher SES, for instance through living or working close to toxic waste sites, industrial areas or highways. Health behavior, such as tobacco use, an inactive lifestyle or dietary habits, can also vary with SES (Adler and Newman 2002). Higher levels of education may have a positive association with risk aversion and can therefore deter highly educated individuals from engaging in unhealthy behavior (Cutler and Lleras-Muney 2010). Another mechanism that can explain inequalities in health is the presence of a socioeconomic gradient in healthcare access, which is presented below.

## 3.5 The Socioeconomic Gradient in Healthcare

A socioeconomic gradient in healthcare access is a potential cause for the gradient in health. Healthcare access in this thesis refers to the utilization, consumption and accessibility of healthcare and healthcare services. Access to and the quality of consumed healthcare is associated with SES in several developed countries, including countries with universal health insurance coverage, such as Sweden (Van Doorslaer and Wagstaff 1992; Van Doorslaer et al. 2000; Adler and Newman 2002). An international comparison of the delivery of healthcare in several developed countries by van Doorslaer et al. (2000) has shown that there exists an inequity in favor of groups with higher income in consumption of specialist care in Sweden when controlling for need. Furthermore, a study by Gerdtham (1997) rejects the null hypothesis that there is no horizontal inequity in the Swedish healthcare system. Instead, the study's significant results indicate that SES is associated with frequency of physician visits and hospitalization in the sample. This motivates the further study of socioeconomic gradients in healthcare in Sweden. A selection of theories behind the socioeconomic gradient in access to healthcare are presented below.

### 3.5.1 The Education Gradient

Cutler and Lleras-Muney (2010) suggest that differences in education can explain differences in healthcare access through a number of channels. For example, education often increases resources at hand, which can facilitate healthcare consumption. A higher educational level can raise incentives for an individual to invest in the future, as education improves future prospects. Differences in education may also lead to differences in knowledge. For instance, well-educated people tend to be better informed and make more use of new research than people with lower levels of education (Cutler and Lleras-Muney 2006). This could lead to individuals with higher education demanding newer and more complex treatments (Rosenzweig and Schultz 1989; Goldman and Smith 2002). Furthermore, highly educated people tend to have wider social networks that can provide emotional, physical and financial support when navigating within the healthcare system (Berkman 1995).

### 3.5.2 Access Costs

A socioeconomic gradient in healthcare access can also be incurred by differences in access costs. Mooney (1983) defines access costs as costs related to initiating the first contact with the healthcare system. Examples are transport costs, out-of-pocket payments, or the opportunity costs of waiting and traveling time, or being on sick leave from work. Opportunity costs can vary with SES. Van Doorslaer and Wagstaff (1992) suggest that even if the out-of-pocket costs for healthcare are the same nominally for all income groups, the lost utility, and thus opportunity cost, of seeking care is higher for individuals with lower income. Non-financial barriers could also be at play in explaining variation in access costs between groups with different SES. For instance, individuals with lower income tend to live in areas with worse access to health facilities, for instance in sparsely populated areas, which can contribute to raising this group's access costs.

One could hypothesize that the socioeconomic gradient in healthcare access is not as large in Sweden, thanks to the presence of universal healthcare. Nonetheless, private health insurances do exist in Sweden, and coverage varies with SES, even though the share of the population with such insurance is relatively low–around 5%. The average privately insured individual in Sweden has one more year of education, and around 50% higher income, than the rest of the population on average (Palme 2018). Individuals with private insurances usually have a lower opportunity cost for seeking healthcare due to shorter waiting time in the private healthcare sector (Van Doorslaer and Wagstaff 1992). Therefore, one can imagine that the presence of private health insurance contributes to a socioeconomic gradient in healthcare access in Sweden.

### 3.5.3 Health Literacy

Differing degrees of health literacy among income and educational groups can impact their respective access to healthcare. Health literacy concerns people's capacity to use complex abilities that relate to health, for instance communicating one's needs to caregivers, or reading and understanding health instructions and information (Sørensen et al. 2012). A report by the Swedish National Board of Health and Welfare (2018) has shown that there exist differences between levels of education and ability to understand a doctor's explanation of a treatment. This indicates an association between health literacy and SES in Sweden.

# 4. Previous Orthopedic Research

## 4.1 International Orthopedic Research

Orthopedic research tends to focus on clinical factors when studying outcomes, rather than socioeconomic factors (Nordenvall 2017). In spite of this, some studies have looked at socioeconomic factors' association with clinical outcomes and found a positive association between orthopedic outcome and SES (Chung, Kotsis and Kim 2007; Allen Butler et al. 2011; Clement, Muzammil and MacDonald 2011; Paksima, Pahk and Romo 2014). Research has also looked at how SES interacts with ethnicity. Goodman et al. (2018) identified no difference in pain or function after hip arthroplasties between blacks and whites living in little deprived communities.

However, blacks had worse pain and function than whites in deprived areas, which indicates an interactive relationship between ethnicity and SES in orthopedic outcomes. Lavernia et al. (2011) also found that ethnic and racial minorities experienced worse perceived pain and function both before and after a type of orthopedic procedure, a total joint arthroplasty. Studies have also looked at whether SES influences access to orthopedic healthcare, as opposed to outcome, and found that surgical treatment and follow-up care were associated with higher levels of SES (Agabati, Picciotto and Cesaroni 2007; Medford-Davis et al. 2017).

### 4.2 Swedish Orthopedic Research

Even though the awareness of the association between health and SES has been established in many Swedish studies (Farrants et al. 2018; Lallukka et al. 2018), relatively few studies have been performed in the orthopedic sector. The ones than have been performed point towards the presence of a socioeconomic gradient. Nordenvall et al. (2017) found a positive relationship between SES and the likelihood of undergoing operative treatment when diagnosed with a cruciate ligament injury. Patients belonging to the highest educational level showed a 29% increased likelihood of receiving surgery compared to those in the lowest educational group when analyzing all patients diagnosed with a cruciate ligament injury from 1987 to 2010. Another study by Marcano et al. (2019) found that early operative treatment for cruciate ligament injuries for some groups–such as women, patients living in cities and patients with higher levels of education–was positively associated with higher income levels. Moreover, Kiadaliri et al. (2017) found a negative relationship between prevalence of knee pain and educational level and occupation. Studies have also found a positive association between orthopedic outcome and SES, as well as worse orthopedic outcomes for patients born outside of Sweden (Krupic et al. 2013; Weiss et al. 2019).

## 5. Research Focus

### 5.1 Our Contribution

This is the first Swedish study to look at the association between SES and the access to knee arthroscopies for a number of common knee conditions with access to such a large population cohort. We contribute to the mapping of a socioeconomic gradient within a specific medical field. By doing this, we investigate how parts of the resources in the healthcare sector are allocated among different socioeconomic groups. Hopefully, the results can assist doctors and policymakers in the development of a horizontally equal healthcare system.

## 5.2 Research Question and Hypotheses

The purpose of this thesis is to investigate the horizontal equity in a branch of Swedish healthcare. We will research whether there exists a socioeconomic gradient in access to knee arthroscopies among patients diagnosed with orthopedic knee conditions where an arthroscopy is a possible treatment.

Our research question is the following:

- Is there a socioeconomic gradient in the probability that a patient receives a knee arthroscopy when diagnosed with a knee condition?

Following the results from previous research on health and healthcare's association with SES, we hypothesize that a socioeconomic gradient exists in access to knee arthroscopies. Our hypotheses are as follow:

- The probability of receiving a knee arthroscopy is higher for individuals with higher income.
- The probability of receiving a knee arthroscopy is higher for individuals with higher levels of education.

# 6. Materials and Method

## 6.1 Data

Our data set consists of unique individual level register data from Statistics Sweden that is connected to clinical data on first-time knee diagnoses and first-time knee arthroscopies from the Swedish National Board of Health and Welfare's Patient Register. The data consist of 996,324 unique individuals from the time period 2002–2016.

### 6.1.1 Statistics Sweden Lisa Database

Statistics Sweden's LISA database was launched in 1990, due to increasing levels of sick leave in Sweden. LISA gathers data from various sources, such as the Income and Taxation Register and the Education Register, into a common database. It contains individual level data on factors such as income, education, unemployment and health insurance over time. There is almost no selection bias in the data, as participation in government-administered registers is obligatory in Sweden. This makes the database suitable from a research point of view, as it allows for large, representative, samples. The data from LISA is often used for studies of the labor market, as well as studies on illness and health among the Swedish population (Ludvigsson et al. 2019).

### 6.1.2 The Swedish National Patient Register

The National Patient Register is a database from the Swedish Board of Health and Welfare and contains data on surgical treatment and diseases of Swedish patients (The Swedish National Board of Health and Welfare 2016). Our data set contains all patients with first-time diagnoses, as well as all first-time knee arthroscopies, that were performed in the time period 2002–2016. This means that data from patients that have been diagnosed or operated more than once are only present in the data set with their first diagnosis or surgery.

## 6.2 Ethics

Our data set contains variables on sensitive information, such as income and health status. All the individuals in our data set have been pseudonymized and de-identified by the Swedish National Board of Health and Welfare. Our data was anonymized before analysis and it is not possible to tie a certain observation to a specific individual. The thesis is part of the project "To operate or not to operate: Evidence, socioeconomics and the invisible hand in orthopaedic decision making". Ethical approval was granted by the regional Ethics Committee in Stockholm. (Dnr: 2010/1713-32 and 2013/581-31/5, 2016/2251-32).

## 6.3 Method

We have developed a linear probability model, LPM, describing the relationship between the probability of receiving surgery and socioeconomic status, SES. We chose to not use a probit or logit model, as the interpretation of an LPM is easier and more straightforward. We developed models, determined independent variables and decided exclusion criteria before running any regressions. This was done in order to avoid data driven analysis. We performed our statistical analyses in Stata, version 15.1.

Robust standard errors were used to deal with heteroskedasticity. In order to establish an unbiased relationship between SES and the probability of receiving an operation, six control variables were identified–year of diagnosis or surgery, region, gender, age, country of birth and diagnosis. Our chosen measurements of SES were disposable income and level of education, and our dependent variable was the probability of receiving a knee arthroscopy.

## 6.4 Dependent Variable: Probability of Surgery

As a linear probability model is used, the dependent variable is a dummy variable, which takes on value 1 for patients undergoing a knee arthroscopy and 0 for other non-surgical treatments. In total, 106,661 individuals in our data set received a first-time knee arthroscopy in the studied time period. This corresponds to 10.71% of the total sample.

## 6.5 Independent Variables of Interest

To limit the scope of the thesis, and following Nordenvall et al. (2017), education and income have been chosen as our measurements of SES. As previously mentioned, they can be argued to be the most basic measurements of SES. We chose to not include region, occupation, country of birth or gender in our measurement to limit the scope of the thesis.

### 6.5.1 Education

We grouped the sample into four levels according to highest finished education. The classification stems from the old SUN2000 categorization used by Statistics Sweden. The four levels in this categorical variable were:

1. Primary and secondary school nine years or less
2. Upper secondary school three years or less
3. Post-secondary education shorter than three years
4. Post-secondary education three years or longer

We created four new levels, instead of using the old SUN2000 framework of seven levels, as relatively few people in Sweden have a doctorate degree or did not finish secondary school (Statistics Sweden 2019a). We decided it was not necessary to keep these respective categories. Primary and secondary school of nine years or less was used as baseline. We excluded a total number of 74,982 observations that lacked data on education for the year they were diagnosed or operated, see Figure 3.

### 6.5.2 Income

We created a relative measurement of income, using data on disposable income per consumption unit. This measurement aggregates the total disposable income of a household and divides it by the number of consumption units in the family. The measurement is often used by researchers and recommended by the European Union for similar studies (Statistics Sweden 2016).

First, we divided all observations into income quintiles for each observed year (2002–2016). Each quintile consisted of 20% of the sample, after dropping observations with missing values. The first quintile contained the 20% with the lowest income, the second contained the 20% with the second lowest income, and so on. We used the entire sample when creating the income quintiles for each year, and not only the patients that received their diagnoses or arthroscopies each specific year. This allowed us to get a more accurate measurement of each patient's position in the national relative income distribution. We did not adjust for inflation, as the income measurement is relative and inflation adjusting is thus not necessary. The consumption unit measurement changed in 2004 in the LISA database. We used the old measurement, as we wanted a consistent measurement for the time period 2002–2016.

Secondly, we created a new variable with each individual's position in the quintiles for the year they were diagnosed or received surgeries. This variable was used as our income measurement. Since it collects different numbers of positions in the quintiles for different years, depending on the time of diagnosis or surgery, each quintile for the final variable does not contain exactly 20% of the sample. Depending on the year of diagnosis or surgery, different numbers of patients from the respective quintiles will be represented in the final variable. For instance, if fewer patients in a particular quintile were operated in some years it will change the distribution of the quintiles in the final variable. In spite of this, the distribution of the sample in the final income variable roughly corresponds to quintiles, see Table 1.

In addition, 2,432 observations had 0 in income. This could be an indicator of faults in the data, or individuals with a very particular life situation (homeless, criminal, extremely wealthy). This suggests that for at least some of the individuals, 0 is not their true income. Therefore, we chose to not include these observations as it could distort the regressions and misplace individuals in the relative income distribution. In total, 57,729 observations had missing values for income the year of diagnosis or surgery. Altogether, we removed 60,161 observations, that either had 0 in income or lacked income data for the year of their surgery or diagnosis, see Figure 3. We used the first quintile with the lowest income group as baseline.

## 6.6 Control Variables

We identified six control variables for our models, that will be presented below.

### 6.6.1 Year of Diagnosis or Surgery

This variable shows the year of surgery for patients that received surgery, and the year of the diagnosis for patients that received a diagnosis, but no knee arthroscopy. There are thus discrepancies in the meaning of this variable.

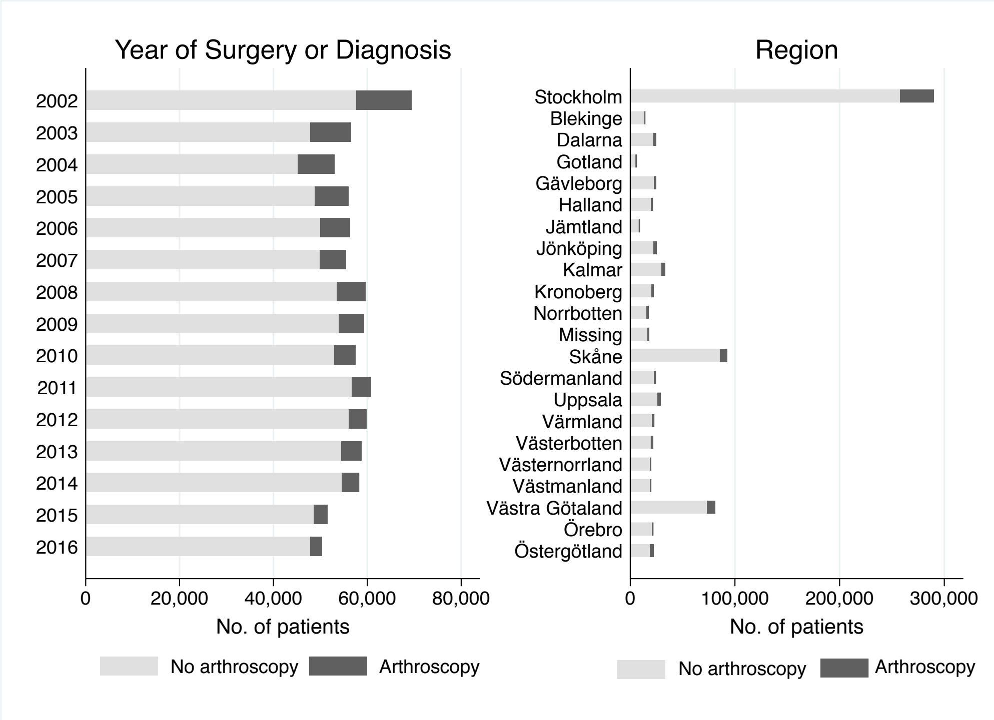
Popularity of certain surgeries can change over time, and with them their respective diagnoses. Fluctuations in the business cycle can also impact the amount of resources available in the healthcare system, and thus influence the number of operations. For instance, Iori et al. (2010) found that the number of orthopedic reconstruction surgeries in the US decreased during the 2008 financial crisis. In Figure 1, we observe that the number of patients diagnosed with a knee condition, and the share of performed arthroscopies among diagnosed patients, has gone down over time. One explanation could be that the national guidelines for knee arthroscopies changed in 2012, and the surgery was no longer recommended to treat osteoarthritis–arthritis in the knee (Swedish National Board of Health and Welfare 2012). Another explanatory factor could be the growing debate within the orthopedic field whether arthroscopy always is the optimal treatment. We thus control for year of operation or surgery. No values were missing for this variable. The year 2002 was used as the baseline category.

### 6.6.2 Region

Sweden is divided geographically into 21 regions, where each region is responsible for providing healthcare to its citizens (Swedish Association of Local Authorities and Regions). The tasks of the different regions in providing healthcare include decision-making regarding structure, organization and finance, but also regarding questions such as responsibility and remuneration models (SOU 2018:55). Moreover, the physical access to care might differ between regions with larger cities compared to rural regions. SES can also vary with regions, as there are differences in median incomes between regions (Statistics Sweden 2019b). In Figure 1, one observes that most of the first-time knee arthroscopies are performed in the regions Stockholm (38%), Skåne (8.3%) and Västra Götaland (9.1%). These are also the regions that house Sweden's three biggest cities, Stockholm, Göteborg and Malmö. Due to these regional differences we chose to use region as a control variable.

20,337 patients reported missing values for region. Since this is quite a large share of the sample (around 2%) we did not want to exclude them from the regression. Instead we chose to create a new region group for these observations. We used Stockholm as the baseline category.

**Figure 1.** Year of surgery or diagnosis and region with share of arthroscopies.




Source: Authors' rendering of data from Statistics Sweden's LISA database and the Swedish National Board of Health and Welfare's Patient Register 2002-2016.

### 6.6.3 Gender

There are indicators of differences in healthcare consumption patterns between men and women (SOU 2018:55). Medical research has shown unmotivated differences in choice of treatment between male and female patients for several diseases (Herold et al. 1997; Jindal et al. 2005; Daly et al. 2006; Norén, Ericsson and Olsson 2016). Moreover, patterns of gender differences in both pre- and postoperative status have been found in previous orthopedic research (Ethgen et al. 2004). In Figure 2, one can also see that men are operated to a larger extent than women in our sample (13.0% vs 6.9%). In addition, SES can vary with gender. Therefore, we controlled for gender by including a dummy variable in our models that took on 1 for woman and 0 for man. Since 32 observations were missing data on gender, they were removed, see Figure 3.

Gender can also be said to impact SES, as there can exist a systematic difference in education and income between men and women. Therefore, one could argue that gender should be included in our measurement of SES. In order to limit the scope of our research question we have chosen to include it as a control variable.

### 6.6.4 Age

Age can be a predictor of differences in healthcare consumption (SOU 2018:55). It is rare to give knee arthroscopies to the elderly, as risks from surgery can be higher for these patients and the benefits of performing this kind of surgery can be called into question. As seen in Figure 2, the share of operations goes down with age. Therefore, we control for age. We segmented the sample into the following age groups:

20–30 years 31–40 years 41–50 years 51–60 years 61–70 years >70 years

As seen in Figure 2, a large share of the sample consists of patients in their 60's, which is why the highest age category is composed of patients above 70. Children cannot be included in our analysis, as they do not have any further education than elementary school. This would distort the regressions, as all children would be assigned the lowest SES. We therefore removed all individuals that were 19 or younger, in total 108,618 observations, see Figure 3. Some of the individuals in the sample will be students, as patients in their 20's are included, and their recorded disposable income will probably be low. In addition, since they have not finished their education, they will change educational level over time. This can distort the results, but we have chosen to include these individuals in our sample, since most of them will be part of the workforce and have a correct education status. We used the age group that contained the ages 20–30 as the baseline category. No observations were missing from the age variable.

### 6.6.5 Country of Birth

Country of birth can have an impact on healthcare consumption, through for instance varying trust in or knowledge of the healthcare system (SOU 2018:55). Looking at our sample in Figure 2, the share of Swedish patients that received a knee arthroscopy was higher (10.1%) than the share of patients that were born in the Nordics (7.0%), in the EU (7.8%) or outside of the EU (8.3%). In addition, education and income can vary with country of birth. Therefore, we want to control for country of birth. We divided the sample into the following geographical areas:

Sweden
Nordics without Sweden
EU28 without the Nordics
Outside EU28

To limit the scope of our study, we chose country of birth as a control variable, even though one can argue that country of birth should be part of SES. In total, we removed 305 observations that were missing on country of birth, see Figure 3. Sweden was used as the baseline category.

**6.6.6 Diagnosis**

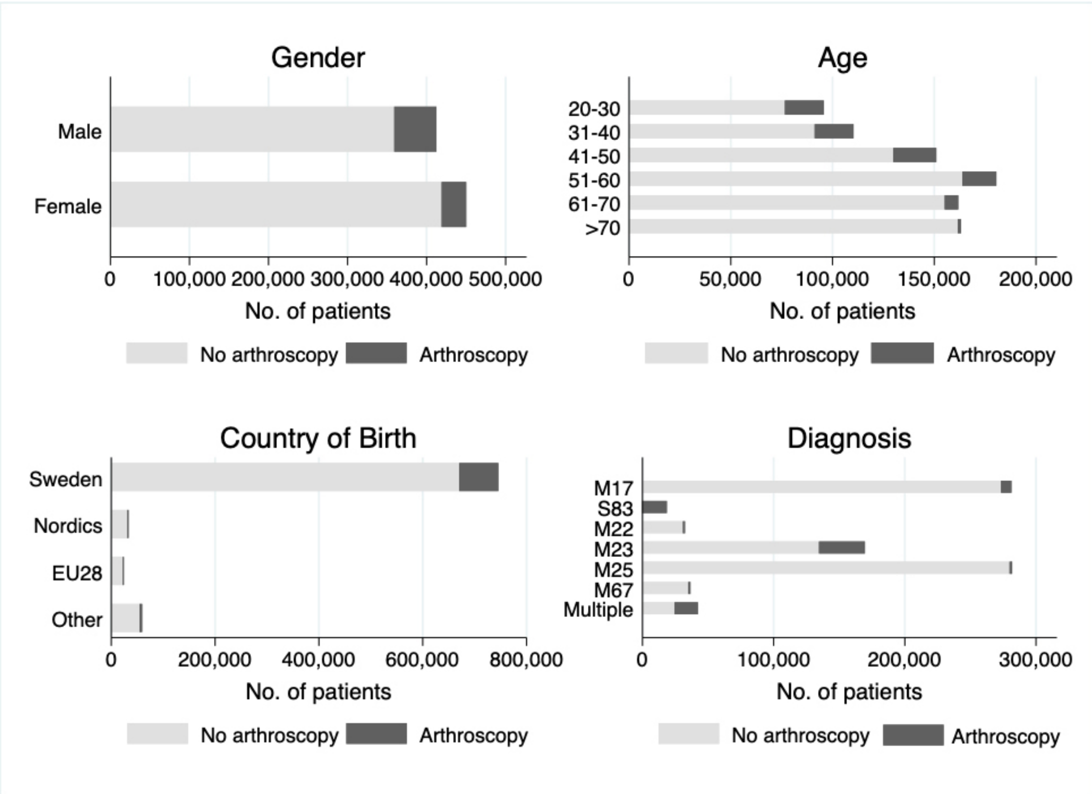
As our aim is to investigate the horizontal equity in access to knee arthroscopies, we wish to control for the need for operation. Need is in this case proxied by diagnosis. As seen in Figure 2, different diagnoses are operated to various extents. Almost all patients with an S83* diagnosis (dislocation, distortion or twist or rupture) received an arthroscopy (99.9%). This can be explained by the fact that it is a diagnosis caused by injury or trauma, which often requires operative treatment.

The classification of the diagnoses stems from the International Statistical Classification of Diseases and Related Health Problems and is used by physicians worldwide (WHO 2011). Our data set contains six different knee diagnoses, where possible treatment includes a knee arthroscopy. In addition, a separate variable for patients that had several diagnoses was created. We used osteoarthritis (M17*) as the baseline category. Each diagnosis was coded into a dummy variable. 45,795 observations had several diagnoses. For them, we created a separate dummy variable that took on value 1 for patients with more than one diagnosis. The following categories were created:

M17*: Osteoarthritis
S83*: Dislocation, distortion, twist or rupture
M22*: Patella conditions
M23*: Meniscus conditions
M25*: Various knee joint diseases
M67*: Ganglion or synovial condition
More than one diagnosis

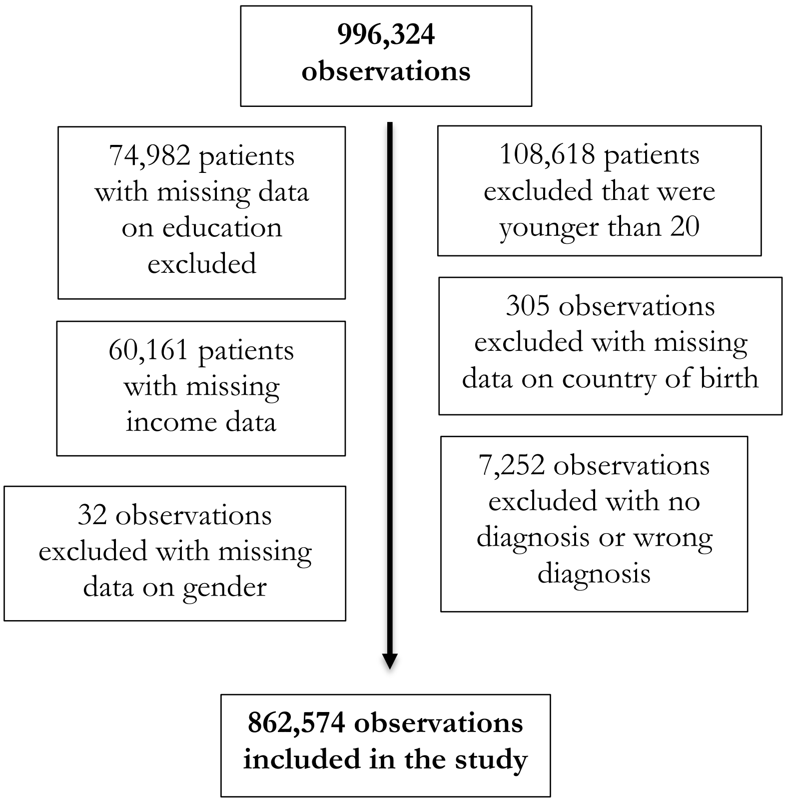
We did not take into account diagnoses where another surgery than an arthroscopy was performed, as our research question only concerns arthroscopies. In total, 6,875 observations had diagnoses that were not relevant for the scope of this thesis and were removed. Some observations, 377, lacked information on diagnosis and were removed. In total, 7,252 observations did not have a diagnosis, or had a diagnosis that did not qualify for arthroscopic treatment and were excluded from the sample, see Figure 3.

**Figure 2.** Gender, age, country of birth and diagnosis with share of arthroscopies.




Source: Authors' rendering of data from Statistics Sweden's LISA database and the Swedish National Board of Health and Welfare's Patient Register 2002-2016.

**Figure 3.** Flowchart of included observations from Statistics Sweden's LISA database and the Swedish National Board of Health and Welfare's Patient Register 2002-2016.




## 6.7 Model Specifications

We created three different models. All models were specified before running any regressions. One model includes both income and education, our measurement of SES, as explanatory variables, whereas the two others include education and income separately as independent variables. When controlling for both income and education, we run the risk of overcontrolling, as income and education are positively correlated, see Appendix 1. Hence, we want to see how the coefficients change for our variables of interest when looking at income and education separately.

Our models are linear probability models, which means that the dependent variable takes on a binary value of either 0 or 1. In order to avoid making assumptions of functional form, all our independent variables are categorical. Our models are specified below:

1. Model 1

$$Operation_i = \beta_0 + \beta_1 Income\_quintile2_i + \beta_2 Income\_quintile3_i + \beta_3 Income\_quintile4_i + \beta_4 Income\_quintile5_i + \beta_5 Education\_level2_i + \beta_6 Education\_level3_i + \beta_7 Education\_level4_i + \alpha_j X_j + u_i$$

2. Model 2

$$Operation_i = \beta_0 + \beta_1 Income\_quintile2_i + \beta_2 Income\_quintile3_i + \beta_3 Income\_quintile4_i + \beta_4 Income\_quintile5_i + \alpha_j X_j + u_i$$

3. Model 3

$$Operation_i = \beta_0 + \beta_1 Education\_level2_i + \beta_2 Education\_level3_i + \beta_3 Education\_level4_i + \alpha_j X_j + u_i$$

Where $X_j$ are our control variables–region, age, gender, diagnosis, country of birth and year of diagnosis or knee arthroscopy, and $\alpha_j$ includes the coefficients for the control variables.

### 6.7.1 Hypotheses

The algebraic interpretations of our hypotheses are the following:

*Model 1*

For income, we hypothesize that:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$

$$H_1: \beta_1 > 0, \beta_2 > 0, \beta_3 > 0, \beta_4 > 0$$

We expect to see the following ranking of the coefficients:

$$\beta_4 > \beta_3 > \beta_2 > \beta_1$$

For education, we hypothesize that:

$$H_0: \beta_5 = \beta_6 = \beta_7 = 0$$

$$H_1: \beta_5 > 0, \beta_6 > 0, \beta_7 > 0$$

We expect to see the following ranking of the coefficients:

$$\beta_7 > \beta_6 > \beta_5$$

*Model 2*

For income, we hypothesize that:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$

$$H_1: \beta_1 > 0, \beta_2 > 0, \beta_3 > 0, \beta_4 > 0$$

We expect to see the following ranking of the coefficients:

$$\beta_4 > \beta_3 > \beta_2 > \beta_1$$

*Model 3*

For education, we hypothesize that:

$$H_0: \beta_1 = \beta_2 = \beta_3 = 0$$

$$H_1: \beta_1 > 0, \beta_2 > 0, \beta_3 > 0$$

We expect to see the following ranking of the coefficients:

$$\beta_3 > \beta_2 > \beta_1$$

## 6.8 Tests

In order to test our hypotheses, we performed t-tests on all of our variables. We also performed F-tests, in order to see if the coefficients for the different income and educational levels were jointly significant. For model 1, we tested if the coefficients for the levels of both education and income were jointly significant. For model 2, we tested if coefficients for the levels of income were jointly significant, and for model 3 we tested if coefficients for the levels of education were jointly significant.

## 6.9 Limitations

There are limitations to our data set, as the data collection for the National Patient Register is not systematic. Sometimes, the diagnoses or dates are recorded after the time of diagnosis, and it is sometimes done by someone else than the treating physician. This can cause discrepancies in the data set between what actually occurred and the recorded data.

Furthermore, the data contains information on the year each patient was diagnosed, but this measurement is not completely uniform across observations. For patients that received surgery, the variable year corresponds to the year of the surgery. If there is a large time gap between time of diagnosis and time of surgery, there will be a time lag in the measurements of income and education, as the patients that received surgery will be compared at different times than those that only received a diagnosis. According to orthopedists, the time between diagnosis and decision of treatment (operative or non-operative) is seldom longer than a couple of months (Berglund, Garland and Marcano 2019). In addition, there is a treatment guarantee in the Swedish healthcare system. This means that patients are entitled to the prescribed treatment within three months after the decision of treatment has been made (Vårdguiden 2019). The time lag means that we have to assume that socioeconomic status remains constant between diagnosis and surgery. Since the time lag usually is less than a year, we make the judgment that it is a reasonable assumption.

There are some omitted variables potentially related to the need of surgery that can affect the probability of receiving an operation that we have been unable to control for. For instance, some occupational groups are more dependent on their knee function than others. As the categorization of occupations that is available (Statistics Sweden 2016) does not reflect how physically demanding an occupation actually is for the knee, we chose to not control for occupation. For instance, one category consists of workers within sales and care services. This category contains occupations that have different demands for the knee. For example, the working tasks of a kindergarten teacher tend to be more demanding compared to working at the till in a shop, even though the two occupations are grouped together. Therefore, it is difficult to control for occupational group based on how demanding it is for the knee.

Moreover, the patients in the data set are present with their first diagnosis or surgery between 2002–2016. If some of them received surgery or had other knee diagnoses that did not qualify for arthroscopy, or had other morbidities, it could impact their need. We are not able to control for this potential orthopedic and medical history. Another factor that could affect the probability of receiving an operation is type of caregiver, as incentive structure for surgery could differ depending on the provider, public or private (Van Doorslaer and Wagstaff 1992). Another issue with our data set is that a patient can be diagnosed in one region, but then operated in another region. The variable region is therefore perhaps not accurate in all cases. These omitted variables can bias the coefficients in the models.

There are some methodological issues with using a linear probability model. For instance, the probability of receiving surgery can take on a value larger than 1, which is an impossibility result. In spite of this, we have made the judgment that it is the most suitable model for our research question, as it is easily interpreted. Moreover, we have avoided making any assumptions of functional form by only using categorical variables in the model. To summarize, our method and data contain several limitations. The results need to be interpreted bearing these limitations in mind.

# 7. Results

## 7.1. Descriptive Statistics

Before presenting the results from the regression, we present some descriptive statistics of the share of arthroscopies in the different income and educational groups without doing controls. As seen in Table 1, see Appendix 2 for visualization, the share of arthroscopies in the different groups are increasing with education and income with one exception–the share of arthroscopies goes down slightly between the second highest and highest educational level.

**Table 1. Share of Arthroscopies per Income and Educational Group.**

| Income | Total No. of Patients | No. of Arthroscopies | Percentage Share |
|---|---|---|---|
| Quintile 1 | 171,601 | 12,684 | 7.4% |
| Quintile 2 | 173,796 | 14,326 | 8.2% |
| Quintile 3 | 173,030 | 18,613 | 10.8% |
| Quintile 4 | 173,563 | 19,645 | 11.3% |
| Quintile 5 | 170,584 | 19,276 | 11.3% |
| **Education** | **Total No. of Patients** | **No. of Arthroscopies** | **Percentage Share** |
| Primary and secondary school nine years or less | 210,534 | 11,608 | 5.5% |
| Upper secondary school three years or less | 399,234 | 43,740 | 11.0% |
| Post-secondary education shorter than three years | 111,299 | 13,161 | 11.8% |
| Post-secondary education three years or longer | 141,507 | 16,035 | 11.3% |

Source: Statistics Sweden LISA database and the Swedish National Board of Health and Welfare's Patient Register 2002-2016.

## 7.2 Model 1

For the first model, all results are significant ($p<0.01$), except for the income coefficient for the second quintile, as seen in Table 2. This could be due to overcontrolling, as the effect of income is not significant when holding level of education fixed. However, one cannot reject that there is a difference between the first and second quintile. Even if the coefficient for the second quintile is not significant, the result still points in the direction of our hypotheses.

In line with our hypotheses, the coefficients for income and education are increasing, see Figure 4. Patients' probability of receiving surgery increases with SES, except between the second-highest and the highest educational group, where the coefficient remains unchanged, see Table 2. This could be due to overcontrolling, as the variation in education decreases when controlling for income. The standard error decreases slightly for the highest educational level, which indicates that its effect on probability is somewhat stronger than the second-highest educational level.

A patient in the highest income level, holding all other variables fixed, has a 1.2 percentage point higher chance of receiving an arthroscopy than a patient in the lowest income level, when controlling for education, as seen in Table 2. Since the baseline probability of receiving an arthroscopy is 16 percentage points, belonging to the highest income group, ceteris paribus, increases the chances of receiving surgery operation with 7.5% (1.2/16). This can be translated into approximately 2,047 more arthroscopies for patients in the highest income group, compared to the lowest income group, all else equal (0.012*170,584). As for education, belonging to the highest educational group, all else equal, increases the chances of receiving an arthroscopy with 0.74 percentage points compared to the lowest educational level. Taking into account the baseline probability, this increases the chances of receiving surgery operation with 4.6% (0.74/16), which translates into around 1,047 more arthroscopies in the highest educational group compared to the lowest (0.0074*141,507).

## 7.3 Model 2

For the second model, which only takes into account income level, all results are significant ($p<0.01$) and the coefficients are increasing, see Figure 4. These findings are in line with our hypotheses. As seen in Table 2, the coefficients increase with income level and are larger than in the first model. This means that the positive association between probability of receiving surgery and income level is stronger than when one also takes into account educational level. An explanation for this could be that when one does not control for level of education, there is more variation in the income variable. This could be since income captures some of the variation in education.

The differences in receiving surgery with regards to income are largest between the highest and second highest income group. If one belongs to the highest group, the probability of receiving surgery increases with 0.91 percentage points compared to the second highest group, see Table 2. This difference is large relative to the other differences between the coefficients of the other income groups. In the second model, the patients in the highest income group have a 1.4 percentage point higher chance of receiving an arthroscopy compared to the baseline income category, which translates roughly into 2,388 arthroscopies (0.014*170,584). This corresponds to an 8.75% increase in the probability of receiving surgery for the highest income group compared to the lowest (1.4/16).

## 7.4 Model 3

For our third model, all coefficients are significant ($p<0.01$), and they are increasing with level of education, in accordance with our hypotheses, see Figure 4. As observed in Table 2, the coefficients for education are larger than in the first model. This could be explained in the same way as in the second model–the coefficients capture a larger variation than in the first model, as education can explain more of the probability when one does not compare individuals in the same income groups. The difference between the highest and the lowest educational level in the probability of receiving an arthroscopy is 1.1 percentage points, which represents a 6.875% probability increase for an arthroscopy compared to the baseline category (1.1/16). This corresponds to around 1,557 more arthroscopies in the highest educational group compared to the lowest (0.011*141,507).

**Table 2. Full Regressions.**

**Dependent Variable: Probability of Knee Arthroscopy.**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | **Education and Income** | **Income** | **Education** |
| **Income** | | | |
| Quintile 2 | 0.0014 (0.00074) | 0.0019** (0.00074) | |
| Quintile 3 | 0.003** (0.00081) | 0.004** (0.0008) | |
| Quintile 4 | 0.0037** (0.00086) | 0.0049** (0.00084) | |
| Quintile 5 | 0.012** (0.00091) | 0.014** (0.00087) | |
| **Education** | | | |
| Upper secondary school three years or less | 0.0057** (0.00061) | | 0.0066** (0.00061) |
| Post-secondary education shorter than three years | 0.0074** (0.00093) | | 0.0094** (0.00092) |
| Post-secondary education three years or longer | 0.0074** (0.00088) | | 0.011** (0.00084) |
| **Constant** | 0.16** (0.0018) | 0.16** (0.0018) | 0.16** (0.0017) |
| **Age** | Yes | Yes | Yes |
| **Gender** | Yes | Yes | Yes |
| **Diagnosis** | Yes | Yes | Yes |
| **Year** | Yes | Yes | Yes |
| **Country of birth** | Yes | Yes | Yes |
| **Region** | Yes | Yes | Yes |
| Observations | 862,574 | 862,574 | 862,574 |
| F-test | 63.33[1] (7,862,516) | 74.52[2] (4,862,519) | 73.97[3] (3,862,520) |
| P-value of F-test | 0.0000 | 0.0000 | 0.0000 |
| Adjusted R-squared | 0.3536 | 0.3535 | 0.3534 |
| R-squared | 0.3536 | 0.3535 | 0.3534 |

Standard errors in parentheses
$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

## 7.5 Additional Comments

As seen in Table 2, the R-squared and adjusted R-squared are the same for all models. This could be due to the fact that there are relatively few independent variables compared to the number of observations. We hypothesized that the coefficients of our variables of interest would increase with SES. Studying Figure 4, one observes that this is the case. However, as seen in Table 3, when taking into account the baseline constant, the coefficients for SES are put in the context of the full regression and the association appears to be weaker.

[1] F-test of joint significance of income and education variables together
[2] F-test of joint significance of income variables together
[3] F-test of joint significance of education variables together

**Figure 4.** Mapping the coefficients for models 1–3.

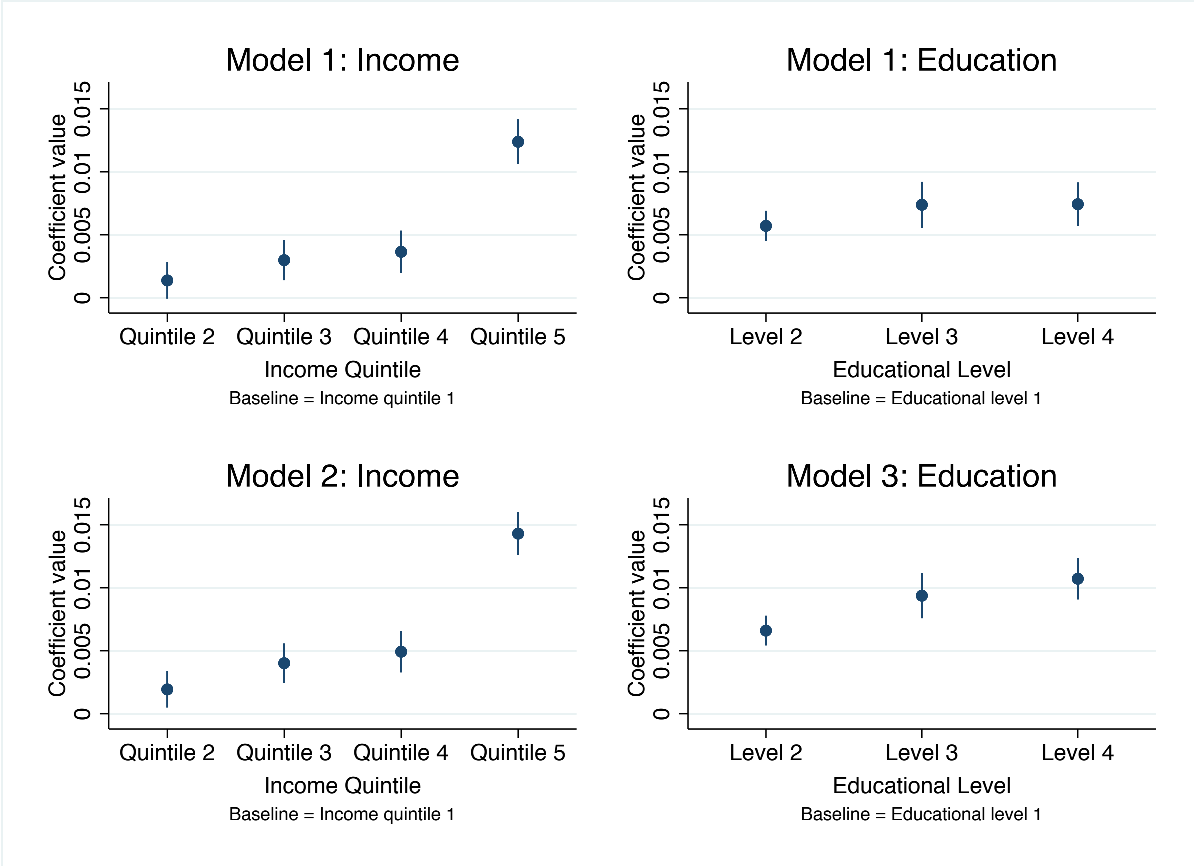



**Table 3. Total Probability by Income and Educational Level.**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | **Education and Income** | **Income** | **Education** |
| **Income** | | | |
| Quintile 1 (baseline) | 0.16** | 0.16** | |
| Quintile 2 | 0.1614 | 0.1619** | |
| Quintile 3 | 0.163** | 0.164** | |
| Quintile 4 | 0.1637** | 0.1649** | |
| Quintile 5 | 0.172** | 0.174** | |
| **Education** | | | |
| Primary and secondary school nine years or less (baseline) | 0.16** | | 0.16** |
| Upper secondary school three years or less | 0.1657** | | 0.1666** |
| Post-secondary education shorter than three years | 0.1674** | | 0.1694** |
| Post-secondary education three years or longer | 0.1674** | | 0.171** |

* $p < 0.05$, ** $p < 0.01$

# 8. Discussion

## 8.1 A Socioeconomic Gradient

Our results display a socioeconomic gradient in the probability of receiving a knee arthroscopy. All coefficients but one were significant ($p<0.01$). We had a large data set, which increases the likelihood of significant results. The coefficients for income and education differ between the three models. This is partly due to the correlation between education and income, see Appendix 1. It explains the slight differences between the coefficients of the three models, as income and education partly capture different variations in the sample. The largest coefficient difference is between the second highest and the highest income group in the second model, which suggests that large parts of the variation in arthroscopy access due to SES are between the highest income quintile compared to the other quintiles, see Figure 4.

Whether the association between SES and access to a knee arthroscopy is small or large is a topic for discussion. One the one hand, the coefficients in the regression can be argued to be small, as they all fluctuate around one percentage point or less. The differences in total probability between the respective income and educational groups could therefore be seen as marginal, as seen in Table 3. In addition, the association between SES and arthroscopy access is small compared to several of the control variables, which have larger coefficients. The coefficients for age, year of surgery or diagnosis, or type of diagnosis are significant and mostly around five percentage points or more, which suggests that the explanatory value of SES is limited compared to other variables, see Appendix 3. On the other hand, taking into account that the baseline probability of receiving surgery is 16 percentage points, the coefficients for SES represent a significant share of the baseline probability, around 6.875%–8.75%. In addition, not controlling for occupational status can contribute to negatively biased coefficients in our regression. One can imagine that there is a positive correlation between patients with occupations that are more demanding for the knee and the probability of surgery. One can also hypothesize that SES is negatively correlated with patients having occupations that are demanding for the knee. This type of omitted variable bias would create negatively biased coefficients. With this in mind, one could thus view our reported coefficients as a lower bound, and that the actual coefficients if one were able to control for knee intensive occupations would be larger.

To contextualize the association between SES and arthroscopy access one can compare the coefficients of income and education with other control variables. Differences in probability of operation vary between regions, suggesting that regional differences in healthcare governance could be associated with patients' healthcare access. Moreover, the probability of receiving a knee arthroscopy decreases with 1.4 percentage points for women, see Appendix 3, which follows previous research on gender bias. The probability also decreases with two percentage points for patients born outside of the EU, see Appendix 3, which is in line with previous orthopedic research. Country of birth and gender thus seem to play a role when determining access to knee arthroscopies. Since we control for need through diagnosis, our results could point towards a conscious or unconscious discrimination. For country of birth, the results could also point towards differing system knowledge and health literacy between patients born in different countries. What exact mechanisms that drive the inequity for gender and country of birth is a topic for further research.

## 8.2 Connection with Previous Research

Our results are in line with previous research in the area that have found SES to be positively associated with orthopedic access. The results from Marcano et al. (2019), where early operative treatment for cruciate ligament injury had a positive association with higher incomes for patients with higher levels of education, are in line with ours. In addition, Nordenvall et al. (2017) found a 29% increased likelihood of receiving surgery for patients belonging to the highest educational level compared to the lowest. However, the study employed Poisson models, as opposed to an LPM, and four income groups and five educational levels were used, which differs from our sample categorization. In addition, the authors only looked at cruciate ligament injuries, as opposed to several knee conditions. This highlights that different diseases and injuries can display socioeconomic gradients of varying strength. It is therefore of interest to see in which medical fields and for which diagnoses the gradient is strong.

In addition, our results can provide an explanation to previous Swedish results that have studied orthopedic health's association with SES. Both Krupic et al. (2013) and Kiadaliri et al. (2017) found a negative association between SES and orthopedic outcomes. Perhaps this could partly be explained by our observed socioeconomic gradient in orthopedic healthcare access.

Our results are also in line with a bigger picture of horizontal inequity in the Swedish healthcare system. Van Doorslaer et al. (1992) found an inequity in favor of those with higher income in Sweden with regards to specialist care. This is reflected in this study, since knee arthroscopies are part of specialist care. Moreover, the results are also in line with Gerdtham's (1997) rejection of the null-hypothesis of no inequity in the Swedish healthcare system, since a gradient is observed.

## 8.3 Potential Causes

The aim of this thesis was not to establish any causal effect, but since a socioeconomic gradient is observed it opens up for a discussion on the potential mechanisms behind it. For instance, health literacy could be important for receiving a knee arthroscopy, and level of health literacy could change with income and educational level. Different access costs for different socioeconomic groups might also contribute to the gradient. It could also be that individuals with high income have private health insurance to a larger extent, which facilitates access to knee arthroscopies. Another explanation could be that patients with different SES have different preferences regarding operations. SES would then be a proxy for willingness to receive an operation, and the results would reflect a willingness gradient rather than a socioeconomic gradient. This introduces a discussion on whether the socioeconomic gradient is a question of healthcare supply or healthcare demand, or perhaps both. Is it a graded buyer-induced supply of healthcare that has created this gradient? Or, is it a graded demand that makes individuals with lower SES more price sensitive to knee arthroscopies with regards to access and opportunity costs?

## 8.4 Implications for Policy-making

Since the exact mechanisms behind the socioeconomic are not well understood at this moment, what specific areas in the healthcare sector policies should target to promote horizontal equity is up for discussion. Nonetheless, one can conclude that simply looking at clinical outcomes when researching healthcare access is not enough. If policymakers are striving for horizontal equity, one could argue that there is a need for active healthcare policies. Moreover, the displayed gradient for knee arthroscopies can be argued to be marginal, which raises a number of questions for policymakers. When do small inequalities in healthcare access turn into horizontal inequity? How large a discrepancy should be accepted in a healthcare system?

## 8.5 Future Research

Our results open up for topics worth of further research in the area. Future research could look at whether the results change if one were to modify the sample and take all arthroscopies, and not just those with first-time diagnoses and first-time surgeries. One could also examine whether the gradient changes when looking at the different diagnoses separately. The analysis could also be deepened by controlling for private or public healthcare, as the two systems could represent different incentive structures.

We previously mentioned that gender or country of birth could be argued to be a part of SES. Our results indicate that these variables are associated with access to arthroscopies. A future study could thus look at SES as a combination of income, education, gender, and country of birth to see how this wider measurement is associated with knee arthroscopy access. This could for instance be done with a factor analysis. It could also be of interest to look at gender and country of birth separately. Our categorization of countries could also be segmented differently. The outside EU28 category could be divided into OECD countries and non-OECD countries, in order to observe potential differences between patients from developed or developing countries.

Future research could replicate our models for studying specialist care in other medical areas, to see whether a socioeconomic gradient can be observed for other conditions and treatments. By looking at newer and more complex treatments that may require higher levels of health literacy, a buyer-induced supply for specialist care can be examined. To summarize, there is much research to be done in the area of a socioeconomic gradient in healthcare access.

# 9. Conclusion

This thesis investigated whether there exists a positive association between socioeconomic status and the probability of receiving an arthroscopic procedure of the knee when diagnosed with a knee condition. We used data on income and education from Statistics Sweden's LISA database, as well as clinical data from the Swedish National Board of Health and Welfare's Patient Register on all patients diagnosed with a knee condition for the first time in the time period 2002–2016. A linear probability model was created to study this association.

A positive association between SES and access to a knee arthroscopy was found for first-time diagnoses and surgeries. All coefficients but one were significant ($p<0.01$) and fluctuated around one percentage point or less. Considering that the baseline probability of receiving surgery is 16 percentage points, the coefficients for SES represent a significant share of the baseline probability, between 6.875%–8.75%. Translated into number of arthroscopies, the differences between groups with the highest and lowest SES are around 1,047–2,388 first-time arthroscopies over the given time period.

These results have contributed to mapping the socioeconomic gradient for a number of common knee-related conditions. Our results shed some light on the role of socioeconomic status in the orthopedic field and can hopefully be of help for policymakers and doctors seeking to reduce horizontal inequity in the Swedish healthcare sector. We hope that future research continues to map the socioeconomic gradient in healthcare, in the quest for improved human health.

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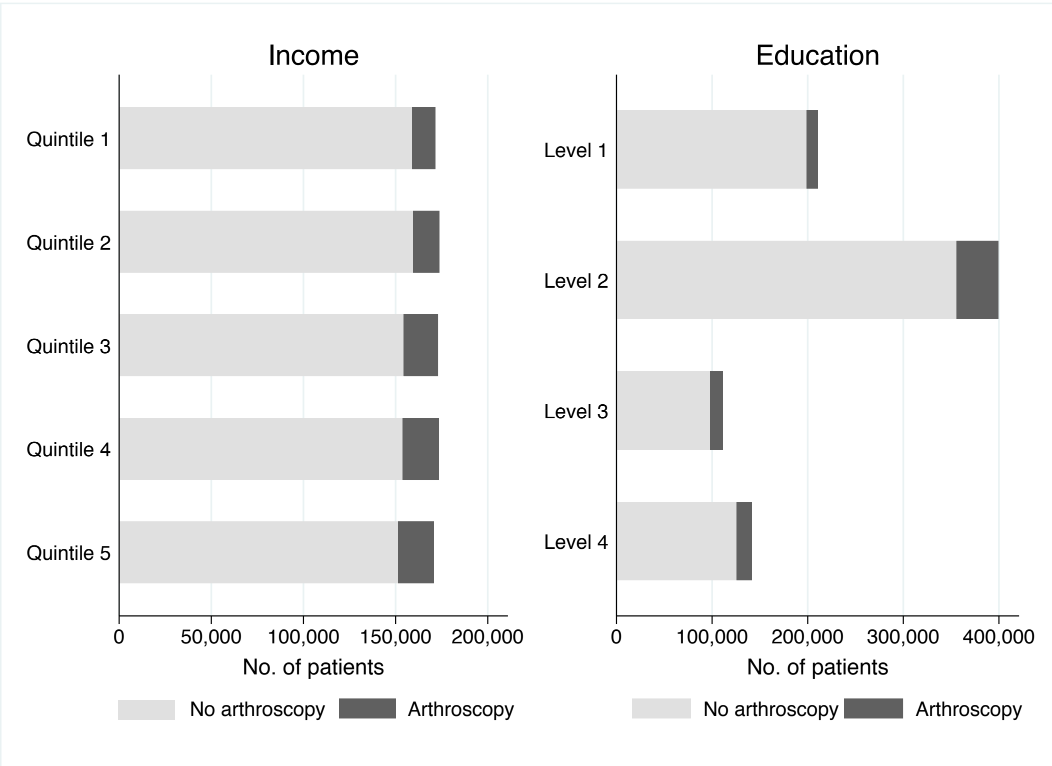
# Appendix

## Appendix 1. Correlation Matrix Income and Education

| | **Education** | **Income** |
|---|---|---|
| **Education** | 1 | 0,2913 |
| **Income** | 0,2913 | 1 |

## Appendix 2. Income and Educational Level with Share of Arthroscopies

**Figure 5.** Income and education with share of arthroscopies.




Source: Authors' rendering of data from Statistics Sweden's LISA database and the Swedish National Board of Health and Welfare's Patient Register 2002-2016.

## Appendix 3. Full Regressions with Coefficients of Control Variables

## Dependent Variable: Probability of Knee Arthroscopy

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | **Education and Income** | **Income** | **Education** |
| **Income** | **Yes** | **Yes** | |
| **Education** | **Yes** | | **Yes** |
| **Age** | | | |
| 31-40 | -0.0027* (0.0013) | -0.0026 (0.0013) | -0.0024 (0.0013) |
| 41-50 | -0.013** (0.0012) | -0.013** (0.0012) | -0.012** (0.0012) |
| 51-60 | -0.039** (0.0012) | -0.039** (0.0012) | -0.036** (0.0012) |
| 61-70 | -0.064** (0.0012) | -0.066** (0.0012) | -0.062** (0.0012) |
| >71 | -0.071** (0.0012) | -0.073** (0.0011) | -0.071** (0.0012) |
| **Gender** | | | |
| Woman | -0.014** (0.00052) | -0.013** (0.00052) | -0.015** (0.00052) |
| **Diagnosis** | | | |
| S83 | 0.91** (0.00087) | 0.91** (0.00087) | 0.91** (0.00087) |
| M22 | -0.024** (0.0013) | -0.023** (0.0013) | -0.023** (0.0013) |
| M23 | 0.14** (0.0011) | 0.14** (0.0011) | 0.14** (0.0011) |
| M25 | -0.045** (0.00051) | -0.045** (0.00051) | -0.045** (0.00051) |
| M67 | -0.0067**(0.0011) | -0.0065**(0.0011) | -0.0064**(0.0011) |
| Multiple diagnoses | 0.36** (0.0024) | 0.36** (0.0024) | 0.36** (0.0024) |
| **Year** | | | |
| 2003 | -0.018** (0.0017) | -0.018** (0.0017) | -0.018** (0.0017) |
| 2004 | -0.021** (0.0017) | -0.021** (0.0017) | -0.021** (0.0017) |
| 2005 | -0.036** (0.0016) | -0.036** (0.0016) | -0.036** (0.0016) |
| 2006 | -0.044** (0.0016) | -0.044** (0.0016) | -0.044** (0.0016) |
| 2007 | -0.056** (0.0016) | -0.055** (0.0016) | -0.056** (0.0016) |
| 2008 | -0.053** (0.0015) | -0.052** (0.0015) | -0.053** (0.0015) |
| 2009 | -0.066** (0.0015) | -0.065** (0.0015) | -0.066** (0.0015) |
| 2010 | -0.076** (0.0015) | -0.075** (0.0015) | -0.076** (0.0015) |
| 2011 | -0.084** (0.0014) | -0.084** (0.0014) | -0.084** (0.0014) |
| 2012 | -0.087** (0.0014) | -0.086** (0.0014) | -0.087** (0.0014) |
| 2013 | -0.078** (0.0015) | -0.078** (0.0014) | -0.078** (0.0015) |
| 2014 | -0.084** (0.0014) | -0.083** (0.0014) | -0.084** (0.0014) |
| 2015 | -0.087** (0.0014) | -0.086** (0.0014) | -0.087** (0.0014) |
| 2016 | -0.091** (0.0014) | -0.09** 0(.0014) | -0.091** (0.0014) |
| **Country of birth** | | | |
| Nordics without Sweden | -0.00097 (0.0012) | -0.0014 (0.0012) | -0.0017 (0.0012) |
| EU28 without Nordics | -0.0087** (0.0014) | -0.0081** (0.0014) | -0.0098** (0.0014) |
| Outside EU28 | -0.02** (0.001) | -0.02** (0.001) | -0.022** (0.00099) |
| **Region** | | | |
| Blekinge | -0.022** (0.0017) | -0.023** (0.0017) | -0.024** (0.0017) |
| Dalarna | 0.0091** (0.0018) | 0.0088** (0.0018) | 0.0075** (0.0018) |
| Gotland | -0.0042 (0.0033) | -0.0045 (0.0033) | -0.0061 (0.0033) |
| Gävleborg | -0.026** (0.0016) | -0.026** (0.0016) | -0.027** (0.0016) |
| Halland | -0.019** (0.0016) | -0.02** 0(.0016) | -0.02** (0.0016) |
| Jämtland | -0.0064** (0.0025) | -0.0065** (0.0025) | -0.0084** (0.0025) |

| | | | |
|---|---|---|---|
| Jönköping | 0.011** (0.0018) | 0.011** (0.0018) | 0.01** (0.0018) |
| Kalmar | -0.018** (0.0015) | -0.019** (0.0015) | -0.019** (0.0015) |
| Kronoberg | -0.044** (0.0017) | -0.045** (0.0017) | -0.045** (0.0017) |
| Norrbotten | 0.0046* (0.002) | 0.0044* (0.002) | 0.0032 (0.002) |
| Missing region | -0.036** (0.0019) | -0.036** (0.0019) | -0.036** (0.0019) |
| Skåne | -0.031** (0.00085) | -0.031** (0.00085) | -0.032** (0.00085) |
| Södermanland | -0.024** (0.0014) | -0.024** (0.0014) | -0.025** (0.0014) |
| Uppsala | -0.009** (0.0015) | -0.0092** (0.0015) | -0.0099** (0.0015) |
| Värmland | 0.0017 (0.0017) | 0.0015 (0.0017) | 0.00036 (0.0017) |
| Västerbotten | -0.0078** (0.0018) | -0.0079** (0.0018) | -0.0094** (0.0018) |
| Västernorrland | -0.029** (0.0016) | -0.029** (0.0016) | -0.031** (0.0016) |
| Västmanland | -0.064** (0.0014) | -0.064** (0.0014) | -0.065** (0.0014) |
| Västra Götaland | -0.025** (0.00097) | -0.025** (0.00097) | -0.026** (0.00097) |
| Örebro | -0.037** (0.0015) | -0.038** (0.0015) | -0.039** (0.0015) |
| Östergötland | 0.021** (0.0018) | 0.021** (0.0018) | 0.02** (0.0018) |
| Constant | 0.16** (0.0018) | 0.16** (0.0018) | 0.16** (0.0017) |
| Observations | 862,574 | 862,574 | 862,574 |

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$