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DISCUSSION PAPERS

MIRA KAJANTIE

Examining Equity in Access to Health Care Using Register Data

Pathways to Coronary Revascularisations in Finland 1995–1998

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Abstract

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Administrative registers provide an inexhaustible source of information being beneficially exploited as a growing trend by social researchers. Register-based research differs in some ways from the traditional ways of carrying out research. The purpose of this study was to examine the possibilities that register data provide for equity in health care research, and to illustrate how the project can be conducted in practice.

The process of register-based research was examined through actual research data. Study data was a part of the STAKES research data originally collected to identify the coronary heart disease population and to examine differences in the treatment of the disease in Finland in 1995–1998. Originally compiled for other purposes, register data were reworked into a retrospective cohort study setting. The purpose was to examine possible socioeconomic differences in treatment histories among patients that underwent their first revascularisation operation (coronary angioplasty or coronary artery bypass grafting) during the years 1995–1998. Statistical methods used in this study are commonly used in epidemiological research, including logistic and multinomial logistic regression, Poisson regression and Cox regression.

Based on previous research, it was known that higher socioeconomic groups received more revascularisations than those worse-off during the 1990s. This study aimed to conclude whether patients in higher socioeconomic groups received the operation during an earlier stage of the disease as based on their treatment history. According to the results, statistically significant differences that favouring those better-off existed in 1995-1998 in the pathways to revascularisation. Patients from higher socioeconomic groups received surgery sooner after the diagnosis and had fewer acute hospitalisations due to coronary heart disease in their treatment histories. The study used several graphic and statistical methods to gain a more detailed picture of the pathways to revascularisation.

Keywords: health services research, equity register-based research, coronary heart disease, statistics

Summary in Finnish

Mira Kajantie. Examining Equity in Access to Health Care Using Register Data. Pathways to coronary revascularisations in Finland 1995–1998 [Miten tutkia hoitoon pääsyn oikeudenmukaisuutta rekisteripohjaisilla aineistoilla? Hoitoketjut revaskularisaation toimenpiteisiin Suomessa 1995–1998]. STAKES, Discussion Papers 4/2007. Helsinki 2007. pp. 48, price 16 €. ISBN 978-951-33-1974-8

Hallinnollisiin tarkoituksiin kerätyt rekisteriaineistot tarjoavat ehtymättömän tietovarannon, jota hyödynnetään enenevässä määrin yhteiskunnallisessa tutkimuksessa. Rekisteritutkimus eroaa joiltakin osin perinteisestä tavasta tehdä tutkimusta. Tämä tutkimus selvittää rekisteriaineistojen tarjoamia mahdollisuuksia ja havainnollistaa rekisteritutkimuksen eri vaiheita käytännössä.

Tutkimuksessa tarkastellaan rekisteritutkimusprosessia todellisen tutkimusaineiston avulla. Analysoitava aineisto on Stakesin tutkimusaineisto, joka on alun perin kerätty identifioimaan sepelvaltimotautipopulaatio ja tutkimaan taudin hoitoeroja Suomessa vuosina 1995–1998. Alun perin muuhun tarkoitukseen kerätty rekisteriaineisto muokattiin vastaamaan retrospektiivistä kohorttitutkimusasetelmaa. Tavoitteena oli selvittää mahdollisia sosioekonomisia eroja vuosina 1995–1998 ensimmäisen sepelvaltimoiden ohitusleikkauksensa tai pallolaajennuksensa eli revaskularisaation läpikäyneiden potilaiden hoitohistorioissa. Käytetyt tilastolliset menetelmät ovat epidemiologiassa yleisesti käytössä olevia, kuten logistinen ja multinomiaalinen logistinen regressioanalyysi, Poisson regressio ja Coxin regressioanalyysi.

Aiemman tutkimuksen perusteella tiedettiin, että 1990 -luvulla ylemmässä sosioekonomisessa asemassa oleville henkilöille tehtiin huonompi-osaisia enemmän revaskularisaatioita. Tutkimuksessa analysoitiin revaskularisaatiopotilaiden hoitohistorioita. Tavoitteena oli selvittää, saavatko ylemmässä sosioekonomisessa asemassa olevat potilaat leikkaushoitoa taudin aikaisemmassa vaiheessa kuin alemmassa sosioekonomisessa asemassa olevat potilaat. Tutkimustulosten perusteella tilastollisesti merkitseviä eroja ylimmän sosioekonomisen ryhmän eduksi oli vuosina 1995–1998. Operaatioon johtaneiden hoitoketjujen tarkastelu osoitti, että ylemmässä sosioekonomisessa asemassa olevien potilaiden hoitoketjuissa oli vähemmän akuutteja hoitojaksoja ja operaatio tehtiin heille nopeammin diagnoosin jälkeen verrattuna alempiin sosioekonomisiin ryhmiin. Tutkimuksessa sovellettiin useita kuvantamismenetelmiä ja tilastollisia menetelmiä yksityiskohtaisen kuvan saamiseksi revaskularisaatiopotilaiden hoitoketjuista.

Avainsanat: terveydenhuoltotutkimus, rekisteritutkimus, oikeudenmukaisuus, sepelvaltimotauti, tilastotiede

Contents

List of abbreviations

CABG	Coronary artery bypass grafting
CHD	Coronary heart disease
ELC	Elective CHD hospital admission
EMC	Emergency CHD hospital admission
HILMO	Finnish Care Register
IRR	Incident rate ratio
MLR	Multinomial logistic regression
MI	Myocardial infarction
OPER	Surgery admission
OR	Odds ratio
PTCA	Percutaneus transluminal coronary angioplasty
REV	Revascularisation (PTCA and CABG)
RRR	Relative risk ratio
SF	Statistics Finland
SES	Socioeconomic status
SII	Social Insurance Institution
SPC	Special payment category
SRR	Special reimbursement right

1 INTRODUCTION

All Finnish residents, regardless of their socioeconomic or cultural background, are entitled by law to health care with equal access. In recent years, there has been considerable debate about the state of Finnish health care and whether it meets the expected standards. Many recent studies suggest that this is not the case. For instance, people with higher socioeconomic status seem to have better access to treatment, and differences have been reported in the quality of care and in outcomes (see Chapter 2).

Equity and rectitude in health care are values that can be difficult to examine through surveys and interviews because the information is based on personal experiences. Such data can easily be affected by patients' own conception on how the health care system should work and whether (s)he was treated accordingly. A patient can feel mistreated even when the system has worked as it should, and vice versa. To be able to determine whether the treatment is equal in respect to others requires a good knowledge on standing treatment practices and overall view on how the system works in general. Administrative registers provide a valuable source of information that is free from subjective bias. During recent years, there has been a growing demand for evidence-based information to support decision-making and other administrative purposes. Administrative registers have been used in increasing volume by health care researchers in Finland and elsewhere. Register-based health care research has particularly good premises in Finland due to extensive recordings that date back for several decades and – even more important – the use of personal identification codes in data-recording that enable linking information from various sources (Sund et al. 2004, Kajantie et al. 2006).

Administrative register data are not recorded for research purposes. Registers are maintained for other means such as billing, customer service and bookkeeping. Therefore, raw data are seldom useful as such for information purposes. The big challenge in register research is to screen feasible information from huge data pools and process it into a form that enables statistical analysis and produces reliable results.

The data compilation process is often very complex and requires a lot of time, expertise and persistence. The researcher must decide what to observe, how to conceptualise variables, how to acquire appropriate data and how to operationalise the process (Sund 2003). To be able to utilise the connection between the raw register data and the research question, the researcher has to have an elevated understanding of both the substance and content of the data available. The research question has to be worked into codes and definitions, and when the data are compiled there is no possibility to specify or expand the data content. All registers have features and specific contents due to their administrative nature that cannot be seen and understood from the register description. The data are seldom compatible with the presuppositions of the researcher (Sund et al. 2004).

Three phases can be perceived from the data compilation process: understanding the problem, understanding the data, and data pre-processing. The latter of the three can be interpreted to be a kind of a technical operationalising phase and includes various phases:

1. Data abstraction
2. Data cleaning
3. Data integration and reduction

In data abstraction, the data are examined and validated in terms of how they correspond with the research question. Data cleaning is a more technically oriented phase. The third phase includes record linking from multiple data files and producing a data file of smaller volume than the original. Event-based data are reduced into an individual-based data matrix through aggregation and computation, without losing too much relevant information. The data pre-processing requires a creative combination of wide-range substance and technical know-how. It is also the most important and time-consuming part of register-based data analysis. (Sund 2003, Sund et al. 2004.)

This study examines equity in access to coronary revascularisation using research data originally compiled to identify the coronary heart disease population and to study differences in health care use in Finland in 1995–1998. The compilation process for the original research data was completed by the 'Differences in treatment, and in treatment pathways, outcomes and cost-effectiveness among coronary heart disease patients – does socioeconomic status have an effect?' STAKES-project group (see Chapter 2). This study is an example of a study that exploits one set of data compiled for a specific research project with other target populations and study settings. Research data can be exploited by modifying the research question and the study setting so that they correspond to the available data. Study setting of the current study is a retrospective cohort study. Information on all preceding inpatient hospital admissions was linked to each patient who had undergone their first revascularisation (coronary angioplasty or bypass grafting) during the 1995-1998 study period. This approach has not formerly been used for examining pathways to treatment, so several methodologies that enable making conclusions from this kind of data set were explored. Traditional epidemiological analytic methods were used, but the response variables and subpopulations were defined and modified in various ways to fit the data.

The aims of this study were both methodological and subject matter problem solving-oriented. Methodologically, the aim was to describe the process of a register-based study. Methods used earlier in other contexts were developed and adapted to fit the study setting and the data. Various ways of examining pathways to treatment in a retrospective setting were explored. The study setting and methods as well as research questions were modified with respect to data availability and quality, as in register research in general. The subject matter-related objective of this study was to examine whether patients' socio-demographic characteristics and comorbidities have an effect on treatment pathways to revascularisation.

The concept of socioeconomic status as well as earlier research covering socioeconomic differences in prevalence of coronary heart disease (CHD) and equity in treatment practices are examined in Chapter 2. In Chapter 3, the processes of data compilation, construction of the data set and data pre-processing are described. It is not possible to describe every technical step of the pre-processing, but the reader is presented with resulting variables and the main principles on how the research question was operationalised. In Chapter 4, some graphical tools are explored and tested as to how they could be used to analyse or illustrate the research question. In Chapter 5, the question is approached through statistical modelling using four different regression models for the analysis: logistic regression, multinomial logistic regression, Poisson regression and Cox regression. Results obtained by different methods are then compared and evaluated. Significance of the results and conclusions of this study project are discussed in Chapter 6.

2 BACKGROUND AND EARLIER STUDIES

Several international studies on western health care systems provided by public funds have shown inequalities in treatment procedures and results as well as in waiting times and mortality rates. The assumptions made on the basis of these results vary and statements about causality should be made with caution. However, according to research to date, factors such as age, gender, income, education, and occupation all seem to be associated with the treatment received and its quality. This does not suggest that the medical personnel involved in decision-making would deliberately favour particular population groups. However, it does imply that the analysis of the differences should be continued so that any possible system-related barriers in access to treatment could be identified and removed by means of political decision-making.

This study examines people with coronary heart disease (CHD). Cardiovascular diseases, of which CHD is the most common, are the major cause of death in adults in their middle years and older in most European countries including Finland (Wood et al. 2002, Statistics Finland 2007(a)). Studies have shown that people with lower socioeconomic background are more likely to suffer from coronary heart disease, and in consequence it is more often the cause of death among them than among people with higher socioeconomic status (Salomaa et al. 2003). Researches have presented multiple explanations for this including unhealthier lifestyle and poor monitoring of one's own health status. Some studies have raised a question concerning the possible effect of the health care system on the differences found. When studies have previously concluded that half of the SES differences in CHD mortality are due to lifestyle factors and comorbidities, at least part of the remaining half have been suggested to derive from differences in treatment decisions and treatment-seeking behaviour (Keskimäki et al. 1997, Salomaa et al. 2001).

The analysis in this study aims to examine whether patients' characteristics have influence on the treatment received after they have requested medical treatment and been diagnosed on condition that has later on been found to be so severe that a surgical operation has been required. The question is approached by examining the two surgical procedures related to coronary heart disease; coronary artery bypass grafting (CABG) and percutaneous transluminal coronary angioplasty (PTCA). The purpose is to construct profiles of the treatment histories that have led to surgery from the register data and to examine whether patient characteristics are connected to the amount and the other characteristics of the care preceding surgery. Treatment pathways (also referred to as spells) leading to surgery are expected to reveal information on how the disease has progressed and at what stage of the disease the decision to operate has been made.

The process of register based research project is described in detail as the question of equal access to surgery relative to need is being examined. Coronary heart disease is a good case for studying this question, since it has clear diagnostic criteria and well established guidelines for treatment (Wood et al. 2002). Additionally, studying procedures in a single disease category narrows down issues concerning disease-related differences, which could affect the decision to operate.

Coronary revascularisation operations

Revascularisation operations (PTCA and CABG) are in principle viewed as preventive operations, i.e., these operations are conducted to prevent possible myocardial infarctions (MI) and coronary death. This study examines patterns in patient profiles and previous hospitalisation histories that would indicate potential socioeconomic differences in access to revascularisation. The study population includes only revascularised patients, so CHD patients who did not receive the operation or died before having the operation are not included in the analysis.

The two types of invasive cardiovascular operations are not completely comparable. Bypass surgery became more common in the early 1970s, whereas the angioplasty technique was developed and more commonly adopted in the 1980s. Because PTCA is based on a newer and fast-developing medical technology, it has had a growing trend in treatment rates compared to CABG. During the study period (1995–1998) CABG was conducted two to three times more often then PTCA, but after the turn of the century the roles have changed, and in 2003 PTCA was almost twice as common treatment procedure as CABG (Kuukasjärvi et al. 2005).

Socioeconomic status

Three measures that are commonly used in equity research to describe socioeconomic status (SES) were considered in this study since they can be understood to cover various aspects of SES: education, income and occupational social class. Obviously, they are not independent of each other but instead form a causal chain, and each can be considered to partly represent varied aspects of socioeconomic status. Different interpretations concerning the reasons behind the differences in CHD incidence and treatment procedures between groups can be made in relation to each of the variables.

Several discussions are embedded in concerning education and income and their impact on revascularisation. It can be assumed that education increases the store of knowledge and information-seeking behaviour whereas income refers directly to purchasing power. Private health care services have been suggested to provide easier and quicker access to medical appointments. The private sector performs revascularisations, but patients who pay for the operation themselves are actually very few. Usually, the operations performed are purchased by hospital districts (Keskimäki et al. 1997). However, because in Finland private practitioners have a right to refer patients to the public sector for operation and since physicians working in the private sector are more often specialists, high income could contribute to better access to surgery (Keskimäki 2003, Hetemaa et al. 2003). Furthermore, up till recent times a special payment category (SPC) for relatively moderate cost has been available for those who can and want to be operated on and followed up by a certain doctor. SPC will be abolished by February 2008, because it has been seen to compromise the equity principal in public health care. Since the SPC is not recorded in HILMO, its possible effect cannot be taken into account.

Occupational social class presents similar aspects of socioeconomic status as education and income. It combines them with additional information about working conditions, both physical and mental. However, using occupational class in the analysis is not as simple. First of all, the classification is not fully ordinal. Heterogeneity inside the groups is large and difficult to unfold. For example, entrepreneurs are a very heterogeneous group in relation to education, income and type of work. In addition, the connection between education and occupational social class tends to vary between age groups. At present, occupational social class can change in shorter intervals, and conclusions about causality may be more rogue then before. In this study, therefore, occupational class was discarded from the analysis.

Earlier research on equity in access to coronary revascularisation

From the 1980s onwards, disparities in access to health care have been subject to many research projects. Researchers in Finland and internationally have suggested that several characteristics of the patients' situation unrelated to the need for surgery may play a role in treatment decisions.

Studies have shown that differences remain even in countries like Finland, where health care is offered free-of-charge (occupational health care) or at minimal cost to the individual patient. Equal access to health care has been an explicit goal in health policy for several decades and is ensured by law (the Constitution of Finland 731/1999, the Act on the Status and Rights of Patients, 758/1992).

It has become evident that clear health differences between socioeconomic groups favouring those better-off exist. These differences are explained largely by lifestyle and nutritional factors. Health-risk factors that increase the risk of getting CHD, such as smoking, cholesterol, high blood pressure and obesity are clearly more common in the low SES groups (Alter et al. 1999, Salomaa et al. 2003). If equal access to care applies, it should be relative to need and therefore lower SES groups would be expected to have higher operation rates. However, many studies have proved the opposite. Studies have repeatedly reported socioeconomic differences in waiting times and revascularisation rates in Finland favouring those better-off (Hetemaa et al. 2004, Keskimäki et al. 1997, Salomaa et al. 2001). Although the large increase in operations in the 1990s – the number of operations doubled – did diminish the difference, it did not abolish the differences in relation to need (Hetemaa et al. 2003, Keskimäki 2003).

Although low SES groups receive less surgical treatment, they receive more often hospital care due to CHD (Keskimäki et al. 1997). Some studies have reported differences in doctor-patient communication between SES groups. Patients in higher SES groups may communicate more actively with the physician, eliciting more information which may affect the evaluation of the condition and treatment decisions (Manderbacka 2005, Richards et al. 2002, Willems et al. 2004). On the other hand, poorer health status in general can lead to confusion with other health problems and CHD symptoms like chest pain can remain unreported (Richards et al. 2002).

Age and gender have also been reported to be connected with treatment decisions. The risk of contracting coronary heart disease increases with age, but the likelihood of revascularisation diminishes (Hanratty et al. 2000, Hetemaa et al. 2003). Although when the symptoms are severe the operation improves the quality of life among the elderly substantially, the unwillingness to operate is often rationalized by reference to the increased risk of complications. Development of the procedure technology in recent years has lowered the risks and enables more active treatment in the higher age groups as well (Airaksinen 2007). Several studies suggest that women are treated less aggressively than men in terms of revascularisations and drug treatment (Hetemaa et al. 2004, Keskimäki et al. 1997, Keskimäki et al. 2004, Salomaa et al. 2001). Because women usually get CHD at a later stage in life, the less aggressive treatment of the elderly may contribute to the worse short-term prognosis for women after suffering myocardial infarction (Hanratty et al. 2000). The increase in supply of the coronary operations during the late 1990s has diminished gender disparities in Finland (Hetemaa et al. 2003).

The most relevant diseases in relation to CHD and revascularisations are heart failure, cardiac arrhythmia, hypertension and diabetes. On the one hand, the first two are often complications of CHD. Diabetes and hypertension, on the other hand, are important risk factors for CHD. Diabetic people often have metabolic disorders which increase the risk of CHD. In addition, continuous high blood sugar level damages vessels. Comorbidities examined in the present study include those that are known to have an effect on revascularisations based either on empirical evidence (Hetemaa et al. 2004) or the likelihood to increase risk of coronary events (Resnick et al. 2002), or they should have an influence on treatment decisions in accordance with current treatment recommendations (Wood et al. 2002).

3 DATA

Registers and linkages

This study is based on administrative register data. Finland and other Nordic countries have exceptional possibilities to exploit administrative data in scientific research. Nordic practices in systematic official data collection are followed in many countries. Many of the developed countries collect data even now, but the existing data bases are disassembled and difficult to utilize in scientific research.

There are three elements that make Finland ideal for register-based health services research. First, our social welfare and taxation system has produced a large amount of reliable administrative register data dating back several decades. Second, the use of the personal identification codes enables linking data from several sources safely and reliably. For instance, linking socioeconomic data to health care data enables us to study the effects of socio-demographic factors on a person's health. Third, our legislation concerning the use of personal data allows data linking for scientific research that is seen to benefit society but does not inflict harm to individuals. Specific legislation (the Personal Data Act, 523/1999) on data protection concerning personal data use in other purposes than the original, provides strict rules and provisions under which the use of personal data is allowed. Health care research in Finland has exploited these possibilities diligently in recent years. (Kajantie et al. 2006)

Data for this study is part of a set of study data compiled for a STAKES research project conducted by the 'Differences in treatment, and in treatment pathways, outcomes and cost-effectiveness among coronary heart disease patients – does socioeconomic status have an effect?' project group. Accordingly, this project has examined socioeconomic equity in hospital treatment and its outcomes among various groups of CHD patients. The original register data was compiled from six different sources;

- The Finnish Care Register (HILMO) – STAKES
- Special reimbursement register – Social Insurance Institution (SII)
- Prescription register – Social Insurance Institution
- Causes of death statistics – Statistics Finland (SF)
- Population census data – Statistics Finland.
- Employment statistics – Statistics Finland

The data was compiled in three stages. The first step was to collect the target population, i.e., search for all individuals diagnosed with coronary heart disease in Finland prior to year 1999. Several registers were used to define the CHD population: HILMO, Special reimbursement register, Prescription register and the Causes of death register. Personal identification codes of individuals who had been hospitalised with, achieved the special reimbursement right for, had been reimbursed for nitrates, or had died of coronary heart disease were extracted from each of the registers. Since most of the target individuals naturally appeared in more than one register, they were merged by the statistical authorities in STAKES. In the second stage, all information on hospital admissions, information concerning special reimbursement rights and medicine used for CHD were linked to these individuals by the relevant authorities. Third, all data were sent to Statistics Finland (SF) for linking information from the Population Censuses, Employment statistics and the Causes of death statistics to each individual. Finally, SF replaced personal identification codes with artificial ID-codes before handing data to the research group.

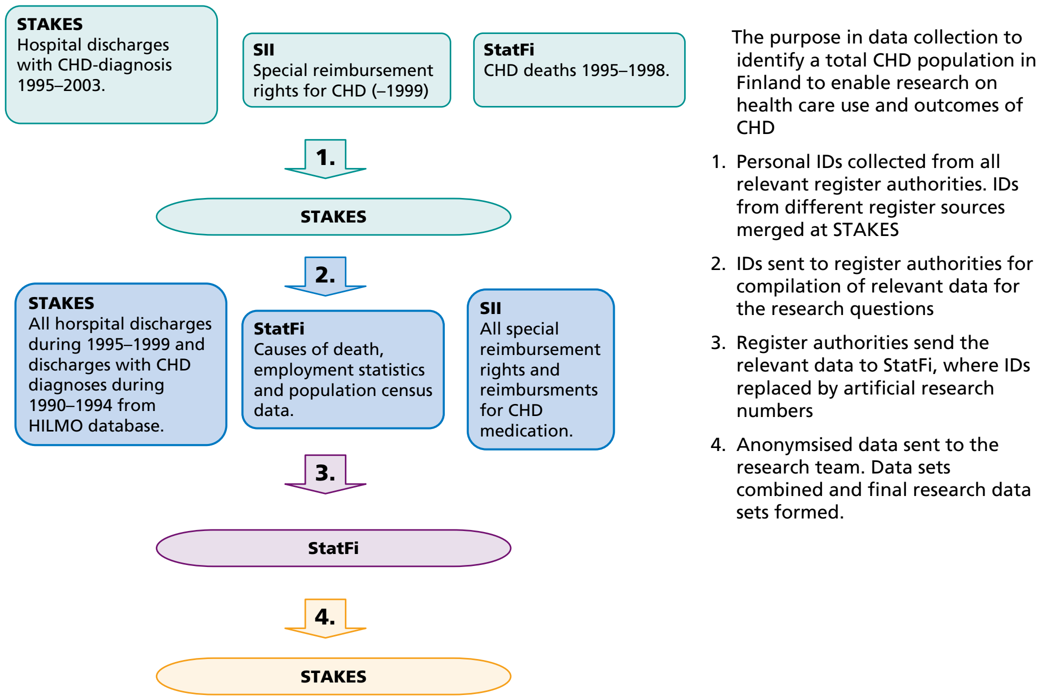

FIGURE 1. The compilation process of the original research data

Construction of the dataset

Original data were received in several files respective to the registers and authorities. The data were delivered in two separate parts; data files for prevalent cases in 1994 and incident cases for 1995-98. The prevalent data included all people who suffered from CHD at the end of 1994 based on the special reimbursement right for CHD medication (SII registers). The incident data included those who had developed CHD during years 1995 to 1998 based on special reimbursement right for CHD medication, hospitalisations due to CHD or CHD death. The target population for the present study combines these two populations. If only the incident data had been used, those who had on average suffered longer from CHD before the operation would have been missing from the study data. In inference to earlier studies, it could be assumed that part of this population would represent people from more deprived circumstances and those with a lower level of educational achievement.

Target population

When datasets were combined, all revascularisations (PTCA and CABG) were extracted from the HILMO data. Coronary angiographies could not be included, since based on earlier research their coverage is known to vary in HILMO. The first operation for each revascularised patient was singled out, and the study period was restricted to 1995–1998. Long-term inpatients and those not permanently resident in Finland were excluded, because relevant socioeconomic information could not be collected for them from the register sources utilised. All in all, the study population consisted of 23 324 patients aged 40–79 years that underwent their first revascularisation during the period 1995 to 1998.

Sociodemographic data

Sociodemographic data extracted from the SF data file included educational degree, family net income, age, gender and place of residence. Information on date and place of death was also available on those who had died before the year 2002. The information was linked to the study data but was exploited only briefly, because the main focus of this study was on the hospital care preceding the operation (see Chapter 6).

Family net income was calculated by dividing the total family net income by family consumption units using the OECD definition (Statistics Finland 2007(b)). Income was derived from the year previous to the operation to guarantee that the disease onset or operation would interfere with it as little as possible. Income was categorized into thirds within the study population. The classification was made for each year separately and then merged into one variable. This was done to avoid the possible confounding effect of inflation. Otherwise, people entering the data at the end of the study period would have ended up being overrepresented in the higher income groups. The level of education was derived from the register of educational achievement and graded into three levels; higher (academic; 13 or more years of education), middle (vocational/ upper secondary; 10–12 years of education) and basic education (comprehensive school; up to 9 years of education).

In the SF data, age was recorded in months at the end of 1994. For the study data, age was calculated at the time of the first revascularisation which was considered as the index date. Age was categorized into eight five year groups. Place of residence by hospital districts at the end of the year preceding the operation was linked to study subjects and also classified further to correspond to the five university hospital districts.

Comorbidity

SII data on special reimbursement rights for medication costs were used to provide information on other medical conditions related to CHD. To receive a special reimbursement right (SRR) for medication expenses, a patient must be diagnosed by a medical doctor and given a certificate. SII then evaluates if the required provisions are met and grants the reimbursement right. There are over forty diseases and conditions that Finnish residents can have SRR for. For this study, information was collected only on those diseases that should advance or that may appreciably prolong the treatment process. These include diabetes, heart failure, chronic arterial hypertension (high blood pressure) and chronic arrhythmia. Information on the reimbursement right for CHD was also extracted from the reimbursement data, in case it would bring additional information on when the condition was validly recognised by medical personnel. Dummy variables and dates for receiving the SRR for each of these conditions were linked to the data. Information was added only if the reimbursement right was in force at the time of the operation. The time from the issuing date to surgery was calculated.

Hospital data

The focal information for this study is information about hospital care prior to the operation. The HILMO data include all inpatient hospital admissions in Finland since 1969. Operations performed during inpatient treatment have been recorded since 1989. Since 1994, operations undertaken in day surgery have also been recorded in the database. PTCA can be conducted as day surgery, and therefore does not always require inpatient admission. From 1995 onwards – the start of the study period – PTCAs can be assumed to be reliably recorded in HILMO. In the present data, hospital admissions from 1990 onwards were included.

HILMO data are event-based, meaning that subjects can have more than one row in the data matrix. Analysing event-based data with statistical methods is complex: therefore, one of the first challenges was to create an individual-based data matrix that would best describe the pathways leading to surgery without losing relevant information.

First, all hospital admissions prior to the operation were extracted for every subject. Admissions including diagnosis for CHD or MI were labelled. An indicator was set for every admission in order to mark whether the patient came through emergency duty or had a scheduled appointment. The length of stay as well as the days from the admission date to the index date and from the discharge date to the patient's next admission date were calculated for each admission. Admissions were labelled in three categories: MI admission (MI), emergency CHD admission other than MI (EMC), and elective CHD admission (ELC).

When patients are moved between hospitals or wards, a new record is entered in HILMO for each admission. This means that many of the records overlap, if the interest is in the combination of continuous admissions related to certain health problems. To describe the total hospital stay in each combined admission, data on the overlapping admissions needed to be squeezed into a combined one, though some information was lost as a result. For instance, transmissions between hospitals could contain interesting information. Not all hospitals in Finland conduct coronary surgery and in some areas distances to the nearest operating hospital could have an effect on seeking treatment and related decisions. Admissions were combined if there was less than two days in between. A label describing the category of the combined admission was set in the following way: if the spell concerned contained any MI admissions, it would have the highest priority and the admission label was set as MI. Emergency CHD (EMC) would have the second highest priority, and elective CHD admission third.

Separate admissions were compressed into one character variable that would describe the whole chain of hospital admissions leading to surgery, and this variable was linked to the individual based data matrix. The resulting variable described the whole treatment pathway (spell) leading to surgery. Other variables calculated were number of different types of admissions in a treatment spell, days from the first admission to surgery for different admissions types, and number of hospital days in different time scales.

Describing the final study data and selecting variables for analysis

TABLE 1. Study data by gender, age and education

		N	Revascularised in 1995–1998 (%)
Gender	Male	17 243	75
	Female	6 081	25
Age	40–44	663	3
	45–49	1 615	7
	50–54	2 476	11
	55–59	3 521	15
	60–64	3 977	18
	65–69	5 030	22
	70–74	4 144	17
	75–79	1 898	7
Education	Higher	3 434	14
	Middle	4 710	18
	Basic	15 180	67
	Total	23 324	100

Table 1 presents the distribution of gender, age and education among the study population. It should be noted that the study data are not a random sample of the CHD population in Finland in 1995 and 1998, but rather the total population of patients who had undergone their first revascularisation operation during the study period. Therefore, the data does not include all those individuals who would have been in need of an operation during those years. It also lacks people who did not seek treatment or who had died of untreated CHD. Therefore some distortion can be expected in the study population compared to the total CHD population. To examine the distorting effect to be expected, three distinct CHD populations from 1995 aged 40-79 were examined and compared according to age, gender and educational distributions as well as mean incomes. Populations presented in Table 2 represent people who have had a valid special reimbursement right for CHD and therefore definite diagnosis, along with people who suffered myocardial infarction and survived; and third, people who were revascularised during 1995.

TABLE 2. CHD populations in 1995 by gender, age and education

		SRR in 1995	MI in 1995	Revascularised in 1995
Gender (%)	Male	57	64	75
	Female	43	36	25
		100	100	100
Age (%)	40–44	1	2	3
	45–49	3	5	7
	50–54	5	7	11
	55–59	10	9	15
	60–64	16	12	18
	65–69	22	19	22
	70–74	23	23	17
	75–79	19	23	7
		100	100	100
Education (%)	Higher	10	9	14
	Middle	16	16	18
	Basic	75	75	67
		100	100	100
Mean income 1995 (FIM)		*55 900*	*57 200*	*63 600*
	N	139 427	8 692	5 518

As earlier studies suggest, male patients and younger age groups are overrepresented among the revascularised population compared to the other two CHD populations. Additionally, there seems to be an association with the level of education. 62 percent of the revascularised patients had basic education, whereas in the two other populations the proportion was nearly 75 percent. As other studies have shown, and the present data demonstrate, people with lower education suffer from CHD more often but do not seem to be operated on to the same degree. The mean income level seems to indicate the same kind of pattern.

Rates in the study data (Table 1) are consistent with the third column of Table 2. When populations are compared, it can be concluded that if evidence of socioeconomic differences in treatment practices is found in the present study, the differences are likely to be underestimates of the real differences existing among CHD patients in general or among MI patients.

Selecting independent variables for modelling

The purpose of this study is not to predict likelihoods for an operation but instead to explore different ways to examine the impact of socioeconomic status to access to revascularisation when confounding effects are taken into account. The two variables chosen to represent socioeconomic status are degree of educational attainment and level of income. Both were classified into three categories; high, middle and low. Income groups are relative to the data so they are approximately equally large. Education follows the classification used by Statistic Finland, and in it lower educational groups are much larger than the higher group. Because people with higher education generally have better income as well, the two variables are obviously highly correlated. Nonetheless, these variables offer varying interpretations when inspecting the differences in seeking medical treatment: therefore, it was decided to carry out a separate analysis for each of the variables.

Table 3. Revascularisations in Finland by hospital district (1995)

Hospital District	Operations	Operations/10 000 inhabitants
Helsinki and Uusimaa	1 125	26
Varsinais-Suomi	396	24
Satakunta	260	29
Kanta-Häme	134	22
Pirkanmaa	379	23
Päijät-Häme	**159**	**20**
Kymenlaakso	243	33
Etelä-Karjala	127	25
Etelä-Savo	141	32
Itä-Savo	84	31
Pohjois-Karjala	229	35
Pohjois-Savo	**442**	**47**
Keski-Suomi	407	43
Etelä-Pohjanmaa	186	25
Vaasa	186	31
Keski-Pohjanmaa	104	38
Pohjois-Pohjanmaa	495	44
Kainuu	141	43
Länsi-Pohja	94	37
Lappi	164	37
Åland	21	23

Table 3 shows revascularisation rates by hospital districts in 1995. Rates varied from 20 per 10 000 inhabitants aged 40–79 in Päijät-Häme to 47 in Pohjois-Savo. It cannot be inferred from the data whether this is due to morbidity differences or other differences in population structures, but the result suggests that the hospital district itself represents an interesting variable for inclusion in the analysis.

Other variables that could affect the treatment received but are also likely to vary according to socioeconomic group are CHD-related chronic diseases, i.e., diabetes, arrhythmia, heart failure and high blood pressure. These conditions were also included in the models.

The fact that the two operations are not equally radical and that PTCA rates grew rapidly during the study period should be taken into account. Table 4 shows a clear connection between education and the type of operation made in 1995. However, using the type of operation in modelling is problematic. PTCA is an easier operation and does not require as much resources, so it could be expected to have shorter waiting times. The decision on the type of operation is also likely to be made on clinical grounds when an operation is already being considered. However, it is possible that higher socioeconomic groups are treated earlier in the natural history of the disease and therefore receive PTCA more often. There is practically no research on whether this is the case and if so, whether it is due to care-seeking behaviour, physician/patient communication, patient demands or other non-clinical reasons. Nevertheless, the data available for the study does not allow an examination of the impact of disease severity.

TABLE 4. The type of operation by income, education and the index year

		N	CABG (%)	PTCA (%)
Income third	High	7 887	67	33
	Middle	7 732	74	26
	Low	7 639	76	24
Education	Higher	3 424	69	31
	Middle	4 699	69	31
	Basic	15 136	74	26
Year	1995	5 307	75	26
	1996	6 015	74	26
	1997	6 028	72	28
	1998	5 974	70	30
	Total	23 324	72	28

4 GRAPHICAL PRESENTATION OF PATHWAYS

Survival curves for waiting times

A common way to study differences in access to health care is to examine waiting times to treatment. In health care research, waiting times as well as mortality rates are often illustrated through survival or proportional hazard curves (e.g., Alter et al. 1999, Hetemaa et al. 2004, Salomaa et al. 2001). In this study, using waiting time in the analysis is problematic since the point of time specific to the beginning of the actual need for revascularisation cannot be identified. One definite date for accurate diagnosis in the data is the issuing date of the special reimbursement right for coronary heart disease. Figure 2 shows that when coming to surgery those better-off had held the SRR for a shorter time than those worse-off. Though the pattern is not obvious in all three educational levels, the curve for the group with basic education exhibits the lowest gradient in both cases.

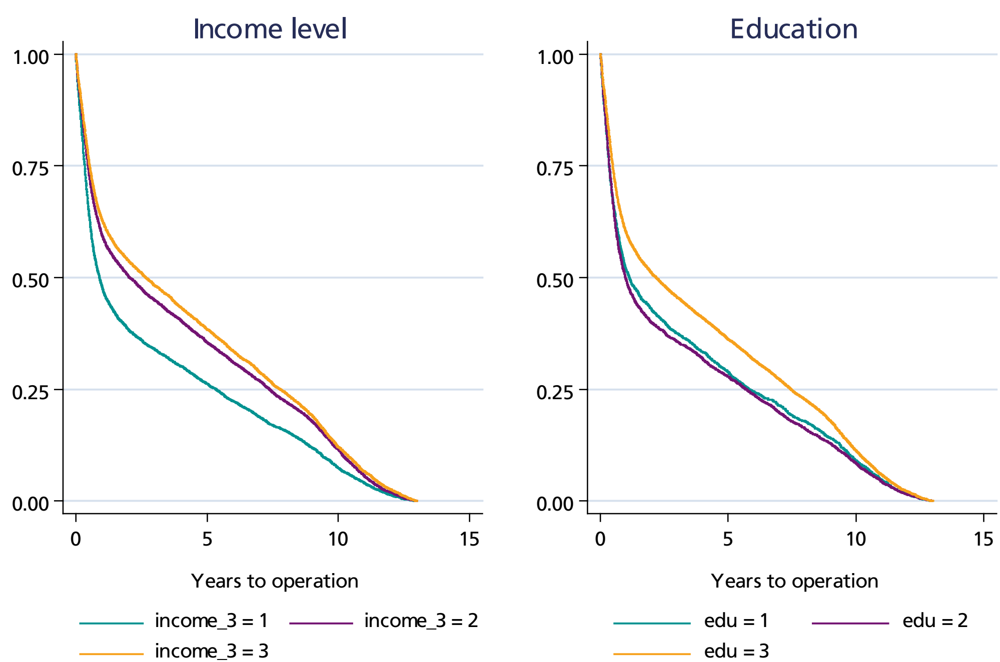

FIGURE 2. Survival curves for time from issuance of special reimbursement right for CHD (SRR) to surgery, by income class and education. Socioeconomic categories: 1 = high, 2 = middle, 3 = low.

The proportion of those having SRR before coming to surgery was 66 percent of the whole population. Among the highest income group, the proportion was 61 percent, and in other two groups about 68 percent. The trend was similar when the beginning of the waiting time to revascularisation was defined as the date of the first hospital admission that had CHD as the main diagnosis (Figure 3).

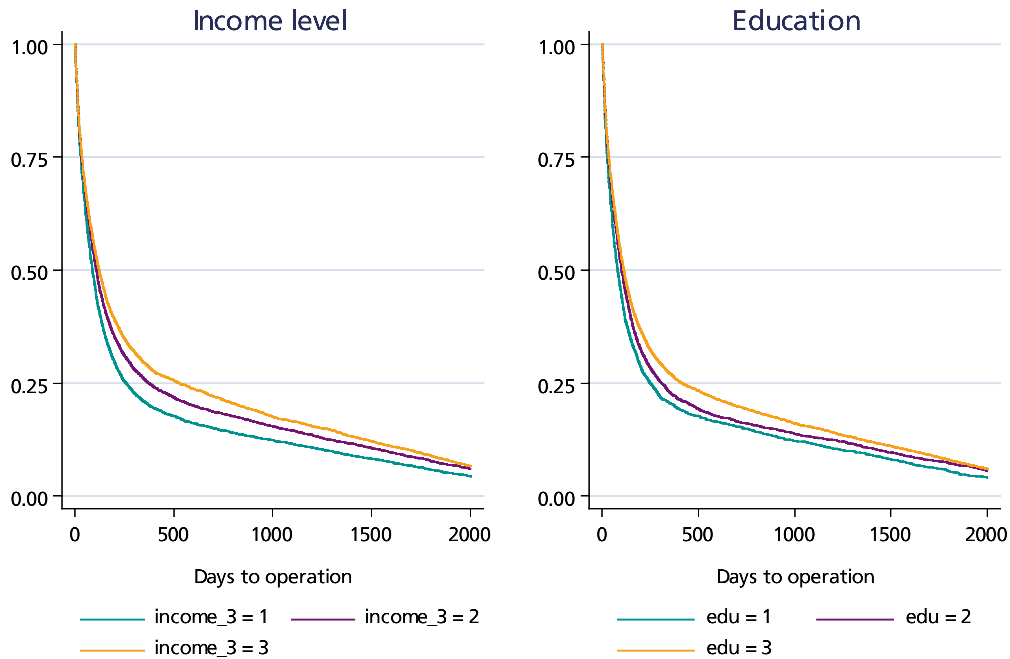

FIGURE 3. Survival curves for time from first inpatient CHD hospital admission to surgery, by income class and education. Socioeconomic categories: 1 = high, 2 = middle, 3 = low.

Number of hospital days before the surgery

There are two different elements that should be taken into account when inequalities in pathways to revascularisation are being analysed. One of them is the time frame during which the patient gets operated, and the other is the treatment received prior to the operation. Table 5 shows that people from lower SES groups spent more time in hospital care before receiving the operation.

TABLE 5. Days spent in hospital care before operation, by income and education

				95 % CI	
		N	Mean	LL	UL
Income	High	7 887	17.8	17.5	18.1
	Middle	7 732	21.4	21.0	21.8
	Low	7 639	25.0	24.4	25.5
Education	Higher	3 434	17.8	17.3	18.3
	Middle	4 710	20.0	19.5	20.5
	Basic	15 180	22.6	22.3	22.9
	Total	23 324	21.4	21.1	21.6

These differences do not show how treatment spells did actually differ between groups. Were the worse-off having trouble throughout the pathway to surgery and going in-and-out of hospital, or did they require more active treatment closer to the operation? The next diagram shows an attempt to examine this in a graph.

The following matrix graphs the few weeks preceding the operation in relation to days spent in hospital care. For every subject, the days preceding the operation were numbered in order from the index date (revascularisation) backwards. Each day was labelled as based on whether the patient was in hospital care that day or not. Subsequently, the daily proportions of hospitalised patients were calculated by income and education. A similar approach has been used with regard to the daily hospitalisation prevalence of schizophrenic patients as based on register data. (Sund 2000.) The results are shown in Figures 4 and 5.

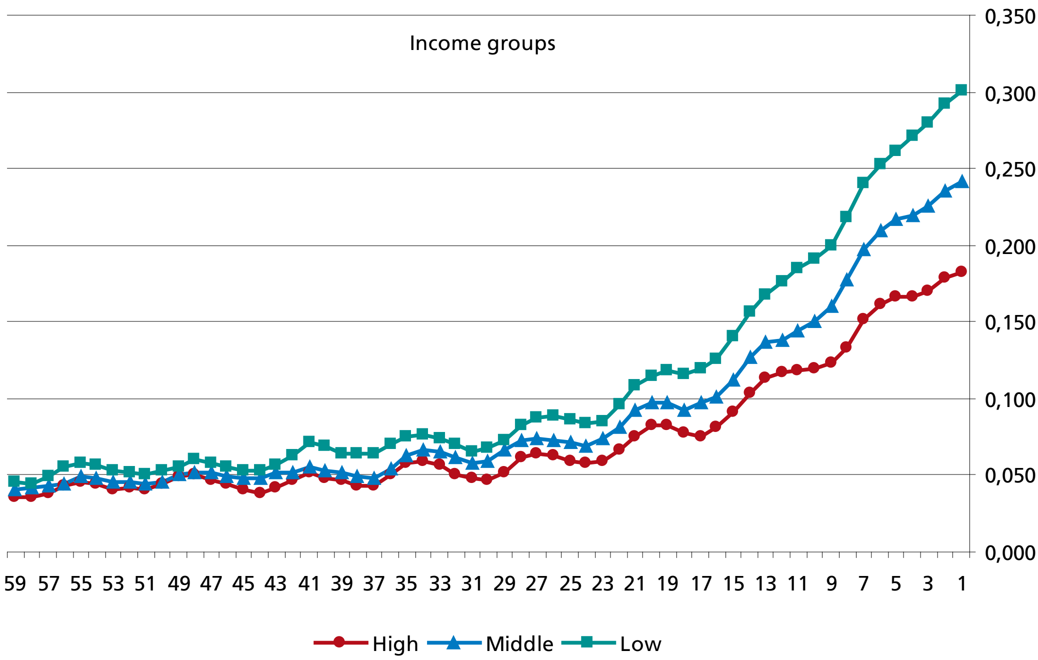

FIGURE 4. Daily proportions of hospitalised patients during 60 days preceding revascularisation, by income

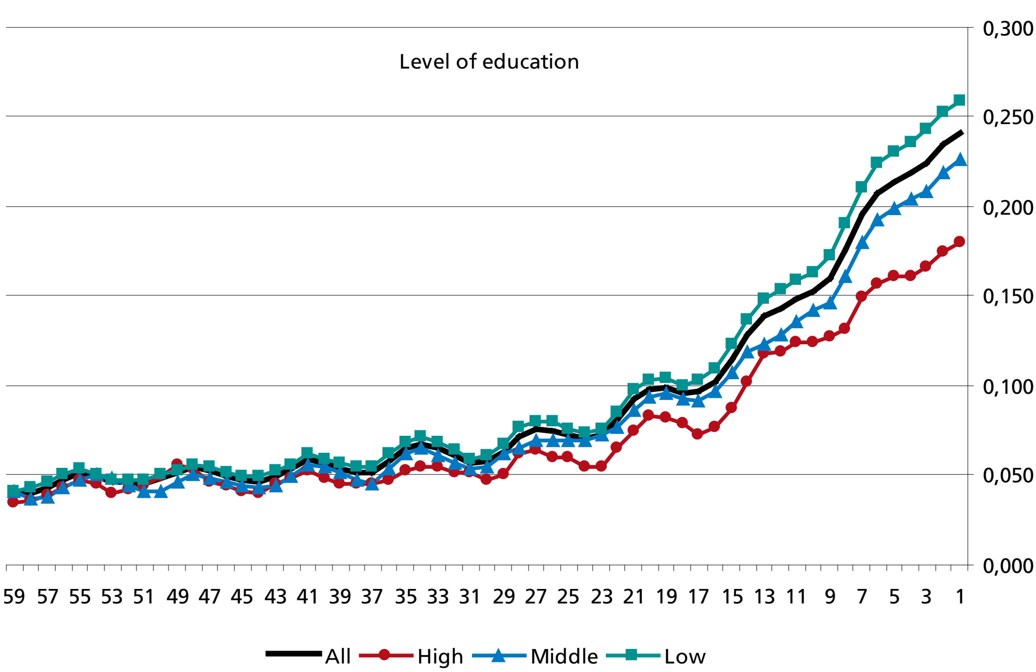

FIGURE 5. Daily proportions of hospitalised patients during 60 days preceding revascularisation, by education

Figures show that patterns started to differ between SES groups about one and a half months prior to the operation. A larger proportion of those in lower SES groups started to spend time in hospital care. One day before the operation, about 30 percent of those with low income were hospitalised compared to the 18 percent of the high income group. Income groups are relative to the data and represent approximately equal proportions of the study population. However, educational groups are not equally divided, but 65 percent of the study population has only a basic level of education. A line for the whole population was included in Figure 5. Because the groups with a low level of education represent a larger proportion of the study data, the line for the population mean is very close to this group and it becomes evident that the group with highest education was clearly spending less time in hospital care before the operation.

Profiles for the treatment pathways

Based on earlier research, it could be assumed that lower SES groups were older and in worse health, therefore possibly spending more time in hospital for other reasons besides CHD. It would be well-founded to focus only on CHD-related hospital care. Therefore, clearer definitions and restrictions on how to graph out various treatment spells were needed. In this study, treatment pathways were defined to include only admissions that have CHD as the main diagnosis. Every admission was labelled as MI, EMC or ELC with respect to the diagnosis and whether the patient came to the hospital through emergency duty or had a scheduled appointment. The following analysis is based on this labelling, and the spells are profiled according to these definitions.

The tree diagram (Figure 6) helps to piece together a general view on how various treatment spells were divided among the study population. Similar figures have been drawn from register data: for instance, when risks for multiple reoperations have been examined (Österman et al. 2003). The data is constructed as a retrospective cohort, so the time perspective is reverse compared to normal follow-up studies. The highest box in the diagram (REV) is the end point of every pathway and is common to all subjects (N = 23 324), i.e., the revascularisation. The levels of the tree diagram represent the admissions in number of order preceding the operation. The first level and the three boxes next to REV represent the label of the index admission.

The diagram shows that almost 70 percent (N = 16 267) of the operations were conducted as appointments and 30 percent came to surgery through emergency duty; 9 percent were due to MI, and 20 percent due to another acute CHD event. The number of patients who had had no prior CHD admissions is shown in the ENTRY boxes. For example, there are 1 162 patients that first came to hospital with MI and received surgery right away. Similarly, there were 5 089 patients who had only one previous elective admission and got operated on the next scheduled appointment. To keep the figure simple, pathways were not graphed for groups under 200 patients.

The diagram shows that in more than half of the cases (51.1 %) the disease seemed to be under control when the operation was conducted. If we sum up the ‘yellow line’ in the diagram we see that more than one-third of the patients (> 7 251) had not had any acute emergency admissions, but received the operation before such an event occurred. However, there was a considerable number of patients who had had an acute CHD event but were not operated on or given an appointment for the operation.

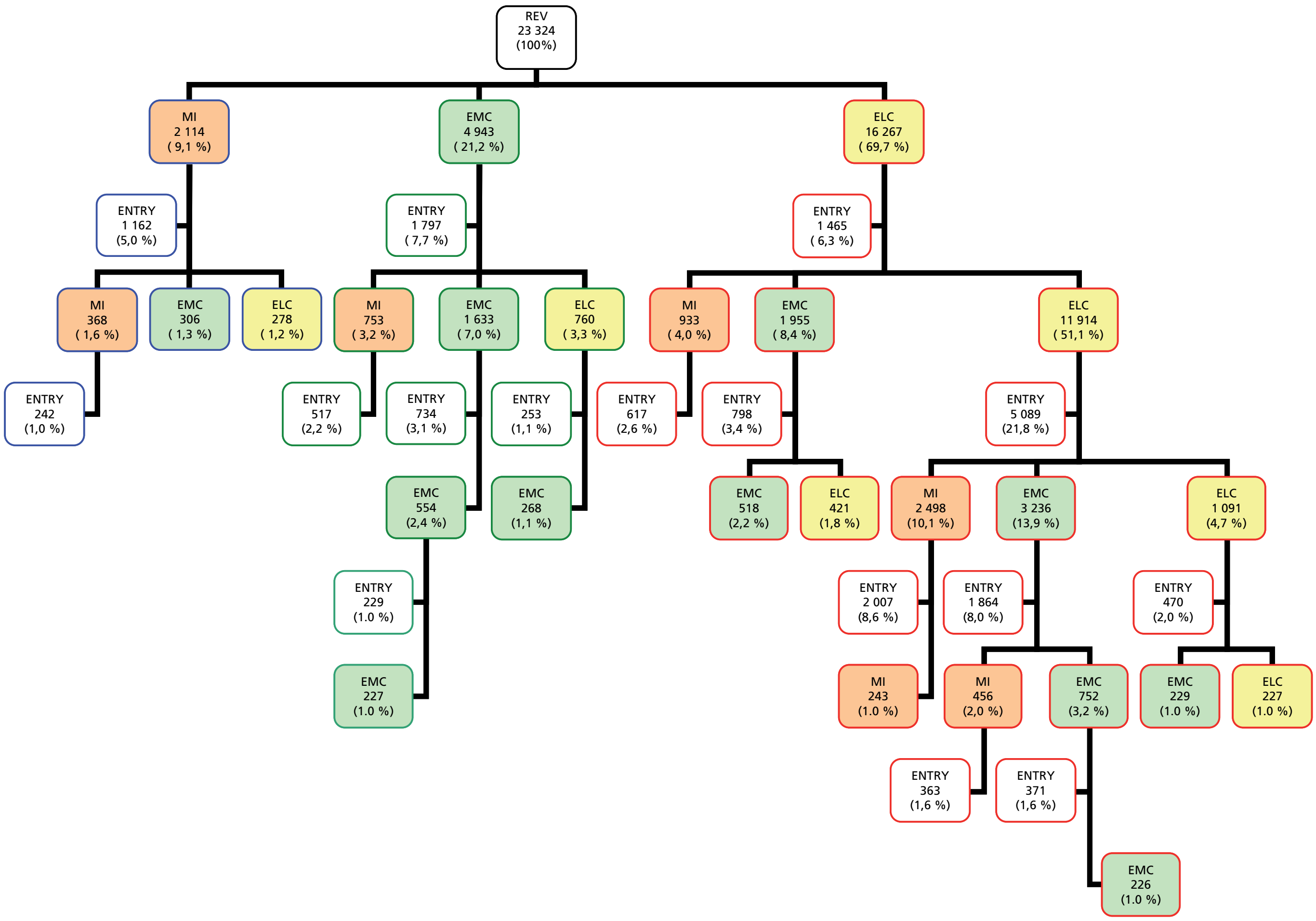

FIGURE 6. The tree diagram for treatment spells

Defining the relevant part of the spell

The tree diagram showed that more than half of the operated patients came to surgery through appointments only, which can be interpreted so that the treatment progressed in an ideal way. Emergency admissions however signal a more advanced stage of the disease or poorer control of the disease where the health risks are more serious. If a patient has more than one emergency admission during the spell it is well-founded to ask for a reason for this. This study aimed to look for SES differences in treatment received for CHD, and therefore the question above is relevant.

Figure 4 and Figure 5 were graphed to illustrate the use of hospital care in various SES groups during the two months before the operation. Two possible stages were defined; in hospital care or not in hospital care. The number of stages is upraised to create more informative view of the pathway. Patients still have stages in which they belong to at each specific day, but whereas in the earlier analysis there were two stages, hospitalised or not hospitalised, now the stages represent the number of acute CHD admissions along the pathway so far. Similar kind of state diagrams have previously been used with register data in order to summarise the treatment paths of hip fracture patients (Sund 2005).

In practice, all emergency admissions (MI and EMC) were extracted from the data and numbered in order of occurrence. The numbers represent the stage the patient belongs to until the next emergency admission occurs, whereupon the stage goes up to the next level. Five stages were drawn, so the highest stage includes pathways with four or more emergency admissions. Separate diagrams were drawn for the highest and the lowest income groups.

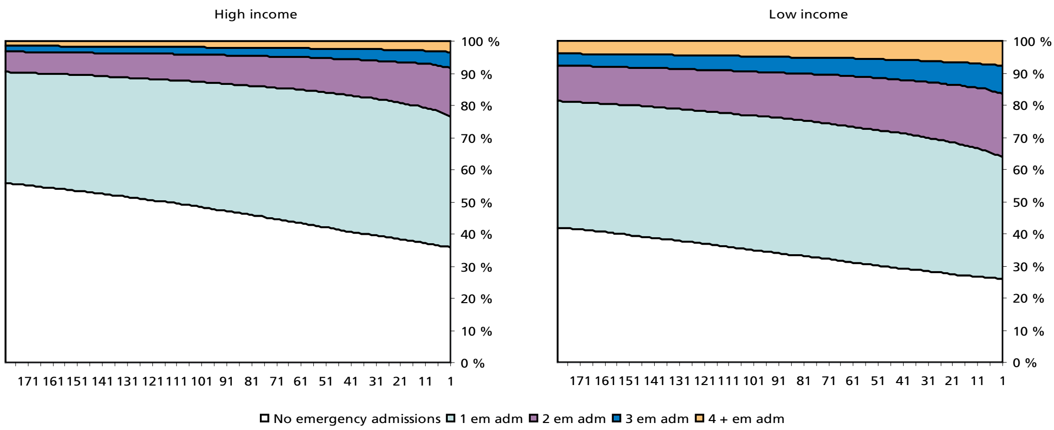

FIGURE 7. The highest and the lowest income groups by number of emergency admissions along the treatment pathway to surgery. X-axis corresponds to time preceding the revascularisation

The state diagrams seem to be similar for both groups, but the scale axis on the right side reveals differences between groups (Figure 7). The proportion of patients arriving for surgery with no preceding emergency admissions was smaller in the low income group and, correspondingly, several emergency admissions were more common.

Truncated pathway

At the beginning of this chapter, the problem of pinpointing the date when the need for surgery becomes topical was discussed. In the same way, it is pivotal to recognise the relevant part of the spell: when the stage of the disease or treatment balance drops to the level where operation is required. Several emergency admissions – especially if they occur at frequent intervals – could be a sign of this kind of adverse issue. The data shows that many patients had had their first CHD admission more than five years before the operation (6.5 %). In many cases, there were several years between CHD hospital admissions. The relevant part of the pathway was therefore defined to be the part of the spell where treatment had been active. If there were very long intervals between hospital admissions, it would be reasonable to consider that the condition of the patient had been stable during that time.

TABLE 6. Mean time (in days) from the 1st CHD admission to operation by income and education – whole spell and truncated spell

			Whole spell			Truncated spell		
				95% CI			95% CI	
		N	Mean	LL	UL	Mean	LL	UL
Income	High	7 887	307	294	320	62.1	60.6	63.6
	Middle	7 732	380	366	395	66.9	65.3	68.6
	Low	7 639	428	413	444	70.0	68.2	71.7
Education	Higher	3 434	300	280	319	59.2	56.9	61.4
	Middle	4 710	349	330	367	66.6	64.5	68.7
	Basic	15 180	394	383	405	67.9	66.7	69.1
	Total	**23 324**	**371**	**363**	**379**	**66.3**	**65.4**	**67.3**

In Table 6, the truncated spell has been defined so that only the intensive part of the care – i.e., where the admissions are no more than 6 months apart – is considered. The rest (or more accurately, the start of the spell) is cut off and dropped from the analysis. This Table presents the mean times from the first CHD hospital admission to the operation by income and education, including the first whole treatment pathway, and then only the intensive part of the pathway (truncated spell).

The average time from the first CHD admission to surgery was about one year, but SES differences were apparent. The difference between the lowest and the highest SES groups was over four months. When the pathway is truncated, the number of days to surgery dropped to a fraction. The mean time to surgery was a few days over two months, and the difference between the highest and the lowest SES group was approximately one week.

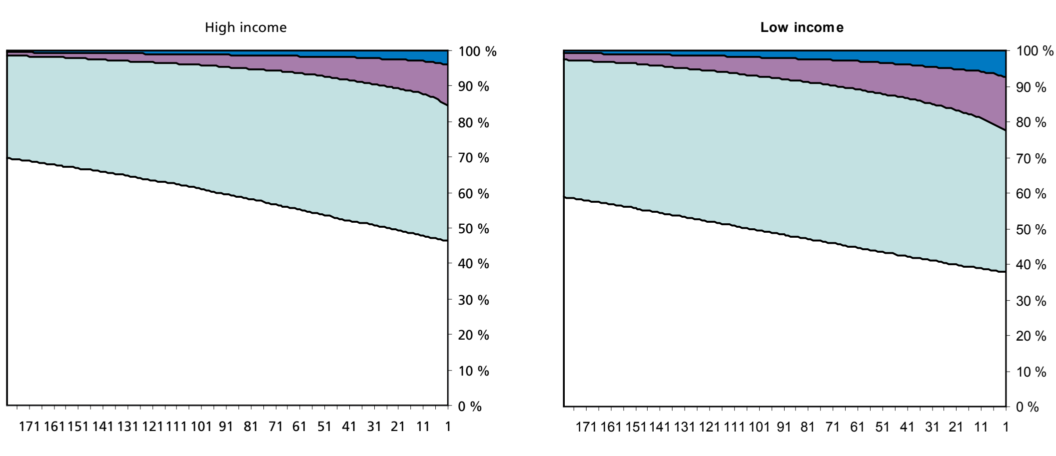

FIGURE 8. The highest and lowest income groups by number of emergency admissions along the treatment spell to surgery. X-axis corresponds to time preceding the revascularisation

The state diagrams for the truncated pathway were produced, and the differences seemed to smoothen somewhat (Figure 8). Nevertheless the difference between the groups was still apparent. The low income group had suffered more often from frequent emergency CHD hospital admissions than the high income group. Some other classifications could be considered for classifying different stages that would present the course of the treatment pathway differently.

These figures are presented mainly to illustrate how graphics could be used for analysing differences in relation to time and content of the pathway at the same time.

Although Figure 8 may not reveal the impact of the new definition for the starting point of a spell to SES differences, the models in the next chapter are in some cases presented for the truncated spell as well, since it does exert an impact on some other variables which may be interesting to examine.

5 ANALYSING SOCIOECONOMIC DIFFERENCES WITH REGRESSION MODELS

The figures and means presented in Chapter 4 indicate that socioeconomic differences existed in treatment practices in the late 1990s. However – based on those results – it is not straightforward to make further conclusions on why they existed. Socioeconomic groups differ from each other in ways that can affect the treatment received but do not make this variation unjustified. Variables and elements that should be taken into account were presented in Chapter 2.

Basic statistical methods were used to analyse the study data. All of them are commonly used in epidemiological research. The models used in the present study were logistic regression, multinomial logistic regression, Poisson regression and Cox regression. Models were estimated for various subpopulations. Response variables were defined in more than one way and the results of models were compared. Eight models are presented in this chapter. Since there are several possibilities to analyse the research question at hand, the following Tables are examples on how the problem could be examined by means of traditional statistics. Methods are explained briefly in the beginning of each section, but the main focus is on the application of different modelling possibilities in order to determine how they could be utilised efficiently in this kind of study.

Analysing probability of a 'good' spell

In epidemiology a dichotomous response variable is usually coded as 0/1, the latter indicating that the phenomena under investigation is true for the study subject. Logistic regression is a statistical tool that is used to model dichotomous response variables. Logistic regression is a generalised linear model that uses the logit as its link function, i.e., the model receives the form

$$\ln\left[\frac{p_j}{1-p_j}\right] = b_0 + b_1x_1 + b_2x_2 + \ldots + b_kx_k \text{ ,}$$

where $pj = \mathrm{E}(Y|Xj) = \Pr(Yj = 1)$, *Xj* the covariate vector for the unit *j* of *n* units, and *B* the vector of *k+1* regression coefficients.

The logistic curve is not linear and therefore it is not as easy to interpret the coefficients of a logistic regression model as it is in ordinary linear regression. Often the coefficients are transformed back to odds ratios. When the explanatory variables are categorical, the odds ratios provide easily interpretable results.

Model 1. 'Good' spell vs.' Bad' spell

Chapter 4 ended with the conclusion that a connection seemed to exist between socioeconomic groups and various types of treatment histories. People in lower socioeconomic groups experienced more acute emergency admissions before the operation. To obtain a dichotomous response variable, there was a need to classify spells into two categories. Two classifications were made. The first one was based on the idea that a 'good' spell would include only elective admissions (ELC). This was assumed to indicate that the treatment progressed as planned and that the operation was conducted before the stage of the disease was severe enough to cause serious health risks for the patient. In another model, the 'good' spell was allowed to include one 'bad' admission

(MI or EMC). The reasoning behind this model was that, in many cases, the first admission that comes through emergency duty would not have been preventable, e.g., because CHD had not been detected or treated before the hospitalisation, and if treatment is provided immediately after such an event, the health care provided can be seen as performing smoothly.

TABLE 7. Logistic regression for a Good spell with no emergency admissions 'Good spell 0' and with one emergency admission 'Good spell 1'. Estimates for other than socioeconomic variables are reported only for the income models

		Good Spell 0			Good Spell 1		
			95% CI			95% CI	
		OR	LL	UL	OR	LL	UL
Education	Higher	1.00			1.00		
	Middle	0.76	0.69	0.84	0.78	0.71	0.87
	Basic	0.74	0.68	0.80	0.73	0.67	0.80
Income	High	1.00			1.00		
	Middle	0.81	0.75	0.86	0.85	0.79	0.92
	Low	0.71	0.65	0.76	0.69	0.64	0.75
Age (years)	40–44	1.00			1.00		
	45–49	0.97	0.79	1.19	0.99	0.80	1.23
	50–54	1.15	0.95	1.40	1.00	0.81	1.23
	55–59	1.18	0.98	1.42	0.89	0.73	1.09
	60–64	1.23	1.02	1.47	0.83	0.68	1.01
	65–69	1.20	1.00	1.44	0.79	0.65	0.96
	70–74	1.10	0.91	1.32	0.63	0.52	0.77
	75–79	0.85	0.69	1.04	0.47	0.38	0.57
Gender	Female	0.97	0.90	1.03	0.96	0.89	1.02
Comorbidity	Diabetes	0.77	0.71	0.85	0.70	0.64	0.76
	Heart failure	0.73	0.66	0.81	0.62	0.57	0.68
	High blood pressure	0.98	0.93	1.04	0.92	0.87	0.98
	Arrythmia	1.05	0.92	1.21	0.82	0.72	0.94
Hospital District	Helsinki	1.00			1.00		
	Other Uusimaa	0.87	0.77	0.97	1.04	0.91	1.18
	Varsinais-Suomi	0.98	0.86	1.11	1.26	1.08	1.46
	Satakunta	0.63	0.54	0.75	0.94	0.80	1.11
	Kanta-Häme	0.45	0.36	0.56	0.53	0.44	0.64
	Pirkanmaa	0.78	0.68	0.88	0.95	0.83	1.09
	Päijät-Häme	0.62	0.52	0.75	0.69	0.58	0.83
	Kymenlaakso	0.84	0.72	0.99	0.91	0.77	1.08
	Etelä-Karjala	0.94	0.77	1.14	1.00	0.81	1.24
	Etelä-Savo	0.75	0.62	0.90	0.94	0.77	1.14
	Itä-Savo	0.67	0.53	0.86	0.83	0.65	1.06
	Pohjois-Karjala	0.64	0.54	0.76	0.60	0.51	0.71
	Pohjois-Savo	0.86	0.76	0.97	1.03	0.90	1.18
	Keski-Suomi	0.91	0.80	1.04	1.02	0.88	1.18
	Etelä-Pohjanmaa	0.59	0.49	0.70	0.67	0.57	0.78
	Vaasa	0.76	0.65	0.90	0.82	0.69	0.97
	Keski-Pohjanmaa	0.68	0.55	0.84	0.66	0.54	0.81
	Pohjois-Pohjanmaa	0.77	0.68	0.87	0.89	0.78	1.01
	Kainuu	0.91	0.74	1.11	0.77	0.63	0.94
	Länsi-Pohja	0.52	0.40	0.67	0.77	0.61	0.99
	Lappi	0.62	0.51	0.75	0.77	0.64	0.92
	Åland	0.83	0.46	1.52	1.07	0.57	2.00

Both models gave similar results. Table 7 shows that ’good’ treatment spells were less common in lower SES groups. The first model indicates that middle-aged patients were most likely to have only elective admissions prior to the operation. The second model shows that the oldest age groups had more commonly suffered more than one acute CHD event before receiving the operation. Especially diabetes and heart failure seemed to lower the probability of a ’good’ spell in both models. A patient was most likely to get the operation without any emergency admissions in Helsinki, but when one emergency admission is allowed shows Varsinais-Suomi even better results. The situation is worse in Kanta-Häme; the likelihood of a ’good’ spell is only about half of what it is Helsinki in both models (OR = 0.45 and OR = 0.53).

Analysing probabilities for multiple types of pathways

Multinomial logistic regression (MLR) is an extension of the logistic regression, allowing the response variable to have more than two categories. MLR performs several logistic regressions simultaneously. One category in the response variable is set to be the reference category, and separate analysis is performed for of the remaining categories. The method is useful when the effects of the independent variables are assumed to differ in different categories of the response variable. The output contains a large amount of information, but in practice it is only several logistic regression models side-by-side. The relative risk ratio (RRR) in the result table (Table 8) is interpreted the same way as the odds ratio (OR) in the logistic regression.

Model 2. Type of treatment spell

In the logistic regression analysis, pathways to revascularisation were classified into two categories. To utilise MLR and bring in more detailed information, we raised the number of categories to five:

1 = MI: Pathway includes 1 or more myocardial infarctions.
2 = EMC2: Pathway includes 2 or more emergency admissions and no myocardial infarctions
3 = EMC1: Pathway includes 1 emergency admission and no myocardial infarctions
4 =ELC: Pathway includes only appointments
5 = REV: Patient was revascularised during the first and only admission.

The ‘good spells’ are represented by categories 3 and 4. A sensible choice for the reference category would be number 4 – where no emergency admissions were allowed – and compare the other four categories against it. This way, the RRRs are also easier to interpret. If the RRR is larger than one, the likelihood of an ideal pathway is smaller than for the reference category. In multinomial modelling, the university hospital district is used instead of the hospital district in order to adjust for area variation.

TABLE 8. Multinomial logistic regression: Response variable; 'type of spell"; Reference category of the response; 'good spell 0' (only appointments). Estimates for other than socioeconomic variables are reported only for the income models

		MI			EMC 2+			EMC 1			OPER		
		RRR	95%	CI	RRR	95%	CI	RRR	95%	CI	RRR	95%	CI
Education	Higher	1.00			1.00			1.00			1.00		
	Middle	1.33	1.18	1.49	1.61	1.35	1.92	1.24	1.07	1.43	1.11	0.98	1.27
	Basic	1.42	1.28	1.56	1.76	1.51	2.05	1.31	1.16	1.48	1.12	1.01	1.26
Income	High	1.00											
	Middle	1.17	1.08	1.28	1.40	1.24	1.59	1.24	1.12	1.38	1.01	0.92	1.12
	Low	1.44	1.32	1.58	1.72	1.52	1.96	1.24	1.11	1.39	1.12	1.01	1.25
Age (years)	40–44	1.00			1.00			1.00			1.00		
	45–49	0.91	0.71	1.17	1.55	0.98	2.46	1.17	0.85	1.60	0.83	0.63	1.09
	50–54	0.77	0.61	0.97	1.33	0.85	2.06	0.99	0.74	1.34	0.67	0.52	0.87
	55–59	0.71	0.56	0.89	1.80	1.17	2.75	1.00	0.75	1.34	0.65	0.50	0.83
	60–64	0.64	0.51	0.80	1.85	1.21	2.82	0.89	0.67	1.19	0.63	0.49	0.80
	65–69	0.62	0.50	0.77	2.07	1.36	3.15	0.91	0.69	1.22	0.63	0.50	0.81
	70–74	0.69	0.55	0.86	2.65	1.74	4.04	0.92	0.69	1.23	0.68	0.53	0.87
	75–79	0.92	0.72	1.18	4.20	2.71	6.49	1.10	0.80	1.52	0.94	0.71	1.24
Gender	Female	0.98	0.90	1.06	1.23	1.11	1.37	1.05	0.94	1.16	1.33	1.21	1.46
Comorbidity	Diabetes	1.30	1.16	1.45	1.44	1.25	1.65	1.07	0.93	1.23	0.97	0.85	1.10
	Heart failure	1.95	1.72	2.21	1.73	1.48	2.02	1.31	1.12	1.53	1.25	1.08	1.45
	High blood pressure	0.97	0.90	1.05	1.07	0.97	1.18	1.01	0.92	1.10	0.97	0.89	1.05
	Arrythmia	0.89	0.75	1.07	1.38	1.12	1.69	1.07	0.86	1.32	1.00	0.81	1.22
University hospital district	HYKS	1.00			1.00			1.00			1.00		
	TYKS	1.01	0.89	1.14	1.01	0.84	1.21	1.14	0.98	1.32	1.16	1.01	1.34
	TAYS	1.14	1.03	1.27	1.69	1.47	1.94	1.24	1.10	1.41	1.42	1.26	1.60
	KYS	0.95	0.86	1.04	1.38	1.20	1.58	0.92	0.82	1.05	1.52	1.36	1.70
	OYS	1.00	0.90	1.11	1.43	1.24	1.66	0.98	0.86	1.12	1.26	1.12	1.43

It is not evident, which of the four response variable categories characterises the least desirable treatment spell. MI surely poses the most substantial risk for the patient. However, if the purpose is to examine whether surgery and treatment is provided to all patients equally, it could be more useful to examine spells where the patient has repeatedly suffered acute CHD episodes before receiving the operation and compare the patient group to those with ideal treatment spells. The category of interest in Table 7 would then be EMC 2. Results show that out of the two spell types, the EMC 2 type of spell was over 70 percent more likely than the ELC among the lowest SES groups, compared to the highest.

It seems that all other types of spells were more common in lower socioeconomic groups than the ideal that includes only elective admissions. Differences were not as evident among patients who were operated on directly with their first admission. They did, however, belong more often to the youngest or the oldest age groups. Women were also more frequently operated right away.

The effect of comorbidity varied in different response categories, but heart failure seemed to decrease the likelihood of the best spell type compared to all other spell types. For instance, a patient with heart failure was almost twice (RR = 1.95) as likely to suffer an MI before the operation than having a treatment spell including only elective admissions.

Analysing a specific transition in a treatment spell

Register research often provides large data sets for research purposes, and this is the case in this study as well, as it covers over 23 000 study subjects. A large data set enables statistical analysis on interesting subpopulations that are only fractions from the original study population.

Model 3. After myocardial infarction (MI)

MI is the most severe result of CHD and can be lethal. Additionally, earlier research suggests that there are no socioeconomic differences in the seriousness of the MI between socioeconomic groups that have survived their first MI (Salomaa 2001 et al.). Therefore, there should be fewer socioeconomic differences in the need for operations among MI patients than among CHD patients in general. A second MLR model is therefore performed on the MI population (N = 8 365). The purpose is to compare the next step in the treatment pathway after MI. The response variable is the type of admission (MI, EMC or ELC) that follows the first MI. The fourth category for the response variable means the patient was operated on during the first MI admission. Hence, the categories for the response variable are:
0 = REV: Operated on the first MI admission
1 = MI: Next admission due to another MI
2 = EMC: Next admission due to other acute CHD event
3 = ELC: Next admission scheduled appointment.

Consistently with previous analysis, category 3 is chosen as the reference category, representing the controlled pathway where the patient is scheduled an elective appointment for the operation or further examinations.

Compared to ELC, both MI and EMC admissions were more common in the lower socioeconomic groups. If the operation was performed during the first MI admission, the results showed no differences between socioeconomic groups. However, women were – more often than men – operated upon admission rather than being scheduled a next appointment. All CHD-related comorbidity increased the likelihood of the next admission to be other than elective. The same was true for age: the oldest age groups were more likely to have a second MI or EMC after their first MI than have an elective appointment.

TABLE 9. Multinomial Logistic regression: Response variable; 'type of admission', reference category of the response; 'elective admission'. Estimates for other than socioeconomic variables are reported only for the income models

		OPER			MI			EMC		
		RRR	95%	CI	RRR	95%	CI	RRR	95%	CI
Education	Higher	1.00			1.00			1.00		
	Middle	0.96	0.77	1.21	1.17	0.94	1.45	1.25	1.02	1.52
	Basic	0.93	0.76	1.13	1.30	1.08	1.56	1.34	1.13	1.59
Income	High	1.00			1.00			1.00		
	Middle	0.96	0.80	1.13	1.03	0.89	1.20	1.03	0.90	1.19
	Low	1.03	0.87	1.24	1.30	1.11	1.52	1.32	1.14	1.53
Age (years)	40–44	1.00			1.00			1.00		
	45–49	0.73	0.50	1.06	0.70	0.46	1.07	0.85	0.59	1.22
	50–54	0.67	0.46	0.96	0.77	0.52	1.14	1.00	0.71	1.41
	55–59	0.59	0.41	0.84	1.17	0.81	1.71	1.16	0.83	1.62
	60–64	0.81	0.57	1.15	1.34	0.92	1.94	1.18	0.84	1.64
	65–69	0.84	0.59	1.18	1.62	1.12	2.33	1.24	0.89	1.73
	70–74	0.92	0.64	1.32	2.23	1.54	3.23	1.78	1.27	2.49
	75–79	1.21	0.80	1.84	3.43	2.29	5.15	2.79	1.93	4.05
Gender	Female	1.47	1.25	1.74	1.02	0.88	1.18	1.26	1.10	1.44
Comorbidity	Diabetes	1.02	0.82	1.27	1.44	1.21	1.72	1.30	1.10	1.54
	Heart failure	0.61	0.47	0.79	1.31	1.09	1.57	1.27	1.07	1.51
	High blood pressure	1.05	0.90	1.21	1.24	1.10	1.41	1.16	1.03	1.30
	Arrythmia	0.99	0.65	1.49	1.37	1.02	1.85	1.35	1.01	1.81
University hospital district	HYKS	1.00			1.00			1.00		
	TYKS	1.42	1.11	1.81	0.99	0.81	1.23	0.80	0.65	0.98
	TAYS	1.45	1.17	1.80	1.44	1.21	1.71	1.45	1.24	1.71
	KYS	2.42	1.99	2.94	1.24	1.04	1.48	1.38	1.18	1.62
	OYS	2.29	1.86	2.83	1.46	1.21	1.75	1.41	1.19	1.67

Analysing number of events in treatment spell

Poisson regression is often used as a modelling tool when the response variable represents the number of events occurring in time. The response variable (Y) follows Poisson distribution if

$$P(Y = k \mid x_1, x_2, ..., x_m) = \frac{e^{-\mu}\mu^k}{k!}$$

where k denotes the number of events and μ the expected value of Y. The logarithm is taken to linearise the relationship between the response and the explanatory variables as in log linear models in general. The same way as log odds in logistic regression, the log of μ in Poisson regression is assumed to be a linear function of the independent variables, i.e.,

$$\mu = \exp(b_0 + b_1 x_1 + b_2 x_2 + ... + b_m x_m) .$$

Presented coefficients are actually incident rate ratios. If estimates are larger than one, the number of events is higher among subjects in the respective group than those in the reference group.

Model 4. Number of emergency admissions (MI and EMC)

Distinction between emergency and elective admissions has been made throughout the analysis, emergency admissions (MI and EMC) being considered 'bad' admissions and elective admissions (ELC) 'good'. In Chapter 4, the number of emergency admissions was used to produce Figure 8. The conclusion of the analysis was that patients in lower socioeconomic groups had more 'bad' emergency admissions along the pathway to revascularisation. The analysis is continued with statistical modelling using Poisson regression and the number of EMC as the response variable.

The results are consistent with those reported earlier. When age, gender, comorbidity and regional variation were taken into account, significant differences between income groups remained. The same was true for educational degree. Treatment spells included 26 percent more emergency admissions in the low income group compared to the high income group. Again, comorbidity increased the likelihood of several emergency admissions. Varsinais-Suomi and Keski-Suomi did well in comparison, whereas Kanta-Häme and Keski-Pohjanmaa had the highest number of emergency admissions on average.

TABLE 10. Poisson model for number of emergency admissions in a spell. Estimates for other than socioeconomic variables are reported only for the income models

		Mod 1.	Mod 2.	Mod 3.	Mod 4.	Mod 4. 95 %	CI
Education	Higher						
	Middle	1.18	1.19	1.18	1.17	1.12	1.22
	Basic	1.34	1.28	1.26	1.24	1.20	1.29
Income	High						
	Middle	1.19	1.14	1.12	1.12	1.08	1.15
	Low	1.42	1.31	1.28	1.26	1.22	1.30
Age (years)	40–44						
	45–49		1.05	1.05	1.06	0.97	1.15
	50–54		1.05	1.02	1.03	0.95	1.12
	55–59		1.05	1.02	1.03	0.95	1.12
	60–64		1.07	1.01	1.02	0.94	1.11
	65–69		1.12	1.05	1.06	0.98	1.15
	70–74		1.24	1.14	1.15	1.07	1.25
	75–79		1.49	1.36	1.37	1.26	1.49
Gender	Female		1.05	1.03	1.03	1.00	1.06
Comorbidity	Diabetes			1.23	1.23	1.19	1.27
	Heart failure			1.36	1.35	1.30	1.39
	High blood pressure			1.07	1.07	1.04	1.09
	Arrythmia			1.18	1.17	1.12	1.23
Hospital District	Helsinki						
	Other Uusimaa				1.00	0.95	1.06
	Varsinais-Suomi				0.86	0.81	0.91
	Satakunta				1.00	0.93	1.07
	Kanta-Häme				1.25	1.16	1.35
	Pirkanmaa				0.94	0.89	1.00
	Päijät-Häme				1.16	1.08	1.24
	Kymenlaakso				0.99	0.93	1.06
	Etelä-Karjala				0.96	0.88	1.05
	Etelä-Savo				0.99	0.91	1.07
	Itä-Savo				1.06	0.96	1.17
	Pohjois-Karjala				1.18	1.11	1.26
	Pohjois-Savo				1.00	0.95	1.05
	Keski-Suomi				0.93	0.87	0.98
	Etelä-Pohjanmaa				1.14	1.07	1.22
	Vaasa				1.05	0.98	1.12
	Keski-Pohjanmaa				1.20	1.11	1.30
	Pohjois-Pohjanmaa				1.01	0.96	1.07
	Kainuu				1.08	0.99	1.17
	Länsi-Pohja				1.17	1.06	1.28
	Lappi				1.10	1.02	1.18
	Åland				0.91	0.70	1.18

Model 5. Number of elective admissions in a 'Good Spell 0' (no emergency admissions)

Previous analysis indicated that those worse-off have less scheduled and controlled treatment chains than the better-off. Differences in access to health care are often explained by reference to occupational health care. People who are gainfully employed have easier access to medical appointments with both doctors and nurses and can get referred to further examinations in the public sector. The economically active may therefore be diagnosed and treated at an earlier stage of disease and can be in better shape.

However, there are also people in low income groups who have not suffered acute CHD events before receiving an operation. An interesting study question may be whether there are SES differences within 'good' treatment pathways. One way to analyse the question by means of Poisson regression is to focus only on the subpopulation with ideal treatment pathways (N=7 141) and use the number of elective admissions as the response variable (Table 11). The type of operation (PTCA or CABG) is included in the model, because it is assumed that CABG could require more visits to the hospital on a systematic basis for testing and consulting.

The model shows no socioeconomic or other differences in the number of elective appointments. Only the type of surgery is significant in the model, but the result is not very significant even there – only 4 percent less appointments among patients having PTCA instead of CABG. The question of equally 'good' spells will be looked at again in the next chapter using Cox regression to see whether the time element shows any differences.

TABLE 11. Poisson model for number of appointments in a spell. Estimates for other than socioeconomic variables are reported only for the income models

		IRR	95%	CI
Education	Higher			
	Middle	1.00	0.95	1.06
	Basic	1.00	0.95	1.05
Income	High			
	Middle	1.02	0.98	1.07
	Low	1.01	0.96	1.05
Age (years)	40–44			
	45–49	1.03	0.91	1.16
	50–54	1.04	0.92	1.17
	55–59	1.03	0.92	1.16
	60–64	1.03	0.92	1.16
	65–69	1.03	0.92	1.16
	70–74	1.03	0.91	1.15
	75–79	1.03	0.91	1.17
Gender	Female	0.98	0.94	1.02
Comorbidity	Diabetes	1.04	0.98	1.10
	Heart failure	0.96	0.90	1.03
	High blood pressure	1.01	0.98	1.05
	Arrythmia	0.98	0.90	1.07
Operation	PTCA	0.96	0.92	1.00
Hospital District	Helsinki			
	Other Uusimaa	0.97	0.91	1.04
	Varsinais-Suomi	1.01	0.93	1.08
	Satakunta	0.99	0.90	1.10
	Kanta-Häme	1.07	0.93	1.22
	Pirkanmaa	0.98	0.91	1.06
	Päijät-Häme	1.04	0.93	1.16
	Kymenlaakso	1.05	0.96	1.15
	Etelä-Karjala	0.95	0.84	1.06
	Etelä-Savo	1.00	0.90	1.12
	Itä-Savo	0.93	0.80	1.09
	Pohjois-Karjala	0.97	0.87	1.08
	Pohjois-Savo	1.00	0.93	1.07
	Keski-Suomi	0.99	0.92	1.07
	Etelä-Pohjanmaa	1.06	0.96	1.18
	Vaasa	1.01	0.92	1.12
	Keski-Pohjanmaa	1.00	0.88	1.14
	Pohjois-Pohjanmaa	1.06	0.98	1.14
	Kainuu	0.97	0.86	1.09
	Länsi-Pohja	1.07	0.91	1.25
	Lappi	1.06	0.95	1.19
	Åland	1.04	0.73	1.47

Analysing time span to surgery

Cox regression is used to model 'survival' times to an event of interest. In this study, an interesting issue would be the time from diagnosis to the operation. Cox regression does not require any assumptions on the shape of the baseline hazard function, but it assumes that the model can be specified in terms of the proportional hazards. Cox regression can be written as

$$h\{(t)|(x_1, x_2, ..., x_m)\} = h_0(t)\exp(b_1x_1 + ... + b_mx_m)$$

where $h_0(t)$ is the baseline hazard where all independent variables are equal to 0. A linear equation is reached by dividing both sides by $h_0(t)$ and taking the logarithm. The resulting equation is

$$\log[h\{(t)|(x_1..)\} / h_0(\mathrm{t})] = b_1x_1 + ... + b_mx_m .$$

From the equation, it is evident that the response variable in Cox regression is the logarithm of the ratio of risks.

Model 6. Time from the beginning of the treatment spell to surgery

Earlier modelling was carried out through classifying and separating pathways according to their content. At the beginning of this study, it was pointed out that waiting times are thought of as important measures when equity in access to health care is examined. Cox regression is used to model different time spans relevant to the study question.

Mean times from the first CHD admission to surgery were examined in Chapter 4. Means were calculated for the more active part of the pathway as well, allowing no more than 6 months' gap between admissions. The truncation dropped waiting times considerably. The basis for the truncation was the assumption that the condition of the patient is stable if admissions are needed less frequently than once per half-a-year period.

Table 12 shows that socioeconomic differences did exist during the study period. Time from the first CHD admission to surgery was significantly longer for the low SES groups even when standardised for age, gender, comorbidity and area of residence. This was true despite whether treatment was active during the whole treatment pathway. The effect of age is diverse in the two models. When the whole treatment history was considered age had a prolonging effect for surgery. However, if only the active part of the treatment was considered, the older age groups had shorter waiting times. Table 12 also shows that if treatment was active, patients having PTCA received surgery sooner. Though truncation of the treatment spell did not affect the SES differences notably, it did bring out stronger variation from one hospital district to another. Helsinki and Uusimaa, Kymenlaakso, Satakunta and Varsinais-Suomi in particular had longer waiting times compared to other hospital districts, if only active part of the treatment is considered.

TABLE 12. Cox model for time from 1st CHD admission to operation; whole spell and truncated spell. Estimates for other than socioeconomic variables are reported only for the income models

		Whole Spell			Truncated Spell		
		HR	**95%**	**CI**	**HR**	**95%**	**CI**
Education	Higher						
	Middle	0.88	0.84	0.93	0.89	0.85	0.94
	Basic	0.87	0.84	0.91	0.86	0.82	0.90
Income	High						
	Middle	0.91	0.88	0.94	0.93	0.90	0.96
	Low	0.87	0.84	0.90	0.88	0.84	0.91
Age (years)	40–44						
	45–49	0.89	0.81	0.98	1.08	0.98	1.19
	50–54	0.85	0.77	0.93	1.05	0.96	1.16
	55–59	0.83	0.76	0.90	1.14	1.04	1.25
	60–64	0.81	0.74	0.89	1.14	1.04	1.24
	65–69	0.79	0.72	0.86	1.15	1.05	1.25
	70–74	0.75	0.69	0.83	1.18	1.08	1.29
	75–79	0.71	0.65	0.78	1.22	1.11	1.35
Gender	Female	1.07	1.04	1.11	1.02	0.98	1.05
Comorbidity	Diabetes	0.86	0.82	0.90	0.91	0.87	0.94
	Heart failure	0.74	0.71	0.78	0.87	0.83	0.91
	High blood pressure	0.98	0.95	1.01	1.00	0.97	1.03
	Arrythmia	0.85	0.79	0.91	0.93	0.87	0.99
Operation	PTCA	1.00	0.97	1.03	1.20	1.16	1.24
Hospital District	Helsinki						
	Other Uusimaa	0.99	0.94	1.05	1.05	0.99	1.12
	Varsinais-Suomi	0.85	0.80	0.91	0.74	0.69	0.80
	Satakunta	1.07	1.00	1.16	1.02	0.94	1.10
	Kanta-Häme	1.06	0.97	1.16	1.13	1.03	1.24
	Pirkanmaa	1.05	0.98	1.12	1.30	1.21	1.38
	Päijät-Häme	1.07	0.99	1.17	1.19	1.09	1.29
	Kymenlaakso	1.09	1.01	1.17	1.01	0.93	1.09
	Etelä-Karjala	1.07	0.97	1.18	1.22	1.11	1.35
	Etelä-Savo	1.08	0.99	1.18	1.25	1.14	1.37
	Itä-Savo	1.20	1.07	1.34	1.39	1.24	1.56
	Pohjois-Karjala	0.97	0.90	1.05	1.16	1.07	1.26
	Pohjois-Savo	1.05	0.99	1.12	1.32	1.24	1.40
	Keski-Suomi	1.22	1.14	1.30	1.35	1.26	1.44
	Etelä-Pohjanmaa	1.01	0.93	1.09	1.14	1.05	1.23
	Vaasa	1.03	0.95	1.11	1.30	1.19	1.41
	Keski-Pohjanmaa	0.93	0.84	1.03	1.15	1.04	1.27
	Pohjois-Pohjanmaa	1.01	0.95	1.08	1.26	1.18	1.34
	Kainuu	1.07	0.97	1.18	1.16	1.05	1.29
	Länsi-Pohja	1.06	0.94	1.18	1.24	1.10	1.38
	Lappi	1.14	1.04	1.24	1.33	1.22	1.45
	Åland	1.15	0.87	1.52	1.82	1.37	2.42

Model 7. Time from the 1st out of two elective admissions to surgery

Patients who had only one preceding elective appointment and were operated during the next hospitalisation can be expected to be a fairly homogeneous group in the sense of treatment. The first appointment has in most cases probably been scheduled for tests and consultation and to prepare the patient for surgery. The tree diagram (Figure 6) shows that the subpopulation in question includes 5 089 patients.

TABLE 13. Cox model for time from 1st and only appointment admission (ELC) preceding the operation. Estimates for other than socioeconomic variables are reported only for the income models

		Whole Spell			Truncated Spell		
		HR	95%	CI	HR	95%	CI
Education	Higher						
	Middle	0.89	0.81	0.98	0.93	0.85	1.02
	Basic	0.88	0.82	0.95	0.90	0.83	0.97
Income	High						
	Middle	0.92	0.86	0.99	0.92	0.86	0.99
	Low	0.92	0.85	0.99	0.91	0.85	0.98
Age (years)	40–44						
	45–49	1.02	0.83	1.25	1.20	0.97	1.47
	50–54	1.03	0.85	1.25	1.21	1.00	1.47
	55–59	1.05	0.87	1.26	1.18	0.97	1.42
	60–64	1.02	0.85	1.23	1.19	0.99	1.43
	65–69	1.03	0.86	1.23	1.23	1.03	1.49
	70–74	1.02	0.84	1.23	1.19	0.98	1.44
	75–79	1.10	0.89	1.36	1.45	1.17	1.80
Gender	Female	1.02	0.95	1.09	1.01	0.94	1.08
Comorbidity	Diabetes	0.91	0.83	1.00	0.91	0.83	1.01
	Heart failure	0.86	0.77	0.97	0.91	0.81	1.03
	High blood pressure	0.94	0.89	1.00	0.98	0.92	1.04
	Arrythmia	0.83	0.72	0.96	0.88	0.76	1.02
Operation	PTCA	1.45	1.35	1.56	1.79	1.66	1.93
Hospital District	Helsinki						
	Other Uusimaa	1.04	0.93	1.17	0.96	0.86	1.08
	Varsinais-Suomi	0.43	0.38	0.49	0.49	0.42	0.56
	Satakunta	0.66	0.56	0.78	0.71	0.60	0.85
	Kanta-Häme	1.02	0.81	1.27	1.17	0.93	1.46
	Pirkanmaa	1.05	0.93	1.20	0.99	0.87	1.13
	Päijät-Häme	1.26	1.06	1.50	1.30	1.09	1.54
	Kymenlaakso	1.13	0.98	1.30	1.06	0.92	1.23
	Etelä-Karjala	1.59	1.32	1.93	1.63	1.35	1.98
	Etelä-Savo	1.13	0.94	1.36	1.17	0.97	1.42
	Itä-Savo	1.51	1.17	1.94	1.31	1.02	1.68
	Pohjois-Karjala	1.30	1.09	1.55	1.22	1.02	1.45
	Pohjois-Savo	1.22	1.08	1.37	1.11	0.98	1.25
	Keski-Suomi	1.47	1.29	1.67	1.40	1.23	1.60
	Etelä-Pohjanmaa	1.50	1.24	1.82	1.27	1.05	1.55
	Vaasa	1.37	1.16	1.62	1.63	1.37	1.93
	Keski-Pohjanmaa	1.48	1.20	1.82	1.49	1.20	1.83
	Pohjois-Pohjanmaa	1.39	1.23	1.57	1.23	1.09	1.40
	Kainuu	1.55	1.28	1.88	1.44	1.19	1.75
	Länsi-Pohja	1.35	1.05	1.74	1.23	0.95	1.59
	Lappi	1.33	1.10	1.61	1.19	0.98	1.44
	Åland	1.84	1.01	3.34	3.91	2.09	7.33

Table 13 reveals that the highest SES group did again have shorter waiting times; however, no significant difference was found between the two lower SES groups. Truncation of the pathway in this subpopulation means in practice that all patients having the preceding appointment over 6 months before the operation (211 patients) were excluded from the analysis. Truncation did not affect SES differences notably. Heart failure and arrhythmia prolonged the waiting time to surgery. The effect of age became apparent after truncation. The oldest age group had significantly shorter waiting times. Results show again that patients waited longer for CABG than for PTCA. In Varsinais-Suomi and Satakunta, patients had the longest waiting times for operations.

Model 8. Time from the 1st MI to surgery

The most severe consequence of CHD is myocardial infarction. Nearly one-third (N=8 365) of revascularised patients had suffered MI before the operation. The number of MI's varied from one to six; 81 percent had one MI, 15 percent two MI's and the rest three or more. MI indicates an advanced, serious stage of the disease and the operation, if possible to conduct, is urgent. Table 14 presents results from the Cox regression model where the response variable is the time from the first MI to surgery.

Results do not indicate significant differences between socioeconomic groups. However, other patient-related factors seemed to have an effect. Age, heart failure and arrythmia prolonged the time to surgery. Men waited longer for revascularisation than women. Patients in Satakunta received surgery fastest after an MI, which is interesting since the previous model (Table 13) showed Satakunta to have the longest waiting times. This could suggest that MI patients in Satakunta are prioritised more than in other hospital districts.

TABLE 14. Cox model for time from 1st MI to operation. Estimates for other than socioeconomic variables are reported only for the income models

		HR	95%	CI
Education	Higher			
	Middle	0.97	0.90	1.05
	Basic	0.97	0.91	1.04
Income	High			
	Middle	0.97	0.92	1.03
	Low	0.95	0.90	1.01
Age (years)	40–44			
	45–49	0.87	0.75	1.00
	50–54	0.82	0.71	0.93
	55–59	0.83	0.72	0.94
	60–64	0.83	0.73	0.95
	65–69	0.78	0.69	0.89
	70–74	0.76	0.67	0.87
	75–79	0.72	0.62	0.84
Gender	Female	1.12	1.06	1.18
Comorbidity	Diabetes	0.95	0.89	1.01
	Heart failure	0.84	0.78	0.90
	High blood pressure	1.04	0.99	1.09
	Arrythmia	0.84	0.75	0.94
Operation	PTCA	1.26	1.19	1.32
Hospital District	Helsinki			
	Other Uusimaa	0.92	0.84	1.01
	Varsinais-Suomi	0.90	0.81	1.00
	Satakunta	1.34	1.18	1.51
	Kanta-Häme	1.08	0.93	1.26
	Pirkanmaa	1.08	0.98	1.21
	Päijät-Häme	1.04	0.91	1.19
	Kymenlaakso	1.03	0.91	1.17
	Etelä-Karjala	1.23	1.05	1.44
	Etelä-Savo	1.14	0.99	1.31
	Itä-Savo	1.31	1.09	1.58
	Pohjois-Karjala	1.03	0.91	1.16
	Pohjois-Savo	1.00	0.90	1.11
	Keski-Suomi	1.20	1.08	1.34
	Etelä-Pohjanmaa	0.99	0.87	1.13
	Vaasa	0.93	0.82	1.07
	Keski-Pohjanmaa	0.97	0.84	1.13
	Pohjois-Pohjanmaa	1.04	0.94	1.15
	Kainuu	1.08	0.92	1.27
	Länsi-Pohja	1.27	1.06	1.51
	Lappi	1.25	1.08	1.43
	Åland	0.85	0.51	1.41

Summary and methodological considerations

This study used information that was extractable from the register data. Assumptions and definitions were made during data pre-processing and analysis to reach a data set that would correspond to the research question. Other alternative ways to conduct the analysis could have been quite as well justified.

Nonetheless, results from all the previous analyses seem to be consistent. Based on the results, differences did exist between socioeconomic groups in pathways to revascularisation. A simplified summary of the results is presented in Tables 15 and 16. In the Tables, plus (+) indicates a significant ($p < 0.05$) positive difference compared to the reference group and minus (-) a significant negative difference. A greater probability of a 'good spell', less acute CHD events and a shorter time span from the specific CHD event to surgery were considered as positive characteristics of the treatment spells.

TABLE 15. Summary table of the results (Logistic and Multinomial logistic regression). Minus (-) indicates a statistically significant negative difference in relation to the reference group, i.e., aspects are worse in the groups indicated by a minus. Summarisations for other than socioeconomic variables are reported only for the income model

		Mod 1.		Mod 2.				Mod 3.		
		G0	G1	MI	EMC2+	EMC1	OPER	MI	EMC	OPER
Education	High (ref.)									
	Middle	-	-	-	-	-			-	
	Low	-	-	-	-	-	-	-	-	
Income	High (ref.)									
	Middle	-	-	-	-	-				
	Low	-	-	-	-	-	-	-	-	
Age	40–44 (ref.)									
	45–49									
	50–54			+			+			+
	55–59			+	-		+			+
	60–64	+	-	+	-		+			
	65–69	+	-	+	-		+	-		
	70–74		-	+	-		+	-	-	
	75–79				-			-	-	
Gender	Female				-		-			-
	Diabetes	-	-	-	-			-	-	
	Heart failure	-	-	-	-	-	-	-	-	+
	High blood pressure		-					-	-	
	Arrythmia		-		-			-	-	

Mod 1. Logistic regression for a 'Good spell.

Mod 2. Multinomial logistic regression for different spell types - reference group; No emergency admissions.

Mod 3. Multinomial logistic regression for the admission type following the first MI – reference group; elective admission.

TABLE 16. Summary table of the results (Poisson and Cox regression). Minus (-) indicates a statistically significant negative difference in relation to the reference group, i.e., aspects are worse in the groups indicated by a minus. Summarisations for other than socioeconomic variables are reported only for the income model

		Mod 4.	Mod 5.	Mod 6.		Mod 7.		Mod 8.
				WS	TS	WS	TS	
Education	High (ref.)							
	Middle	-		-	-	-	-	
	Low	-		-	-	-	-	
Income	High (ref.)							
	Middle	-		-	-	-	-	
	Low	-		-	-	-	-	
Age	40–44 (ref.)							
	45–49			-				
	50–54			-			+	-
	55–59			-	+			-
	60–64			-	+			-
	65–69			-	+		+	-
	70–74	-		-	+			-
	75–79	-		-	+		+	-
Gender	Female			+				+
Co morbidity	Diabetes	-		-	-			
	Heart failure	-		-	-	-		-
	High blood pressure	-						
	Arrythmia	-		-	-	-		-
PTCA					+	+	+	+

Mod 4. Poisson regression for the number of emergency CHD admissions in the spell.

Mod 5. Poisson regression for the number of elective admissions in the spell among those with only elective admissions.

Mod 6. Cox regression for the time from the first CHD admission to surgery (Whole Spell / Truncated Spell.)

Mod 7. Cox regression for the time from the first admission to the surgery among those with only two elective admissions in the spell (Whole Spell / Truncated Spell).

Mod 8. Cox regression for the time from the 1st MI to surgery.

Results show consistently that lower SES groups seem to have been treated less effectively than the highest group. Ideal spells were more common in the highest SES groups, whereas lower SES groups were more likely to suffer from acute emergency CHD events before receiving the operation. Time spans between the first CHD hospital admission and the operation were longer for low SES groups.

Model 5 included patients that had received the operation without antecedent acute CHD events, indicating early stage of the disease and controlled treatment spells. It showed no trend between SES groups in the number of hospital admissions. The result could indicate that when the treatment goes according to plan and decision to operate is made before the condition is too severe, no clear differences in treatment practices exist. On the other hand, Model 7 showed that patients in the highest SES group did have shorter waiting times to surgery when the operation was already conducted on the second elective hospital admission, and this cannot be explained with the higher PTCA rate.

Models 1 and 2 showed that the low SES groups are clearly underrepresented in the subpopulations that have no antecedent acute CHD events. Results from Model 4 consistently prove that patients in low SES groups were more likely to suffer from acute CHD events before receiving the operation. Multiple emergency admissions due to CHD are a signal of an advanced stage of the disease. Based on the results, it can be concluded that the threshold to operate is lower for patients in the higher SES group.

Model 6 showed that the time span from the first CHD event to surgery was longer in the lower SES groups. This applies for the whole treatment history and also for the more active part of the pathway. However, among the MI population, no significant SES differences were found in waiting times to surgery after the first MI (Mod. 8). This could mean that SES differences in waiting times disappear when the stage of the disease has become very severe. However, results from Model 3 show that in the lowest SES group, MI was more likely to be followed by another acute CHD event than in the highest SES group.

Basic statistical methods were used for statistical modelling. Models were produced stepwise so that one variable at the time was included in the model (Table 10). The purpose was to monitor confounding effects and dependencies between variables. Some questions might be raised as to whether more complex models should have been used and the diagnostics examined more thoroughly. Not much emphasis was laid on the reporting of the model assumptions or diagnostics, as the idea was not to find any single best model; moreover, the results of various models with different assumptions seemed to be consistent. CHD manifestations are quite different between genders, so separate models or interactions could have been appropriate. Some interactions and sensitivity analysis for the follow-up times were examined briefly. Justification for division into ’good’ and ’bad’ spells was examined in relation to post-operative mortality. This study focused more on exploring various ways to use register data for scientific research and on the application of various statistical techniques than on the technical details of statistical models.

6 DISCUSSION

This study explored various possibilities that register data can provide for health services research: in this case, equity research. The objectives were both methodological and subject matter-oriented. The process of a register-based study was illustrated through a case study. The main question was whether patients' socio-demographic characteristics and comorbidities had an impact on pathways to revascularisation between 1995 and 1998. In this retrospective cohort study, pathways leading to revascularisation were compared between different SES groups by constructing a retrospective cohort study setting from a set of study data that was originally collected for other research purposes. The aim was to examine whether some people receive invasive coronary operation in a more straightforward manner than others, and to look for reasons for these possible inequities.

The results of the various analyses performed were consistent and indicated that differences between SES groups existed in pathways to revascularisation. Higher SES groups were less likely to suffer acute CHD events before receiving the operation and more likely to experience shorter waiting times. Their treatment pathways were more frequently controlled and only included scheduled appointments. However, among patients who had suffered MI, the SES differences in waiting times to surgery disappeared. This suggests that differences favouring those better-off existed, but when health risks were as severe – as they are likely to be among the MI population – access to surgery was equal for all socioeconomic groups.

Nevertheless, further analyses should be made on how significant the differences found between SES groups actually are. In an ideal situation no differences exist, but the significance of the differences needs to be weighed as well. The data sizes in register based research are massive and small differences become statistically significant, though in practice they may have little meaning in, for instance, explaining the reasons of increasing health risks specific to a patient. The significance of these kinds of findings requires further examination and should be evaluated by researchers with a thorough knowledge of health care practices as well as expertise on coronary heart disease.

The Finnish health care system has gone through several changes since the study period. For example, a six months' care guarantee has been issued, the private sector has increased its role as a provider of invasive coronary procedures and techniques have developed; e.g., more and more PTCA's are conducted compared to CABG. It would be of interest to conduct a similar study using a newer set of data. Recent study results have, in fact, suggested that since the study period 1995-1998, SES differences in access to elective surgery have diminished and in some cases even disappeared altogether. However, since coronary heart disease incidence is larger in lower socioeconomic groups, differences still exist in relation to need (Manderbacka et al. 2006).

Methodologically, several different approaches were illustrated during the study, both graphical and statistical. To reach an overall view on a set of study data of this kind and to find the best way to draw conclusions on the appropriate approach concerning the research question, several definitions and analysis were tested. The construction of a retrospective cohort study setting from register data and profiling treatment histories in the way that was presented in this study have not previously been implemented when SES differences in access to treatment have been studied. During this study, new insight was gained into the treatment pathways and their differences between SES groups. The methods and definitions chosen are not the only possibilities to conduct the analysis, and other solutions might have been justified as well. Each detail of the process could not be reported, nor all reasoning behind every definition. The framework of the study made some simplifications in the analysis necessary.

The process of this work revealed the differences between studies based on administrative register data and traditional ways of collecting and analysing research data. In the latter case, the study question is usually defined first, data are then collected to correspond with it, and the data are then analysed by means of methods that are often predefined. In register research, the process is more complicated since these various phases overlap. Interaction between formulation of the study questions, data pre-processing, construction of the data sets and choosing methods for the analysis continues throughout the project (Sund 2003, Sund et al. 2004). This project required extensive effort simply to construct a data set that enabled analysis. Defining and constructing variables for the study as well as creating graphical presentations required multiple phases and the constructions of several data sets. Some of the ideas that seemed advantageous or presentable in the beginning proved to be complicated and even impossible to realise. However, as this study shows, it is possible to find fresh perspectives for the analyses of important subject matter problems when an open-minded use of register data is applied.

The potential that administrative register data have as sources of information for health services research is substantial, though it is clear that the process of generating eligible information from register data is neither simple nor straightforward. It requires a lot of time and expertise in both the nature and content of the data and the relevant subject matter (Sund 2003, Sund et al. 2004). When used in a competent and creative way, administrative register data provide unlimited possibilities to generate important and valid information capable of benefiting all.

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