Are there socioeconomic differences in outcomes of coronary revascularizations—a register-based cohort study

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Background: Earlier studies have reported socioeconomic differences in coronary heart disease incidence and mortality and in coronary treatment, but less is known about outcomes of care. We examined trends in income group differences in outcomes of coronary revascularizations among Finnish residents in 1998–2010. Methods: First revascularizations for 45–84-year-old Finns were extracted from the Hospital Discharge Register in 1998–2009 and followed until 31 December 2010. Income was individually linked to them and adjusted for family size. We examined the risk of major adverse cardiac events (MACEs), coronary mortality and re-revascularization. We calculated age-standardized rates with direct method and Cox regression models. Results: Altogether 69 076 men and 27 498 women underwent revascularization during the study period. Among men [women] in the 1998 cohort, 41% [35%] suffered MACE during 29 days after the operation and 30% [28%] in the 2009 cohort. Myocardial infarction mortality within 1 year was 2% among both genders in both cohorts. Among men [women] 9% [14%] underwent revascularization within 1 year after the operation in 1998 and 12% [12%] in 2009. Controlling for age, co-morbidities, year, previous infarction and disease severity, an inverse income gradient was found in MACE incidence within 29 days and in coronary mortality. The excess MACE risk was 1.39 and excess mortality risk over 1.70 among both genders in the lowest income quintile. All income group differences remained stable from 1998 to 2010. Conclusions: In health care, more attention should be paid to prevention of adverse outcomes among persons with low socioeconomic position undergoing revascularization.

Methods

Study sample

The dataset used in the present study was collected for the PERFECT (Performance, effectiveness and costs of treatment episodes) study. Data on all coronary revascularizations (including both coronary artery by-pass operations and coronary angioplasties) in years 1998–2009 were obtained from the Hospital Discharge Register for persons aged 45–84 years, and these persons were followed from their first revascularization up until 31 December 2010. Data on special reimbursement right for medication costs for specific disease as well as reimbursed costs of prescription drugs were individually linked to these data from the registers maintained by the Social Insurance Institution (SII). Additionally, data on deaths from the Causes of Death Statistics and sociodemographic data from the Employment Statistics maintained by Statistics Finland were individually linked to the aforementioned data. Those in long-term care were excluded from the analyses since family income could not be reliably obtained for them from the registers used.

Introduction

Socioeconomic position has repeatedly been reported to be associated with health and health outcomes in industrialized countries. Persons with lower socioeconomic position have consistently been shown to have poorer health and higher mortality compared with persons with higher socioeconomic position.¹² Lower socioeconomic position has also been found to be associated with increased coronary heart disease (CHD) incidence and mortality.¹³ Studies from Finland and elsewhere have reported differences in CHD mortality before reaching the hospital.⁵⁻¹⁰ in the first month after myocardial infarction (MI) hospitalization⁶⁻¹¹ and longer term.⁶⁻¹²,¹³ Further, some studies have reported socioeconomic differences in medicine use to prevent adverse cardiac events among patients with CHD⁶⁻¹⁴,¹⁵ and in access to investigations and invasive treatment among CHD patients¹⁶⁻¹⁹ as well as use of cardiac rehabilitation.²⁰,²¹ It has also been suggested that among those undergoing revascularization, persons with lower socioeconomic position have poorer pathways to the procedure in terms of higher likelihood of emergency hospitalizations both among the general population²² and among persons with diabetes.²³

An important but less studied question is whether there are socioeconomic differences in the outcomes of coronary revascularizations. There have been some studies including several outcome measures: subsequent hospitalizations,²⁴ revascularization,²⁴,²⁵ MI,²⁴⁻²⁶ stroke²⁶ and mortality²⁷⁻²⁹ as well as health related quality of life.²⁴ However, these studies have mainly been based on regionally restricted population samples and on ecological data on socioeconomic position.

The aim of the current study was to examine outcomes of coronary revascularizations, and trends and socioeconomic differences in them among a cohort of 45–84-year-old total resident population in Finland from 1998 to 2009 followed up until the end of 2010. We further examined whether the possible differences in outcomes of revascularizations can be explained by differences in disease severity or co-morbidity.
**Measurement**

We used 'income' as the indicator of socioeconomic position. We used family net income of the year preceding revascularization (including all earned income, capital income and all income transfers subject to taxation and excluding paid taxes) adjusted for family size using The Organisation for Economic Co-operation and Development modified equivalence scale by dividing net household income by weighted household consumption units (1 for the first adult, 0.5 for each other persons older than 13 years and 0.3 for children until 13 years). We used four outcome measures. Data on 'major adverse cardiac events' (MACEs) up to 29 days after the first revascularization admission [including hospitalization due to ischemic heart disease (ICD-10 codes I20-I25), atrioventricular and left bundle-branch block (I44), other conduction disorders of the heart (I45), cardiac arrest (I46), paroxysmal tachycardia (I47), atrial fibrillation and flutter (I48), other cardiac arrhythmias (I49), or heart failure (I50) as the main diagnosis] and 30–365 days after the first admission, ‘subsequent revascularizations’ from the Hospital Discharge Register and 'CHD deaths' from the Causes of Death Statistics maintained by Statistics Finland. There is some overlap between indicators of MACE and other outcome measures, since these patients can undergo a revascularization or die during a hospitalization due to MACE. Data on 'co-morbidities' included data on hypertonia, hypercholesterolemia, heart failure, alcohol-related disorders, dementia, depression and other mental disorders, asthma and chronic obstructive pulmonary disease (COPD), cancer, epilepsy, Parkinson’s disease and renal failure. Dummy variables for each of these co-morbidities were formed to be used as covariates in the analyses. These data were obtained from the additional codes from the Hospital Discharge Register and SII registers for reimbursed pre-scriptions medicine costs and special reimbursement right for medicine costs for specific chronic disease. The data for reimbursed medicine costs are based on actual reimbursements paid by the SII. For a special reimbursement right, a physician’s certificate is required for conforming that certain diagnostic criteria are met and it is further reviewed by a physician at the SII. ‘Disease severity’ before the operation was measured using the New York Heart Association (NYHA) classification\(^{30}\) obtainable from the Hospital Discharge Register. All these data were individually linked to the cohort using the personal identification code unique to each resident.

The study protocol was approved by the Ethics Committee of the National Institute for Health and Welfare. Permission to use the earlier described register data was obtained from the competent authorities.

**Statistical methods**

We calculated age-standardized rates with direct age-standardization method using the weights derived from the European standard population including age groups between 45 and 84 years in 5-year age bands. Repeated measures Poisson models adjusted for age were conducted to assess income differences in revascularizations. Further, we conducted preliminary analyses of Kaplan-Meyer—curves for the four responses stratified by income group to study the risk to four subsequent response events following initial revascularization. Cox regression models were used to assess differences between the income quintiles while adjusting for age, year, co-morbidities, NYHA and an indicator for a MI preceding revascularization. In the models, patients with no event were censored at the end of the follow-up period or prior death. In case of subsequent revascularizations and CHD deaths an indicator for a MI following initial revascularization was included in the model as a time-varying covariant. As some 13.2% of patients had missing values for NYHA, multiple imputation was used to impute the missing values to include these observations in the analyses. Predicted values of a linear regression of NYHA on gender, age group, study year and hospital district were used to create plausible values for those missing in NYHA. All analyses were conducted separately for men and women.

**Results**

Altogether 69,076 men and 27,498 women aged 45–84 years underwent coronary revascularization during 1998–2009. The rate of first revascularization was 53 per 10,000 in the Finnish population of the same age among men and 15 among women in 1998, and it increased up to the mid-2000s among both genders and decreased somewhat after that. In the 2009 cohort, the rates were on the 1998 level among both genders. There were relatively stable stepwise income group differences in access to revascularization: the lower the income group the higher the revascularization rate. However, among men the lowest income group had lowest access rate in the beginning of the study period and the second lowest group had the highest access rate throughout the study period (figure 1). Income differences were statistically significant throughout the study period according to Poisson regression models.

Table 1 presents basic background information of the 1998 and 2009 cohorts. Towards the end of the study period, the patients undergoing revascularization were somewhat older. However, those with higher income were younger during the time of

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**Figure 1** Rates of first revascularization (/10 000 persons) by income in 1998–2009 among men and women in Finland

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revascularization. A shift in medical practice happened during the study period: there was a large increase in the number of revascularizations on MI and other emergency hospitalizations from the 1998 cohort to the 2009 cohort. Of the co-morbidities, hypertonia was prevalent among this patient group. Other co-morbidities were relatively rare among persons undergoing revascularization except depression, asthma and COPD especially among women.

Figure 2 presents trends in age-standardized rates of the outcome indicators studied per 1000 patients undergoing their first revascularization. The rate for MACE within 29 days was 41% among men and 35% among women in the 1998 cohort. The rates decreased steadily throughout the study period among both genders and the respective rates were 30 and 28% in the 2009 cohort. The rates for subsequent revascularizations increased slightly among men from 9% in the 1998 cohort to 12% in the 2009 cohort and decreased slightly among women from 14 to 12%. MACE 30–365 days after the initial revascularization remained relatively stable among men being 12% in the 1998 cohort and 11% in the 2009 cohort, among women the rates were 19 and 12%. MI death rates during 1 year remained stable at c.a. 2% among both genders.

Controlling for age, co-morbidities, year, previous MI and disease severity before the operation a stepwise gradient of lowering hazard ratio (HR) with increasing income was found in MACE incidence within 29 days among both genders (table 2). In MACE incidence
countries, we found a systematic socioeconomic gradient in adverse outcomes after first coronary revascularization in 1998–2009 among men and women in Finland (Cox regression models controlling for age, prior MI, year, co-morbidities and disease severity). Table 2

<table>
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<tr>
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*MACE, major adverse cardiac event; **CHD, coronary heart disease.

30 days after the operation or later, a similar but less prominent gradient was found among men; among women no differences were found between income quintiles. In CHD mortality, the aforementioned inverse income gradient was most pronounced of the outcomes studied: the lowest income quintile had more than 1.7-fold mortality risk compared with the highest among both genders. In subsequent revascularizations, no income group differences were found among either gender. No statistically significant interactions were found between study year and income suggesting that while adverse outcomes diminished during the study period, all income group differences found remained stable throughout the study period.

Although disease severity (NYHA measured prior to the operation) was highly significant in explaining adverse outcomes and adjusting for it decreased the income group differences slightly, it did not abolish the differences.

Discussion

Principle findings

We found socioeconomic patterning in revascularization operations throughout the study period: the lower the income group the higher the operation rate. The only exception from this pattern was the lowest revascularization rate in the lowest income group among men in the late 1990s. Earlier research both from Finland8,19 and elsewhere18,27 suggests that persons with lower socioeconomic position have poorer access to revascularization operations. From the 1990s up to 2005, revascularization rates increased rapidly in Finland, which seem to have benefited especially the lower income groups. The development is consistent with results suggesting that both CHD prevalence31 and coronary mortality9 are higher in lower socioeconomic groups. However, earlier research has also reported increasing coronary mortality differences between socioeconomic groups5 and an earlier study from Finland32 suggests that if need is approximated with CHD incidence or coronary mortality, the distribution of revascularizations is still pro-rich.

In line with earlier studies, which have reported higher risk of low health related quality of life, readmission, MI, MACE and death among patients with lower socioeconomic position after revascularization operation and cardiac surgery24–28 in different countries, we found a systematic socioeconomic gradient in outcomes of coronary revascularization. In our study, this was true for MACEs both within 30 days and after that and in coronary mortality. Further, these differences were not explained by age differences, differences in co-morbidity or disease severity. Our study adds to the literature by examining a 13 year time trend in outcomes of coronary revascularizations in a country with a health care system operating on universal access. There are several potential explanations for the differences found in the current study.

One of the reasons behind socioeconomic differences found in the current study is likely to be socioeconomic differences in risk factors. Studies from Finland31,33 and elsewhere34,35 have reported higher risk factor levels among persons with lower socioeconomic position in, e.g. food habits, smoking, blood cholesterol and diabetes incidence. Additionally, there may be socioeconomic differences in adherence to secondary prevention of adverse outcomes.36

Socioeconomic differences might partly be explained by possible barriers in access to health care and to further examinations and care among lower income group patients due to the three tier organization of ambulatory care in Finland including municipal health centres, occupational health care and private ambulatory care partly refunded by the National Health Insurance.37 Access to services is strongly influenced by income and employment status. Municipal health centres are the only channel open to all residents, and while patients’ co-payments are typically relatively low, there have still been problems in access.38 This may in turn lead to delays in diagnosis and poorer continuity of care as well as delays in access to specialist care. Visits to the doctor have consistently been shown to be distributed in favour of those with higher incomes in Finland when need for services is taken into account.39 This has especially been the case in occupational health care and in private ambulatory services.

In contrast to an earlier study from Israel25, no income group differences were found in subsequent revascularizations. There may be several reasons behind this finding. Because coronary mortality after revascularization is higher among lower income groups, some of these patients may have died shortly after the first operation. It is also possible that higher risk factor levels and poorer health behaviours among low income patients, as suggested by studies concerning the population,31,33–35 or poorer adherence to secondary prevention after the operation36 have an effect on their eligibility to further operations. Additionally, patients from lower
income groups are older during the time of the initial operation and may thus not be eligible to subsequent operations. Unfortunately, our register data did not enable us to further elaborate these factors. Further research is needed to disentangle the possible mechanisms behind this finding.

Reasons behind our finding that persons from lower income groups come to be operated at an older age compared with higher income groups are not entirely clear. We performed additional analyses using education and occupational social class as indicators of socioeconomic status, since they are typically acquired at a younger age and neither is affected by, e.g., retirement or ill-health. We found a similar difference in the operation age between those with basic education only compared with other educational groups, and a small difference between blue-collar workers and white-collar groups especially among women and among farmers. However, the differences were smaller than those by income suggesting that a large part of the age difference in operations is due to differential age-structure of high and low income quintiles.

Methodological considerations
It is a major strength of our study that we were able to use individual-level register data on hospital use among all Finnish residents aged 45 to 84 years from a 13-year period. The accuracy and coverage of the Hospital Discharge Register has been reported to be generally good. We were also able to use individually linked income data derived from the registers of the tax administration, which form the base of censuses. Furthermore, we used family income instead of individual income, which is likely to yield more robust results, since family income is less influenced by income loss due to ill health and is therefore less sensitive to reverse causation. Additionally, we used prescription register data of reimbursed medicine costs and of special reimbursement right for medicine costs for specific disease as indicators of co-morbidities. Because they are based on actual reimbursements, neither is likely to have large numbers of missing data or false positive cases. In addition to reimbursement data, we used codes of additional diagnoses in the Hospital Discharge Register to build our indicator of co-morbidities. The codes may be vulnerable to differential reporting in different hospitals or over time. However, this should not bias our results on socioeconomic differences since reporting is not likely to vary according to socioeconomic position of the patients. A weakness of the Hospital Discharge Register is that it does not register detailed information on the patient’s clinical status or treatment beyond diagnosis and procedure codes. We were, however, able to examine the effect of disease severity on differences in outcomes using the NYHA classification concerning chest pain available in the Hospital Discharge Register for cardiac patients. We used imputed NYHA values in the analyses. Although the imputed values produced slightly different values of hazards ratios, it did not alter any of the substantive results or conclusions suggesting that missing values did not introduce systematic bias to the results.

Conclusions
Although coronary revascularization rates are higher in lower socioeconomic groups in line with their higher CHD incidence as suggested by their higher coronary mortality, more attention should be paid in health care to prevention of adverse outcomes among persons with low socioeconomic position undergoing revascularization. Further research is needed on the pathways to coronary revascularization among groups with lower socioeconomic position and their possible effect on differences in outcomes of care in order to ensure equal access to invasive care among vulnerable patient groups.

Acknowledgements
Results of the study have been presented in the EPH Congress, in Glasgow 20–22 November 2014 (poster presentation) and in the annual meeting of the Finnish Society of Social Medicine, in Helsinki 3–4 November 2014 (oral presentation).

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Conflicts of interest: K.M. has received funding from the Academy of Finland for the study, but the Academy had no involvement in its design, data collection, findings or decision to publish; I.K. has been asked to advise the Finnish Ministry of Health and Social Affairs from time to time on matters relating to health policy and services; regardless of the findings of this study, the outputs of this research would form part of that advice; and the other two authors do not have anything to declare.

Key points
- Earlier studies have reported socioeconomic differences in CHD incidence and mortality.
- Socioeconomic differences favouring the better-off have also been reported in medicine use to prevent adverse cardiac events and in access to investigations and to invasive treatment among patients with CHD, but less is known about potential differences in the outcomes of coronary care or trends in them.
- We found a systematic inverse gradient in MACEs and coronary mortality after first revascularization operation by income, not explained by age differences, differences in co-morbidity or disease severity.
- Although poor outcomes of coronary revascularizations decreased, the socioeconomic gradient in them persisted throughout the study period.
- In health care, special attention should be paid to prevention of adverse outcomes among persons with low socioeconomic position undergoing revascularization in order to increase equity.

References
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