Social and Health Systems Research Unit
Department of Health and Social Care Systems
National Institute for Health and Welfare
Helsinki, Finland

Doctoral Programme in Population Health
Department of Public Health
University of Helsinki, Finland

DEVELOPING METHODOLOGY OF MEASURING SOCIOECONOMIC EQUITY IN HEALTH CARE USING REGISTER DATA

Sonja Lumme

ACADEMIC DISSERTATION

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Supervisors
Ilmo Keskimäki, MD, PhD, docent, research professor
Social and Health Systems Research Unit, National Institute for Health and Welfare, Helsinki, Finland
School of Health Sciences, University of Tampere, Finland

Alastair Leyland, PhD, professor
MRC/CSO Social and Public Health Sciences Unit, University of Glasgow, UK

Reviewers
Ragnar Westerling, MD, PhD, docent, professor
Department of Public Health and Caring Sciences, Uppsala University, Sweden

Janne Pitkäniemi, PhD, docent
Finnish Cancer Registry, Helsinki, Finland
Department of Public Health, University of Helsinki, Finland

Opponent
Gert Westert, PhD, professor
Scientific Institute for Quality of Healthcare, Radboud University Medical Centre, Nijmegen, The Netherlands

In memory of my father

ABSTRACT

In most countries, the health care system aims to achieve equity as one of its primary goals. However, evident and persistent inequities in health care exist despite the improvement in the overall level of morbidity, health care performance and technology.

This thesis develops statistical methods to evaluate equity in health care using register data. Previous methodological studies on equity have mainly concentrated on survey data and examined health and health economics outcomes. Besides contributing to the methodology of measuring equity, this thesis provides information on socioeconomic equity in health care in Finland between 1992 and 2010 from several viewpoints.

Studying health care requires comprehensive datasets, while survey data cannot always provide the necessary information to evaluate equity in health care due to lack of suitable indicators or non-representative indicators of socioeconomic position and the need for care. Register data have been recognised as having powerful and cost-effective potential for research and offer a good opportunity to study equity. Using register data, socioeconomic equity in both hospital services and primary health care can be studied.

This thesis utilised two outcomes in health care – the use of coronary revascularisations and mortality amenable to health care interventions – as empirical examples of the use of individual-level register data to evaluate equity in health care. Coronary revascularisation is a common invasive procedure and provides a good indication of health care system performance. Amenable mortality refers to causes of death that should be avoided in the presence of timely and effective health care interventions. It serves as an indirect measure of performance and the quality of health care. Data on revascularisations were obtained from the Finnish Care Register for Health Care and data on amenable deaths from the National Causes of Death statistics. These datasets were individually linked to population registers maintained by Statistics Finland to obtain sociodemographic data.

This thesis developed a method to compare regional differences in socioeconomic equity in health care. This method takes dependence of observations within regions into account and its advantage is in overcoming problems associated with random error in small regions. Additionally, it takes into account the effect of variation in the population size by age and socioeconomic position in regions, in addition to different needs for health care.

The existing methods measuring absolute differences do not provide solutions for evaluating absolute inequity in health care while taking the need for care into account. This thesis proposes a non-numerical approach to evaluating absolute horizontal socioeconomic equity in health care.

Moreover, thesis developed methods to assess uncertainty in the inequity indices when using register data. Evaluation of the uncertainty of the equity measures ensures that comparisons at different levels (between hospitals, areas, countries, in time) are meaningful. The results showed that standard methods estimate uncertainty in the inequity indices too conservatively for register data.

Finally, this thesis introduces an improved approach to studying socioeconomic equity in the effectiveness of health care using register data. The approach uses amenable mortality as an indicator of health care performance and allows for an analysis of time trends in equity while utilising the whole socioeconomic distribution. Causes of deaths are assigned to categories according to the time and site of the interventions, which allows the indicative estimation of the effect of different sectors of health care systems on inequity in deaths that should have been avoided by effective and timely medical interventions.

This study detected marked and persistent relative horizontal inequity in the use of revascularisations favouring the better-off among both genders in the period 1995–2010 in Finland. Contrary to earlier research, this study found no decrease in relative inequity despite the increasing supply of revascularisations during the study years. The results suggest that absolute horizontal inequity decreased although this cannot be quantified numerically. However, differences in inequity between regions were minor in 2001–2003, especially among men.

The results of this study indicate that socioeconomic inequities in relative terms in deaths amenable to health care were marked and increased between 1992 and 2008 in Finland. Inequity was greater in deaths amenable to specialised health care, but the influence of primary health care on widening inequities was more substantial. In absolute terms, major socioeconomic inequity in amenable mortality remained throughout the study years.

These results suggest that socioeconomic disparities in either access to or quality of health care in Finland did not diminish. The results of this thesis should prompt a serious consideration of actions to improve equity in health care in Finland.

Keywords: socioeconomic equity, health care, register data, statistical methods, inequity index, coronary revascularisations, amenable mortality

TIIVISTELMÄ

Useimmissa maissa terveydenhuoltojärjestelmän keskeisimpiä tavoitteita on terveyspalveluiden oikeudenmukainen jakautuminen väestöryhmien välillä. Viime vuosikymmeninä väestön yleinen terveydentila on huomattavasti parantunut, ja terveydenhuollon toimintakyky ja teknologia on kehittynyt, mutta silti terveydenhuollon palvelut jakaantuvat sosiaalisen aseman mukaan epäoikeudenmukaisesti.

Tämän väitöskirjan yleisenä tavoitteena on kehittää tilastollisia menetelmiä terveydenhuollon sosioekonomisen oikeudenmukaisuuden arvioimiseksi rekisteriaineistoja hyödyntäen. Aiempi menetelmällinen oikeudenmukaisuustutkimus on pääasiassa keskittynyt otanta-aineistoihin ja on lisäksi tarkastellut oikeudenmukaisuutta terveyden tai terveystaloustieteen lopputuloksien näkökulmasta. Oikeudenmukaisuuden mittaamisen menetelmien kehittämisen lisäksi työn osatutkimukset kertovat terveydenhuollon oikeudenmukaisuuden tilasta vuosien 1992 ja 2010 välillä Suomessa monesta eri näkökulmasta.

Terveydenhuollon tutkimus edellyttää kattavia aineistoja eivätkä otanta-aineistot useimmiten sisällä tarvittavia tai riittävän edustavia tietoja sosioekonomisesta asemasta tai hoidon tarpeesta palveluiden käytön oikeudenmukaisuuden arviointia varten. Rekisteriaineistojen käyttö tieteellisen tutkimuksen informaatiolähteenä tarjoaa hyvät lähtökohdat oikeudenmukaisuuden tarkasteluun ja niiden käyttö on lisäksi kustannustehokasta. Rekisteriaineistojen avulla voidaan tutkia sosioekonomista oikeudenmukaisuutta sekä sairaalapalvelujen että perusterveydenhuollon palveluiden käytössä.

Tutkimuksessa käytettiin sepelvaltimotautitoimenpiteitä ja terveydenhuollon keinoin vältettävissä olevia kuolemia empiirisinä esimerkkeinä terveydenhuollon oikeudenmukaisuuden arvioimisessa kun hyödynnetään yksilötason rekisteriaineistoja. Sepelvaltimotaudin kajoavat hoitomuodot ovat yleisiä toimenpiteitä ja niiden käytön jakaumat tarjoavat hyvän esimerkin terveydenhuoltojärjestelmän toiminnasta. Vältettävissä olevilla kuolemilla tarkoitetaan kuolemia, joita ei pitäisi tapahtua, jos terveyspalvelut ovat vaikuttavia ja oikea-aikaisia. Vältettävissä olevien kuolemien avulla voidaan epäsuorasti mitata terveydenhuollon toimintaa ja laatua.

Tiedot sepelvaltimotautitoimenpiteistä saatiin terveydenhuollon hoitoilmoitusrekisteristä ja tiedot vältettävissä olevista kuolemista kuolemansyyrekisteristä. Nämä aineistot yhdistettiin henkilötunnuksien avulla Tilastokeskuksen rekistereihin, joista saatiin henkilöiden sosiodemografiset tiedot.

Tutkimuksessa kehitettiin menetelmä, jonka avulla voidaan vertailla alueellisia eroja sosioekonomisessa oikeudenmukaisuudessa

terveydenhuollossa. Alueiden välisten riippuvuuksien lisäksi metodi ottaa huomioon iän, sosioekonomisen aseman ja alueiden mukaan vaihtelevat hoidon tarpeet ja väestöryhmien koot. Menetelmän etuna on välttyä pienten alueiden satunnaisvaihtelun aiheuttamilta ongelmilta.

Tutkimuksessa esitellään ei-numeerinen lähestymistapa absoluuttisen horisontaalisen (hoidon tarpeen huomioivan) sosioekonomisen oikeudenmukaisuuden arvioimiseksi, sillä tähän asti käytössä olleet menetelmät eivät ole tarjonneet ratkaisua absoluuttisen horisontaalisen eriarvoisuuden arvioimiseen terveydenhuoltopalveluiden käytössä.

Tutkimuksessa kehitettiin tilastollisia menetelmiä oikeudenmukaisuusindeksien epävarmuuden estimoimiseksi kun aineistona käytetään rekistereitä. Oikeudenmukaisuusindeksien epävarmuuden arvioiminen takaa, että tulosvertailut ovat mielekkäitä muun muassa sairaaloiden, alueiden ja maiden välillä tai eri ajanjaksoilla. Tutkimus osoitti, että perinteiset menetelmät eriarvoisuuden epävarmuuden estimoinnissa antavat liian konservatiivisia tuloksia rekisteriaineistolle.

Lisäksi tutkimuksessa esitetään tapa mitata rekisteriaineistolla sosioekonomista oikeudenmukaisuutta terveydenhuollon toiminnan tehokkuudessa. Tämä lähestymistapa käyttää vältettävissä olevia kuolemia terveydenhuollon toiminnan indikaattorina ja sen avulla voidaan tutkia sosioekonomisen oikeudenmukaisuuden muutoksia ajassa hyödyntäen sosioekonomista jakaumaa yksityiskohtaisesti. Kuolemansyyt on jaoteltu ryhmiin interventioiden ajankohdan ja paikan mukaan. Ryhmittelyn avulla pystytään arvioimaan terveydenhuollon eri sektoreiden vaikutukset epäoikeudenmukaisuuteen kuolemissa, jotka pitäisi pystyä estämään oikea-aikaisilla ja tehokkailla terveydenhuollon interventioilla.

Terveydenhuollon oikeudenmukaisuutta tutkittaessa havaittiin huomattavaa, jatkuvaa ja hyvätuloisia suosivaa suhteellista horisontaalista epäoikeudenmukaisuutta sepelvaltimotautitoimenpiteissä vuosina 1995–2010 Suomessa. Aiempien tutkimusten tuloksista poiketen suhteellinen epäoikeudenmukaisuus ei vähentynyt huolimatta sepelvaltimotautitoimenpiteiden tarjonnan merkittävästä kasvusta. Tulokset osoittavat kuitenkin, että absoluuttinen horisontaalinen epäoikeudenmukaisuus väheni, vaikka sitä ei pystytä numeerisesti määrittämään. Alueiden väliset erot epäoikeudenmukaisuudessa olivat vähäisiä vuosina 2001–2003, erityisesti miehillä. Myös vältettävissä olevissa kuolemissa todettiin huomattavaa hyvätuloisia suosivaa suhteellista epäoikeudenmukaisuutta, joka kasvoi vuosien 1992 ja 2008 välillä. Epäoikeudenmukaisuus oli suurempaa erikoissairaanhoidon keinoin vältettävissä olevissa kuolemissa, mutta perusterveydenhuollon vaikutus kasvaviin eroihin oli suurempi. Absoluuttisesti arvioituna sosioekonominen epäoikeudenmukaisuus säilyi merkittävänä.

Väitöskirjan tutkimusten tulokset viittaavat siihen, että sosioekonomiset erot terveydenhuollon laadussa ja hoitoon pääsyssä ovat Suomessa säilyneet. Oikeudenmukaisuuden parantamiseksi tulisi ryhtyä toimiin, joiden avulla

voidaan turvata sosiaalisesti huonomassa asemassa olevien tarpeenmukainen hoito.

Avainsanat: sosioekonominen oikeudenmukaisuus, terveydenhuolto, rekisteriaineisto, tilastolliset menetelmät, oikeudenmukaisuusindeksi, sepelvaltimotautitoimenpiteet, vältettävissä oleva kuolleisuus

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Lumme S, Leyland AH, Keskimäki I. Multilevel Modeling of Regional Variation in Equity in Health Care. Medical Care 2008; 46(9): 976-983. doi: 10.1097/MLR.0b013e3181791970. Wolters Kluwer Health Lippincott Williams & Wilkins©

II Lumme S, Manderbacka K, Keskimäki I. Trends of relative and absolute socioeconomic equity in access to coronary revascularisations in 1995–2010 in Finland: a register study. International Journal for Equity in Health 2017; 16:37. doi: 10.1186/s12939-017-0536-8.

III Lumme S, Sund R, Leyland AH, Keskimäki I. A Monte Carlo method to estimate the confidence intervals for the concentration index using aggregated register data. Health Services and Outcomes Research Methodology 2015; 15: 82-98. doi: 10.1007/s10742-015-0137-1.

IV Lumme S, Sund R, Leyland AH, Keskimäki I. Socioeconomic equity in amenable mortality in Finland 1992–2008. Social Science & Medicine 2012; 75(5): 905-913. doi: 10.1016/j.socscimed.2012.04.007.

The publications are referred to in the text by their roman numerals and are reprinted with the permission of the publishers.

ABBREVIATIONS

AC	Absolute concentration index
AMI	Acute myocardial infarction
AP	Unstable angina pectoris
C	Concentration index
CI	Confidence interval
CABG	Coronary artery bypass grafting
CRHC	Care Register for Health Care
CSDH	Commission on Social Determinants of Health
HII	Horizontal inequity index
ICD	International Classification of Diseases
ID	Index of dissimilarity
IHD	Ischaemic heart disease
L(s)	Concentration curve
OECD	Organisation for Economic Co-operation and Development
PCI	Percutaneous coronary intervention
PHC	Primary health care
RD	Redistribution measure
RII	Relative index of inequality
SE	Standard error
SEG	Socioeconomic group
SHC	Specialised health care
SII	Slope index of inequality
SIIF	Social Insurance Institution of Finland
STAKES	National Research and Development Centre for Welfare and Health
THL	National Institute for Health and Welfare
WHO	World Health Organization

d	number of cases
f	population share
p	population size
r	correlation coefficient
R	relative rank
w	weight

1 INTRODUCTION

Inequity in health care is defined as systematic disparities that are avoidable, unfair, and unnecessary (Whitehead, 1992; Braveman and Gruskin, 2003). Apart from efficiency and effectiveness, equity is, and has long been, an important value and goal in health policy worldwide (Musgrove, 1986). Equity in health care has been seen as a human right and also as an opportunity: the question of whether or not the opportunity is used is not relevant to equity defined in terms of access to care (Le Grand, 1987; Patrick and Erickson, 1993).

Socioeconomic inequities in health care are the outcome of a wide-ranging and complicated network of different factors. These factors function at several levels and are also connected to each other. Some variations in the use of health care between population groups are justified in terms of patient preference or underlying conditions, whilst others are not.

Studies all over the world show that despite the type of social or political system in a country, inequities in health care exist between groups with different levels of underlying social advantage, such as wealth, prestige, and education (Costa-Font and Hernández-Quevedo, 2012). People from lower socioeconomic groups suffer higher rates of morbidity and mortality (Kunst, 2007; Miething, 2013). Despite their greater morbidity, however, they use less health care in relation to need (van Doorslaer et al., 2006). The relationship between socioeconomic position and the use of health care is not unequivocal; the direction of inequity in the use of primary health care tends to vary between countries (van Doorslaer et al., 2006), while evidence of inequity in the use of specialised health care is mainly pro-rich (Devaux and de Looper, 2012; van Doorslaer et al., 2000; Manderbacka et al., 2009).

The overall level of quality of health care has improved widely. However, this development has not prevented socioeconomic inequity from increasing. The economic crisis in the 1990s worsened the situation in many countries and health care inequities have continued to widen (Mackenbach et al., 2003).

Evidence of regional differences in the allocation of health care resources is also indisputable (Horev et al., 2004). Especially the supply of specialised care cannot be allocated entirely equally across regions in some countries due to geographical circumstances (Oliver and Mossialos, 2004). Thus, regional differences in the use of specialised health care also originate from the varying distances from medical services to some extent. Despite the extensive research on regional differences in health care, there are few studies on differences in socioeconomic equity in health care between regions within a country.

Anderson et al. (2005) claim that health care interventions may have the same relative effect on mortality in different socioeconomic groups if there is good access to health services for the disadvantaged, and hence health care does have an important role in reducing inequities. Nolte and McKee (2004) found evidence supporting the alternative view that health services can contribute to the reduction of health inequities.

Information on the state of inequity from different perspectives is important and has major health policy consequences (Macinko and Starfield, 2002). Equity in health care has, in fact, become an increasingly popular research topic since the early 1990s and has benefited from the contributions of diversified perspectives of experts from several study fields. The obvious purpose of measuring socioeconomic equity in health care is to describe the distribution of health services between socioeconomic groups in order to inform policy makers of changes over time, differences between regions and countries, and to monitor whether certain policy actions or targets have been reached. Trend data provide a pointer for the future and can be used to set priorities and allocate health care resources.

Thus, good methods for the analysis of equity in health care are of major importance. Williams and Doessel (2006) claim, however, that inequity measurement lacks clarity. The definition of inequity, for example, is complex. Access to health care and need for care can be interpreted and valued very differently, depending on subjective judgements, adaptations to disease, and to the extent of reference bias due to both individual and cultural factors (Crossley and Kennedy, 2002; Groot, 2000; Jürges, 2007; Lindeboom and van Doorslaer, 2004; Mooney, 2000). There are also properties of equity measures that need to be evaluated properly.

So far, the majority of the existing research on equity in health care is based on probability and inference theory, due to the dominance of survey data as the source of the data (Wallgren and Wallgren, 2011). However, these sampling theories and methods cannot be directly applied to register studies since register data often covers nearly all members of the study population, whereas survey data covers a subset of the population, and thus the statistical variation and uncertainty of the measures are different. Administrative register data also enables the studying of equity in health care. However, good quality individual-level register data – including information on socioeconomic position – have been available only in a few countries, such as the Nordic countries. Presumably, the utilisation of individual-level register data will increase considerably in other countries due to improvements in information systems and changes in data privacy regulations. Finnish register data offer good possibilities to carry out research on equity in health care, since the personal identification code system allows researchers to link administrative data from several databases reliably and easily.

Multidimensional measures are practical, since they allow the simultaneous study of equity from aspects other than socioeconomic distribution. Other dimensions, such as time and regions, are often useful to include in the examination. The concentration index is a quantitative measure for the degree of equity and it has all the minimal requirements that have been pointed out for a good inequity measure (Wagstaff et al., 1991). It is widely used to measure the degree of socioeconomic inequity in health care. So far, methods to study equity using the concentration index have focused on survey data.

The main goals of this thesis are:

1) To develop methodology, including a new measure, to evaluate socioeconomic equity in health care using register data. These methods include several aspects that are important in evaluating equity, such as measuring regional differences and trends in equity, differences in effectiveness, measuring absolute and relative differences, and evaluating the uncertainty of equity measures.

2) To offer information on socioeconomic equity in health care in Finland covering several decades. However, the focus of this thesis is not to investigate the underlying causes of inequity but merely to develop methods to measure and recognise these inequities.

This study exemplifies how comprehensive Finnish register data from several sources can be utilised in measuring equity using inequity indices, mainly the concentration index, as a measure of equity. Two examples of outcomes in health care, the use of coronary revascularisations and mortality amenable to health care interventions are used. Coronary revascularisation is a common invasive procedure and provides a rather good indication of health care performance. Amenable mortality, on the other hand, represents an alternative measure of quality of health care (Nolte and McKee, 2004), that is an indirect measure of performance and quality of health care. Earlier studies have demonstrated clear socioeconomic differences in rates of coronary revascularisations (e.g. Haglund et al., 2004; Hetemaa et al., 2003; Hetemaa et al., 2006; Keskimäki et al., 1997; Vehko et al., 2010) and amenable mortality (e.g. Marshall et al., 1993; Poikolainen and Eskola, 1995; Schwarz and Pamuk, 2008; Stirbu et al., 2010; Tobias and Yeh, 2009; Westerling et al., 1996) and thus they are good examples of health care outcomes.

2 SOCIOECONOMIC EQUITY IN HEALTH CARE

2.1 EQUITY

Equity is an ethical concept denoting social justice or fairness (Beauchamp and Childress, 1994; Rawls, 1985). In practice, and most commonly, inequity refers specifically to disparities between population groups categorized a priori according to particular features of their underlying social position of substance (Braveman, 2003). Systematic, unnecessary, unfair, and conceivably remediable differences between population subgroups defined according to social class, education, occupation, area of residence, race, religion, gender, wealth, power, or ability to function are considered inequities (Whitehead and Dahlgren, 2007). These differences remain virtually static regardless of the individuals in the groups changing over time.

Defining equity involves normative judgements of justice or fairness (Whitehead, 1991). Thus, the definition of equity is much more complex than the definition of equality. Equality is a broader concept and used generally to describe differences between individuals, for example, in regard to human rights or health (Starfield, 2011). It is also agreed that equity indicates equality. Equality is more like a comparison without a normative evaluation (Harper et al., 2010). It is stated that equity is the means and equality is the intended outcome. Since individuals have different needs, similar health care is not needed by all and therefore differences in the allocation of health care resources can rather be seen as a question of equity. Culyer and Wagstaff (1993) suggest that equality of health should be the dominant principle, while equity in health care aims to achieve this principle.

EQUITY THEORIES

Philosophical discussion of the ethical dimensions of justice originates from the time of Aristotle and Plato. Their discussion about the complex theory of distributive justice – how society should allocate its scarce resources among individuals with competing claims and needs – has been ongoing ever since. Distributive justice makes a formal premise for the consideration of equity in health care, and underpins the literature on equity in this field. Aristotle suggests that by nature people are unequal. Aristotle's formal theory of distributive justice distinguishes two types of equity: horizontal and vertical equity. Equity in health care is commonly defined as equal availability of treatment for people in equal need of health care irrespective of their socioeconomic status, place of residence or other demographic characteristics, emphasizing horizontal equity (Culyer, 2003; Culyer and Wagstaff, 1993; Keskimäki, 1997; Mooney, 1983). Vertical equity, on the other hand, requires that health care resources are appropriately allocated in a different way for people with unequal needs (Cuyler, 2001). Mooney (2000) calls this as a theory of positive discrimination. Vertical and horizontal equity have dramatically different policy implications and cannot be applied to certain questions without proper justification (Bambas and Casas, 2001). Vertical equity is studied much less than horizontal equity, since using it as a principle requires strong appraisals of the way the use of resources should vary between individuals with unequal needs (van Doorslaer et al., 1992; Mooney, 1996; Wagstaff et al., 1991). Defining the appropriate way in which health care resources should be allocated between the individuals with different needs for care is one of the main challenges of measuring vertical equity. In practice, however, studying horizontal equity requires that the assumption of vertical equity is true (O'Donnell et al., 2008), despite this assumption not usually being verified. This thesis focuses on horizontal equity.

In 1971, liberal egalitarian John Rawls published his Theory of Justice, which is one of the most famous theories adapted to health care in modern times (Rawls, 1971). He invokes the idea of an original moral equality between individuals, meaning that deliberate inequalities are unfair unless the privileged try to improve the circumstances of the underprivileged. Rawlsian theory, as well as Marxism, emphasizes a distribution of resources according to need. Rawls' theory has also features from egalitarian conceptions of distributive justice demanding equal opportunities, treatment and resources for everyone and stating that equality itself is the highest justice. Though being partly based on Rawlsian theory in defining equity, this study assumes that neither the social position of an individual nor human attributes are randomly distributed within a society.

Liberalism ensures individuals' rights and opportunities, and sees access to health care as 'part of society's reward system', whereas utilitarianism (also called the welfare approach) aims at maximizing the sum of individual utilities, basing political decisions on consequences. Policy makers in Europe have a viewpoint that is more egalitarian than libertarian. For example, the World Health Organization (WHO) has used egalitarian views in defining goals for equity in health care. Also, several highly quoted researches in health care have had egalitarian approaches (van Doorslaer et al., 1992).

Communitarianism stresses the connection between the individual and the community. It emphasises that individuals who are well-integrated into communities are better able to reason and act in responsible ways than isolated individuals and criticizes liberals' view on underlining individuals' rights (Black and Mooney, 2002).

2.2 THE FRAMEWORK OF SOCIOECONOMIC EQUITY IN HEALTH CARE

Neither theories of equity nor their variations provide any practical interpretation of the equitable distribution of health care. The principles of equity need to be defined unambiguously, since they are dependent on the ethical values of the society as a whole. Equity is a normative concept; hence it cannot be directly measured in health care (Braveman, 2003). In order to gain appropriate information on disparities, an explicit agreement of the definition of equity is required. Additionally, there needs to be consensus about how and on what basis resources are allocated to different groups of people. Moreover, equity is not operational without a proper definition of the concept of the need for care, which is a difficult task that has led to many interpretations (Culyer, 1995; Culyer and Wagstaff, 1993).

Equity can be evaluated from different aspects of health care, for example, access to health care and use of health care (Culyer and Wagstaff, 1993; Whitehead, 1990; Williams, 2005). These are difficult concepts to define and measure exactly, since they can be interpreted and valued very differently, depending on subjective judgement, adaptation to disease, and the scale of the reference bias due to both individual and cultural factors (Crossley and Kennedy, 2002; Groot, 2000; Jürges, 2007; Lindeboom and van Doorslaer, 2004; Mooney, 2000).

Access to health care

Le Grand (1982) and Mooney (1983) suggest that access to care refers to the opportunities open to individuals. The question of whether or not the opportunity is used is not relevant to equity defined in terms of access. Equity of access to health care is thus a question of supply; patients with equal need have the same opportunity to use available services. Inequities in access arise if health care resources are unevenly distributed throughout the country, or there are financial or organizational obstacles, such as long waiting times and language barriers, restricting access in practice. Generally, access to care has been approximated by the use of care, since access can rarely be measured directly (Allin et al., 2007; Goddard and Smith, 2001; Menzel, 1993).

Use of health care

The use of health care, on the other hand, is dependent on existing opportunities and if a person has benefited from them or not. It is a question of both supply and demand. Use of care is usually easier to observe than access to care, but when interpreting the results, several issues must be taken into consideration. The use of health care omits those patients who would have had access to care but did not exploit their right, either by ignorance or knowingly. There are barriers to the use of care that are related to the patient and to the health care system. A patient might not have the capacity to use health care due to economic or social disadvantage, or morbidity. Patients' ability to seek care may also be influenced by the lack of information or knowledge, cultural beliefs, or communication barriers between the patient and health care practitioners. Barriers to the health care system exist if the supply of services is inadequate. For example, in Finland the three-tiered health care system in outpatient services in part induces barriers. There are marked differences between public health care, private health care and occupational health care systems. People entitled to occupational health care or people who can afford private services might have, for example, a broader scope of provided services and have shorter waiting times (Vuorenkoski et al., 2008). Referral practices in primary health care may also impact on specialised health care.

Need for health care

Bradshaw (1972) proposes four dimensions of need: 1) normative need; 2) felt need; 3) expressed need; and 4) comparative need. Of these definitions, comparative need is the most used in studying equity in health care (Oliver and Mossialos, 2004). In the sense of comparative need, there is no generally accepted definition of need for care, although several population characteristics for those receiving a service are commonly used as a proxy for need due to relative ease of measurement, such as ill-health, mortality, age, gender, and socioeconomic position. Earlier studies have shown that different measures of need for care might induce varying interpretations of equity (Morris et al., 2005). Thus, a careful consideration of the indicator of need is crucial when evaluating equity.

There is indisputable evidence of varying needs for care by socioeconomic position; the lower the socioeconomic position, the higher the morbidity is. Despite the greater need for care among people with a lower socioeconomic position, they do not always receive care according to need relative to people with a higher socioeconomic position. This inequity exists almost everywhere regardless of the cultural environment, region, health care system, or type of disease (Whitehead, 1991).

Socioeconomic position

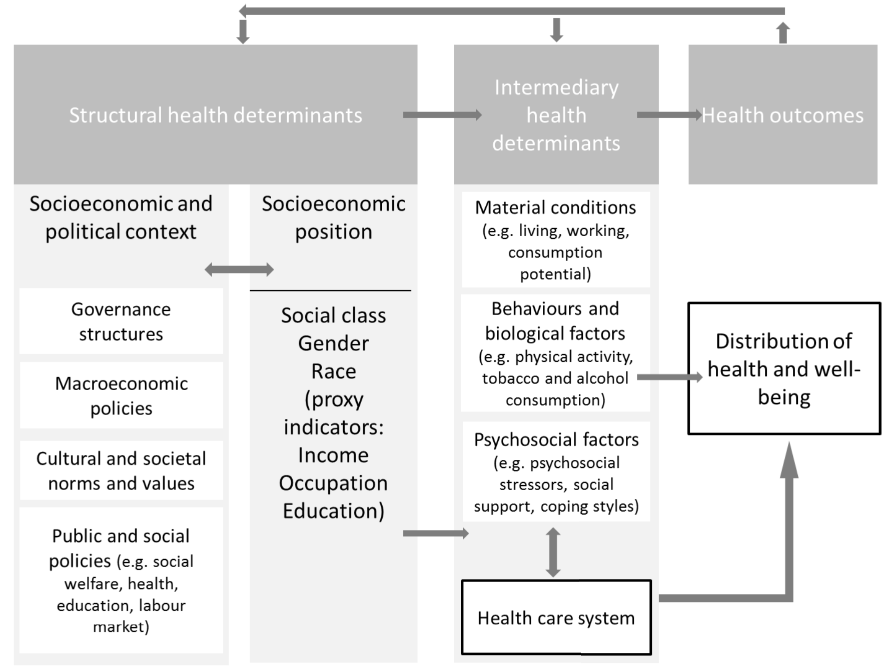
Socioeconomic position is a strong underlying factor in explaining health care inequities (Black, 1980). The measure of social grouping that is associated with different levels of social advantage or disadvantage must be defined meaningfully. It is, however, a complex concept to operationalize. It reflects several positions of an individual in his or her social structure from different dimensions and refers to the obtainable level of power, wealth, and resources of an individual (Mausner et al., 1985). These factors are, for example, education, occupation, income, area of residence, and living conditions, of which income, education, and occupation are the most used indicators of socioeconomic position in equity studies. Measurement of socioeconomic position is problematic, since an individual's standing may change rapidly. In addition, the relationship between different positions can be divergent. Overall, these measures are conceptually related to each other and overlapping, but are different dimensions of socioeconomic positions. They have parallel connections within equity in health care, but observed correlations between socioeconomic measures have been only modest (Geyer et al., 2006; Winkleby et al., 1992). Importantly, the choice of a socioeconomic measure can even have a significant impact on the measured inequities (Lindelow, 2006).

Socioeconomic position can be measured as the position of a family (e.g. income, parental education), individual (income, education, occupation, house ownership) or area in a social structure (indices based on an array of social characteristics of residential areas or an aggregate income). Individual and family measures are considered more appropriate indicators than area-based measures in some studies, since area-based indicators tend to underestimate the effect measure (Cesaroni et al., 2003; Krieger, 1992). Area measures make it difficult to separate the health effects of an individual's socioeconomic position from the effects of the wider neighbourhood since the neighbourhood characteristics used as an area measure might modify the risk associated with an individual's risk factors.

Education reflects mainly cognitive resources and knowledge but it is also connected to social status in society and position in the labour market. Occupation mirrors physical and mental working conditions (e.g. noise, pollution, work stress, autonomy in management of work) in addition to social status and prestige. From the individual measures, income is most directly associated with material resources and wealth and perhaps the most effective single proxy for overall level of disadvantage (Duncan et al., 2002). Both education and income may have an influence on the aetiology of many diseases and the ability to seek after and benefit from health care. Differences between income groups in mortality, however, are larger than differences in education groups (Elo et al., 2006; Tarkiainen et al., 2012). Also, greater differences in hospitalisation rates tend to exist between income groups than with other social indicators. The level of disposable income is the best descriptor of the standard of living and well-being of a people (Saunders, 1996). Household income is more indicative of a standard of living and of life chances than individual-level income. As a direct measure, income is relatively easy to obtain and is sensitive to changes. In most cases, annual incomes are used. The ratio nature of the income is an advantage, due to rational meaning and easy interpretation of the order of the categories.

2.3 THE ROLE OF HEALTH CARE IN HEALTH DISPARITIES

Equitable distribution of health care can be regarded as an important target in itself, apart from its contribution to equal health outcomes. The WHO set up a global network of policy makers, researchers and civil society organizations called the Commission on Social Determinants of Health (CSDH). The CSDH developed a conceptual framework on social determinants of health (Figure 1). In this framework, the health system is conceptualised as a social determinant of health and plays an important role in mediating the differential consequences of health between people of varying socioeconomic positions. Tobias and Yeh (2009) have claimed that improvements in access to and quality of health care for the disadvantaged could narrow health inequities. Health care does not, however, guarantee equal health because many determinants of health and health-related quality of life are independent of the health care system, such as health-related behaviours and biological factors (see Figure 1). While health care is not necessarily capable of impacting health inequalities directly, it might at least prevent or reduce differences, yet also maintain or increase differences.



Source: Amended from Solar and Irwin, 2010

Figure 1 A simplified theoretical framework of the social determinants of health and health inequities

3 MEASURING SOCIOECONOMIC EQUITY

3.1 FACTORS AFFECTING THE CHOICE OF PROPER EQUITY MEASURES

The purpose of this chapter is to introduce statistical methods to measure socioeconomic equity in health care based on previous research. The statistical methods introduced in this thesis have in part been developed in the light of inequities in health or health economics. Some methods are applicable to the study of equity in health care as such but some need further development.

The most important question when considering the proper methods to study equity is ‘What is measured?’ and additionally, ‘In relation to what/whom?’. Is the aim to compare disparities over time, and/or between regions or population groups? Of interest might also be the evaluation of differences between health care indicators. The appropriateness of the method of measuring inequities using this chosen viewpoint is dependent on several fundamental factors:

1) Is it meaningful to compare only the extreme socioeconomic groups, or is the objective to provide a summary measure across all socioeconomic groups?

2) Are absolute or relative differences being studied?

3) The source of the available dataset (register/survey data) determines what study questions can be explored. Additionally, the study setting, how the data are collected, and what health care indicator measures of socioeconomic position are available and chosen in the study are all factors that impose their own criteria on the estimation.

4) The fourth factor is related to the third, but can be discussed separately from it; what are the types of health care indicators and measures of socioeconomic position, and how can and should the measure of socioeconomic position be grouped? Furthermore, if the socioeconomic variable is grouped and the available data are aggregated by it in addition to other explanatory variables, this must be taken into account in the analysis phase.

Thus, the choice of appropriate methods involves several factors that must be taken into account. It includes normative, methodological, and conceptual considerations. The second factor is a pure normative choice and the other factors involve all of these three different considerations. All of these four factors need to be taken into account to ensure reliability of the results as well as the comparability of the results between studies. Moreover, different choices may even lead to contradictory results (Boström and Rosén, 2003; Keppel et al., 2005; Masseria and Allin, 2008). It is also crucial to emphasise these factors and discuss the normative judgements made when interpreting and presenting the results (Harper et al., 2010).

The vast majority of previous research on equity in health care has used survey data, while the development of methodology has mainly concerned survey research. However, the methods developed for sampled data are not directly applicable to register data due to the different nature of the data. As Mackenbach and Kunst (1997) argue, the choice of the measure should depend on the nature of the data. This issue is very important and will be discussed in more detail in Chapter 4 of this thesis.

Variables of the health care indicator and socioeconomic position

The variables must be selected so that the research question receives as definite an answer as possible. However, the data collection procedure and source of the data determine the actual variables that are selected for the analyses. In Chapter 4, the influence of the data source on the measurement of socioeconomic equity is discussed. The second factor that determines how equity can properly be measured is the type of available health care (outcome) indicator and measures of socioeconomic position. Additionally, when studying equity, it is necessary to decide how the socioeconomic variable should be grouped (if necessary). Braveman (2003) has stated that the identification of appropriate social groups is as important a question as the selection of outcome indicators. In this chapter, the features of the variables, the level of the dataset (see explanation below) and their effect on the measurement of equity are introduced. The requirements introduced by the type of health care variable on the estimation of equity are introduced along with the specific measures.

The level of the dataset also defines partly the methods suitable for the measurements. In this thesis, an individual-level dataset indicates data in which a record exists separately for each individual or study object of the corresponding study population. This means that the information is at the level of individuals for all the variables. In some studies, these are denoted as ‘micro data’. On the other hand, an aggregated dataset is defined here as data that have information on outcome variables grouped by socioeconomic and other explanatory variables. The information is sourced (similarly to individual-level data) from individuals and recorded at the individual-level, but at the data collection or at the pre-processing phase, the data have been aggregated.

The use of individual-level data is generally preferred to that of aggregated data, since aggregated data ignore information on within-group associations between the socioeconomic variable and the health care variable in measuring equity (Kakwani et al., 1997). Moreover, it is likely that some information is lost if the grouping of the data is too broad and fails to reproduce the actual distribution of the measured outcome. However, Kakwani et al. (1997) compared empirical results on health equity using individual-level and aggregated survey data and concluded that the precision gained using individual-level data was surprisingly small.

It is not, however, always possible to use individual-level data. In some cases, for example, a registrar or other data collector, to ensure the privacy of individuals, tabulates the data since a failure to do so would mean that rare events would make it possible to identify individuals from the individual-level data set. Evaluating the need for care for certain procedures is sometimes only possible using aggregated data. Ill-health might be evaluated with the use of medication, morbidity, or mortality, while data are aggregated by variables characterising need, such as gender, age, and socioeconomic position. Thus, studying equity by socioeconomic groups instead of an individual ranking of people by socioeconomic status is convenient, and even the only possibility in some cases due to practical reasons. The aggregation of the dataset and interpretation of the results are straightforward if the outcome variable is dichotomous and can happen only once (e.g. death).

Categorisation of the socioeconomic variable needs to be sensible. Braveman (2003) states that the most important issue in defining the socioeconomic groups is ‘to determine which categorizations will best describe patterns of population health and most effectively guide research on causal mechanisms and subsequent interventions’. As a continuous variable, income can be categorised in many ways (at least in principle). This also allows the use of various inequity measures (described in more detail below). Categorisation of income can be done using the total distribution of the study population (if that is known) and dividing income into a number of groups according to the distribution, or setting income limits based on an hypothesis of reasonable limits. Fixed limits have problems, however, due to rapid inflationary trends in the economy and changing economic conditions. Fixed limits may also cause challenges from the methodical point of view. A suitable number of income groups depend on several factors. Some equity measures provide less accurate estimates if the number of income groups is too small. Kakwani and Podder (1976) found that increasing the number of income groups from 11 to 20 improved the accuracy of income inequality estimates using empirical survey data. Clarke and Ourti (2010) showed empirically a relevant and improved impact on inequity estimates when increasing the number of income groups to 10 or more. Their study used survey data from several countries. On the other hand, it is not always appropriate or even possible to use too many groups due to features of the specific equity measure or for practical reasons. Additionally, too many groups might cause unreliable estimates of equity if the number of studied events becomes too low in income groups (Braveman, 2003). An obvious reason for using a particular number of groups is the availability of the research data. Using individual-level data but reporting and analysing income information in categories is also possible. Estimates of inequity measures might be less accurate in this case as well (Clarke and Ourti, 2010).

Education and occupation are naturally categorical socioeconomic indicators and thus they are more limited than income with regard to the choice of methods. Categorisation of these variables is not, however, always straightforward. For to practical reasons (recording, pre-processing, and analysing the data), it may be necessary to undertake further categorisation. Education is of an ordered nature and might be used with equity measures that require an ordinal socioeconomic variable. Education can be categorised, for example, by years of education. Categorisation of occupation differs between countries. In Finland, for example, the most commonly used indicators of occupational social class do not include an inherent ranking.

Absolute and relative measures

When measuring equity, it must be decided whether to study absolute or relative equity. The choice between an absolute and a relative equity measure has been an important topic in equity research papers with a special focus especially on equity in health (Asada, 2005; Houweling et al., 2007; Masseria and Allin, 2008). The use of absolute measures has been suggested when assessing the effect of public health policies on health inequality, since the goal is to decrease the number of cases (Harper and Lynch, 2005; Regidor, 2004b). Boström and Rosén (2003) propose presenting basic data in terms of absolute values per population before showing results of relative or absolute differences. Relative measures are appropriate when evaluating the strength of the association between an intervention and the reduced frequency of the disease in question. A relative measure can be used to compare equity between outcomes that are measured on different scales (Harper et al., 2008). Additionally, relative measures are insensitive to a change in the mean and reflect better egalitarian viewpoints in measuring equity (Mackenbach et al., 1997; Wagstaff et al., 1991).

It has also been suggested that socioeconomic equity should be measured using approaches estimating both absolute and relative differences, as these may move in opposite directions if the ill-health rates in the population groups being compared either increase or decrease, while ranking countries based on the size of the inequity may vary depending on which approach is used (Etches, 2003; Houweling et al., 2007; Lahelma et al., 1994). Maybe the most common case is that relative differences increase while absolute differences decrease when the ill-health (e.g. mortality) rate declines. It has been shown that absolute differences tend to be low if overall ill-health rates are high or low and differences tend to be high when rates are intermediate (Moonesinghe and Beckles, 2015). Relative differences tend to be higher if overall ill-health rates are low.

There is, however, a lack of theoretical and methodological research on choosing between absolute and relative measures of equity in health care. Even though the methodology of measuring equity in health is sometimes and to some extent applicable to measuring equity in health care, the inclusion of need for care in the measurement poses different demands for the methods of measuring equity in health care, i.e. horizontal equity.

Evaluating the need for care is not necessarily straightforward. Even when the information on the need for specific treatment is based on clinical individual level evaluation, it might be measured on a continuous scale or categorised rather than dichotomised. Additionally, it is not always possible to measure need on the same scale as the use of care. Thus, these indicators can be at different levels. Furthermore, the relationship between need and use is not always linear. When measuring relative horizontal equity, the scale difference, however, is not an issue due to scale invariance of the relative inequity measures. The benefit of scale invariance is the ability to combine indicators measured on different scales. Sometimes the evaluation of the need for care is not possible using direct indicators but is rather done using proxy indicators that can also be composite indicators. In this case, the use of care and the need for care are measured on different scales. How the need for care can be measured depends also on the available data. This is discussed in detail in Chapter 4.

The choice of the socioeconomic groups in the measurement

The fourth factor involves the question of socioeconomic groups to be included in the comparison. Equity can be measured comparing only the extreme socioeconomic groups (Keppel, 2005; Wagstaff et al., 1991). Another possibility is to make pairwise comparison between groups of specific interest. The research objective might also be to include all socioeconomic groups in the examination. If all the socioeconomic groups are studied, the measurement can be done making comparisons between all socioeconomic groups compared to one reference group or using a summary measure that combines information from all the groups at the same time by comparing each group with every other socioeconomic group.

3.2 EQUITY MEASURES

Preliminary measurement

The preliminary step in measuring equity, depending on the data collection process and design and available measured information, is usually to estimate events relevant to the health care indicator. Measures of interest are estimated in terms of means, proportions, percentages, or rates by the socioeconomic groups. Often the interest is to include only the first occurrence of a particular event. Some health-related outcomes are irreversible states, such as death or diabetes and are thus easily determined. One common approach is to calculate the incidence or prevalence rates of the outcome variable by socioeconomic groups. This enables the sizes of the socioeconomic groups to be taken into account. Crude rates are calculated as the numbers of events as a proportion of 1000 or 100000 persons or person years, for example, of the corresponding target population.

Confounding factors

To enable a valid comparison between socioeconomic groups with different levels of confounding factors, the effect of these factors that could affect (or are believed to affect) a particular result needs to be removed. Confounding factors are those that are correlated with both socioeconomic and health care variables. Most commonly, gender and age are considered to be potentially confounding factors. In many countries, confounding factors also include race or ethnicity. An adjustment procedure is a way to seek a more refined description of the relationship and to remove the non-desired effects of the confounders. There are many different methods to do the adjustment, such as stratified or subgroup analyses, multivariable statistical analyses, life tables, or direct or indirect standardisation of rates, from which the standardisation methods are perhaps the most common ways used to solve the problem. Standardisation for other factors than age and gender is more complicated due to somewhat ambiguous definitions of these variables. However, standardisation allows only a descriptive analysis, and cannot build a causal or structural model of health or health care determination (O'Donnell et al., 2008). Gravelle (2003) claims that direct standardisation is better than indirect approach for measuring income related-inequality in health, because indirect standardisation underestimates inequality estimates.

Indirect and direct standardisation

Indirect and direct methods are common procedures to take into account different age structures of the socioeconomic groups. The indirect method compares the observed number of events to the expected number of events for each stratum-specific group of the population of interest. The direct method, in contrast, calculates the number of events in a standard population that would be expected if that population had the age-specific rates of a population of interest. Thus, directly standardised rates reflect the number of events that would have been expected if the populations being compared had identical age distributions. For socioeconomic group (SEG) g, the age-standardised rate y_g is calculated as the weighted sum: $y_g = \sum_{i=1}^{I} \frac{d_{ig}}{p_{ig}} w_i$, where i is age group, d_{ig} is the number of cases and p_{ig} is the population size in the i^{th} age group of the g^{th} SEG, and w_i is the proportion of the age group according to the chosen standard population.

Both methods of standardisation (direct and indirect) can also be implemented through regression analysis, for example, Poisson regression or logistic regression (O'Donnell et al., 2008; Wagstaff and van Doorslaer, 2000). For individual-level data, it is also possible to use regression methods.

Standard population

The choice of the standard population is arbitrary, but the choice can markedly modify comparisons. Choosing a standard population with higher proportions in the younger age groups weights the studied events at these ages disproportionately and similarly choosing an older standard population weights the other end of the distribution. In general, the standard population should be chosen to reflect the average age-structure of the populations or population groups under comparison during the study period. Standard populations have been developed for specific regions to facilitate the comparison of data from different countries, for example, as with the European Standard Population (Eurostat, 2013). Sometimes it might also be appropriate to use the average age-structure of the specific population group studied from one country (e.g. Finnish patients with diabetes) if the age-structure differs markedly from the average population. Then, however, the results cannot be used to make comparisons between countries. Usually, the standard population is in 5-year age-bands. It is a common practice that mortality data, for instance, are produced in this form (Eurostat, 2013). Additionally, using single-year age grouping would be inconvenient to apply and might provide estimates of false precision.

Measures using extreme socioeconomic groups

Equity can be measured comparing only the extreme socioeconomic groups; the range is the absolute rate difference of the lowest versus highest socioeconomic groups and the rate ratio of these groups is the relative measure (Keppel, 2005; Wagstaff et al., 1991).

The index of dissimilarity (ID) – the relative version

The index of dissimilarity is a relative measure (Duncan and Duncan, 1955). It measures the proportion of cases that would have to be redistributed across socioeconomic groups to obtain the same rate of the studied outcome for all groups. The ID is calculated as:

$$ID = \tfrac{1}{2}\sum_{i=1}^{g}\left|s_{gh} - s_{gp}\right|,$$

where s_{gh} is proportion of the health care variable of the g^{th} SEG and s_{gp} is the proportion of the population of the g^{th} SEG. The ID has a shortfall; it is insensitive to the socioeconomic dimensions to inequities in health care. It ignores some parts of the available information; it does not take into account where high rates exist. The assumption behind the ID is that socioeconomic differences are a redistribution issue (Mackenbach and Kunst, 1997).

The index of dissimilarity (ID) – the absolute version

The absolute version of the ID is calculated as:

$$ID = \tfrac{1}{2}\sum_{i=1}^{g} \left| d_g - p_g y_{pop} \right|,$$

where d_g is the observed number of cases of the g^{th} SEG, p_g is the population size of the g^{th} SEG, y_{pop} is the rate in the total population, and $p_g y_{pop}$ is the expected number of cases if the g^{th} SEG had the same rate of the event as the total population.

Measures using all socioeconomic groups

Another common practice in studying the distribution of equity is to compare the average levels or the frequencies, rate differences, or rate ratios of the measured event for all the socioeconomic groups compared to the highest group (Braveman, 2006; Regidor, 2004). The rate difference quantifies the excess rate attributable to being in the disadvantaged group of interest. The rate ratio, on the other hand, is a scale-neutral measure and expresses the relative scale of inequalities and is the traditional choice in etiological investigations. Thus, using rate ratios alone does not indicate the level or direction of trends in overall or group-specific health or health care outcomes but is useful for directly comparing rates on different scales. These measures, however, might fail to take into account the relative sizes of the socioeconomic groups or ignore some parts of the available information (Mackenbach and Kunst, 1997; Wagstaff et al., 1991). When studying time trends or comparing areas or countries using the range, for example, the results can be misleading where the sizes of the socioeconomic groups have changed, since measures relying on the range only ignore the sizes of the groups. Thus, it is suggested that the relative size of the socioeconomic groups should be taken into account to avoid bias when using rates to evaluate differences between socioeconomic groups (Gulliford et al., 2002).

The regression coefficient

If the relationship between the outcome and the socioeconomic variable is linear, and the scale of the socioeconomic variable is interval or ordinal, one potential way to study differences in health care is to fit a regression line across the socioeconomic groups (Regidor, 2004b). The regression coefficient describes the change in the absolute level of the outcome variable for each unit of increase in the socioeconomic variable. The outcome variable needs to be measured on an interval scale. A relative version of this measure can also be estimated. First, the outcome variable is transformed onto the log scale. The exponent of the regression coefficient minus 1 represents the proportion of change in the outcome variable for each unit of increase in the socioeconomic groups. The regression coefficient is a summary measure of inequity and allows comparisons to be made easily between populations or over time.

Properties of a good measure

It has been proposed that a good measure of inequality or inequity should meet three minimal requirements: 1) It reflects the socioeconomic dimension of inequities, 2) it reflects the distribution of the measured outcome across the entire population, and 3) it is sensitive to changes in the distribution of the population across socioeconomic groups (Wagstaff et al., 1991). In this sense, the categorisation of the socioeconomic variable must also meet the requirement of reflecting accurately enough the distribution of the entire population. Mackenbach and Kunst (1997) have, however, criticised the third minimal requirement. They argue (when measuring health inequalities) that measures that do not take into account the whole distribution of the population across socioeconomic groups are as important as those taking the whole distribution into account. They suggest that these measures (such as the range and the ID) should be used beside measures that meet all the three minimal requirements and are commonly named 'more sophisticated' measures.

Equity measures that meet all these three requirements are inequity indices, such as the relative index of inequality (RII), the concentration index (C), and the slope index of inequality (SII) (Wagstaff et al., 1991). The indices are introduced in detail in the following chapters. The RII and C are measures of relative disparity and the SII is a measure of absolute disparity. These indices give a single, quantitative measure for the degree of inequity and have become increasingly popular. Mackenbach and Kunst (1997) argue, however, that these measures have a complex interpretation and can lead to misunderstandings. The most notable difference between the regression coefficient and inequity indices is that the regression coefficient is not sensitive to changes in the distribution of the population sizes of the socioeconomic groups.

The SII and the RII assume that there is a linear association of the outcome with the ranking of individuals by the socioeconomic indicator (Blakely et al., 2004). This assumption is not required for C. The reasoning for this is explained in Chapter 3.3 of this thesis. Both individual-level and aggregated data can be used with each of these three indices. They require that the socioeconomic variable is measured at least on an ordinal scale and the outcome variable on a ratio scale. If using a categorised measure of socioeconomic position, the number of socioeconomic groups should be at least five, since estimates may be unreliable without a sufficient number of groups. The suitable number of socioeconomic groups must be evaluated, however, case-specifically, since there needs to be a sufficient number of cases in each group and thus the number of groups cannot be increased without limit.

Inequity indices are based on ranking of the population by their socioeconomic position, beginning with the most disadvantaged. If using aggregated data, each socioeconomic group is characterised by a midpoint of its range in the cumulative distribution of the population ranked by socioeconomic group. Since these indices rank individuals or groups by socioeconomic position, the socioeconomic dimension to inequity in health care is taken into account.

3.3 RELATIVE INEQUITY INDICES

Inequity indices measuring relative equity are not translation independent, i.e. they are sensitive to changes in the mean of the outcome variable. Thus, adding a constant to the outcome variable of all individuals will change the relative differences between socioeconomic groups (Amiel and Cowell, 1999). On the other hand, relative inequity indices are scale invariant, so multiplying the outcome variable of all individuals will not change the relative differences between socioeconomic groups.

THE CONCENTRATION INDEX

The concentration index (C) is a widely used tool to measure the degree of socioeconomic inequity in health and health care (Ásgeirsdóttir and Ragnarsdóttir, 2013; Kakwani et al., 1997; Wagstaff et al., 1989; Wagstaff et al., 1991). C is based on the concentration curve L(s), which is a bivariate curve and enables the visualization of the distribution of the health care variable. C takes into account the sizes of the socioeconomic groups when using aggregated data. The development of C and the concentration curve originates from the inequity measures used in the field of econometrics, such as the Gini coefficient and its visual counterpart the Lorenz curve (Kakwani, 1977; Kakwani, 1980). The Gini coefficient and the Lorenz curve are measures analysing the size distribution of income or wealth.

The L(s) plots the cumulative proportion of the health care (or health) variable against the cumulative proportion of the population (s), ranked by socioeconomic group (SEG) from the least to the most advantaged (Figure 2). Similarly, it can be used to illustrate the distribution of the health care variable for individual-level data, with individuals ranked by their socioeconomic position, mainly income. The area between the concentration curve and the diagonal (the line of equity) provides a measure of inequity and C is calculated as twice this area:

$$C = 1 - 2\int_0^1 L(s)ds.$$

If the concentration curve coincides with the diagonal, all socioeconomic groups or individuals receive the same level of health care (or have the same level of health). If the curve is under the diagonal, the distribution of the outcome variable is concentrated on the people of higher socioeconomic groups or individuals and the index gets positive values, and vice versa. C can have values between [-1, 1]. The value 0 denotes total equity. For individual-level data when the outcome variable is binary, however, the limits are shown to be [μ-1, 1-μ], where μ is the mean of the outcome variable in question (Wagstaff, 2005).

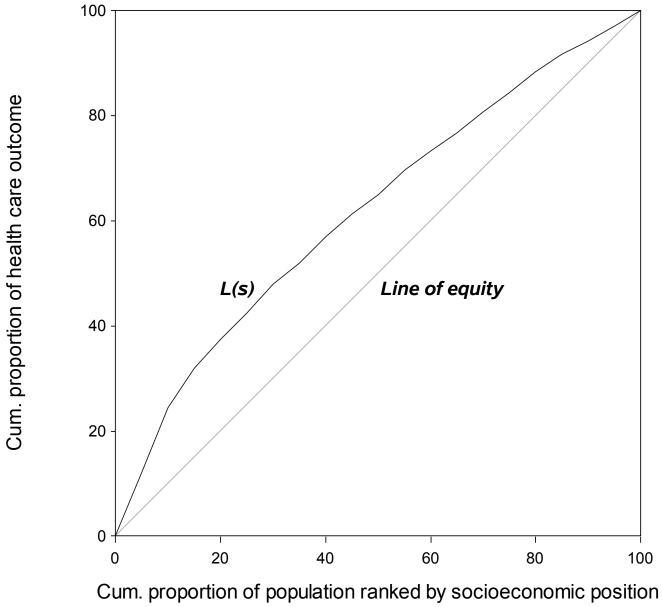


Figure 2 An example of the concentration curve

C can also be estimated for aggregated data as:

$$C = \frac{2}{\bar{y}} \sum_{g=1}^{G} (y_g R_g f_g) - 1,$$

where y_g is the health care score of the g^{th} SEG and $\bar{y}$ is the mean of the y_g, R_g is the relative rank of the g^{th} SEG, and f_g is its population share (Kakwani et al., 1997). The relative rank is defined as $R_g = \sum_{k=1}^{g-1} f_k + 0.5 f_g$ and indicates the cumulative proportion of the population up to the midpoint of each group interval. The y_g is usually the rate of the outcome variable of the g^{th} SEG.

For individual-level data, C can be computed as:

$$C = \frac{2}{n\bar{x}} \sum_{i=1}^{n} x_i R_i - 1,$$

where n is the number of individuals (or the sample size), x_i is the health care score of the i^{th} individual and $\bar{x}$ is the mean of the x_i, and R_i is the individual's fractional rank in the socioeconomic distribution, with individuals ranked according to their socioeconomic position beginning with the most disadvantaged. The fractional rank is: $R_i = n^{-1}(i - 0.5)$.

Kakwani (1980) showed that the concentration index is equal to:

$$C = 2\operatorname{cov}(R_g, y_g) / \bar{y},$$

since (due to weighted data):

$$\begin{aligned}
C &= \frac{2}{\bar{y}} \operatorname{cov}(R_g, y_g) \\
&= \frac{2}{\bar{y}} \sum_{g=1}^{G} f_g (R_g - E(R_g))(y_g - E(y_g)) \\
&= \frac{2}{\bar{y}} \sum_{g=1}^{G} f_g (R_g - \tfrac{1}{2})(y_g - E(y_g)) \\
&= \frac{2}{\bar{y}} \sum_{g=1}^{G} \left[f_g R_g y_g - f_g R_g E(y_g) - \tfrac{1}{2} f_g y_g + \tfrac{1}{2} f_g E(y_g) \right] \\
&= \frac{2}{\bar{y}} \left[\sum_{g=1}^{G} f_g R_g y_g - \sum_{g=1}^{G} f_g R_g E(y_g) - \sum_{g=1}^{G} \tfrac{1}{2} f_g y_g + \sum_{g=1}^{G} \tfrac{1}{2} f_g E(y_g) \right] \\
&= \frac{2}{\bar{y}} \left[\sum_{g=1}^{G} f_g R_g y_g - \tfrac{1}{2} \bar{y} - \tfrac{1}{2} \bar{y} + \tfrac{1}{2} \bar{y} \right] = \frac{2}{\bar{y}} \sum_{g=1}^{G} (y_g R_g f_g) - 1 .
\end{aligned}$$

Now, since

$$C = \frac{2}{\bar{y}}\operatorname{cov}(R_g, y_g) = \operatorname{cov}(R_g, \tfrac{2}{\bar{y}} y_g) = \frac{\operatorname{cov}(R_g, \tfrac{2}{\bar{y}} \operatorname{var}(R_g) y_g)}{\operatorname{var}(R_g)},$$

it is possible to compute C using a regression method and the estimate of β_1 is equal to C:

$$\left[2\sigma_R^2\left(\frac{y_g}{\bar{y}}\right)\right] f_g = \beta_0 f_g + \beta_1 R_g f_g + e_g ,$$

where σ_R^2 is the weighted variance of the rank R_g, defined as

$$\sigma_R^2 = \sum_{g=1}^{G} f_g \left(R_g - \tfrac{1}{2}\right)^2 .$$

It can be shown that this result holds also for individual-level data. Using C, the linearity assumption between the socioeconomic indicator and outcome (or other typical assumptions) is not required, since the regression method is just a 'trick' to compute the index. Regidor (2004b) has stated, however, that there must be a linear gradient between the socioeconomic indicator and the outcome variable when using C.

Interpretation of the concentration index

The value of C has the disadvantage of lacking a straightforward practical interpretation. Koolman and Doorslaer (2004) have presented a redistribution measure (RD) that can be translated into a percentage indicating the proportion of the total amount of the (health care) variable that needs to be transferred between the extreme socioeconomic groups to remove inequity. This measure is defined as $RD = 75C$.

C does not take into account the level of health care within the population, only how much it varies. The absolute concentration index (ACI), however, is a measure containing information on both the level and distribution of an outcome variable. The ACI is introduced in Chapter 3.4.1.

Decomposition of the concentration index

C can also be decomposed into items contributing separately to the overall C. This approach has been used in income and health inequality studies (e.g. Clarke et al., 2002; Rao, 1969). Clarke et al. decomposed C by item scores in physical functioning using health survey data. The weighted average of the decomposed concentration indices can be calculated as:

$$C = \sum_{j=1}^{J} w_j C_j ,$$

where $w_j = y_j / \bar{y}$ is the weight the item represents of the total outcome variable and C_j is the concentration index of the component j.

THE HORIZONTAL INEQUITY INDEX

When studying horizontal equity in health care, the need for care is taken into account. If the indicators for the use of care and the need for care can be meaningfully combined and this joint variable is estimable using one model and the interpretation of the results is straightforward, the relative horizontal equity can be estimated using for example C. However, this is rarely the case since the need for care is rarely unequivocal or measured on the same scale as the use of care. Despite these challenges, horizontal equity in health care can be evaluated by estimating separately the distributions of the use of care and the need for care by socioeconomic groups and comparing these distributions. Since relative disparity measures are scale invariant, the possible scale differences between these distributions is not a problem and the measurement of horizontal relative equity is relatively straightforward.

The horizontal inequity index (HII) is a relative measure of equity which takes the need for care into account and is based on C. It is defined by comparing the distributions of the use of health care and the need for health care among socioeconomic groups using C:

$$HII = C_m - C_n ,$$

where C_m is the concentration index for health care and C_n is the concentration index for need (Wagstaff and van Doorslaer, 1999). As with C index, a positive value for the HII indicates a concentration of the distribution of the outcome variable on the people of higher socioeconomic groups or individuals, and vice versa. The HII can have values between [-2, 2]. When the HII is zero, health care and the need for care are proportionally distributed across socioeconomic groups, and horizontal equity exists. The HII can be estimated using individual-level data or aggregated data. The HII allows the use and need variables of health care, which are measured on different scales, to be combined by normalising the variables (Moonesinghe and Beckles, 2015).

THE RELATIVE INDEX OF INEQUALITY

The relative index of inequality (RII) compares the rates of the outcome variable between the lowest and the highest socioeconomic groups (Pamuk, 1985). The RII is calculated by fitting a linear regression line to the values of the outcome variable by socioeconomic groups by means of weighted least-squares and dividing by the mean of the outcome variable:

$$RII = \frac{\beta}{\bar{y}}.$$

The socioeconomic groups are ranked similarly as with the estimation of C: $R_g = \sum_{\gamma=1}^{g-1} f_\gamma + 0.5 f_g$. The RII is the proportional difference in the outcome across the socioeconomic distribution, with negative values indicating that the distribution of the outcome variable is concentrated on the people of lower socioeconomic groups or individuals, while a positive value indicates a concentration of the outcome variable on the people of higher socioeconomic groups or individuals. A value of zero indicates no association between the outcome variable and socioeconomic position, i.e. total equity.

It is assumed that the association between the outcome variable across the socioeconomic groups is linear. Thus, when the association is non-linear, the estimation of the RII is inconsistent.

3.4 ABSOLUTE INEQUITY INDICES

Inequity indices measuring absolute equity are translation independent. Thus, adding a constant to the outcome variable of all individuals will not change the differences between socioeconomic groups (Amiel and Cowell, 1999).

THE ABSOLUTE CONCENTRATION INDEX

The absolute version of the concentration index is the absolute concentration index (ACI), also called the generalized concentration index (Clarke et al., 2002; Wagstaff et al., 1991). It is defined as C multiplied by the mean level of the outcome variable:

$$ACI = C \cdot \bar{y} = 2\operatorname{cov}(R_g, y_g),$$

where y_g is the health care score of the g th SEG and R_g is the relative rank of the g th SEG.

THE SLOPE INDEX OF INEQUALITY

The slope index of inequality (SII) is an absolute counterpart to the RII (Preston et al., 1985). It can be interpreted as the absolute effect on health care of moving from the lowest socioeconomic group to the highest (Wagstaff et a., 1991). It can be obtained by the regression equation:

$$y_g f_g = \beta_0 f_g + \beta_1 R_g f_g + e_g .$$

The SII is the slope of the regression line, showing the relationship between the outcome variable of the socioeconomic group and its relative rank variable $R_g = \sum_{\gamma=1}^{g-1} f_\gamma + 0.5 f_g$. A negative value of the SII indicates that the distribution of the outcome variable is concentrated on the people of lower socioeconomic groups or individuals, while a positive value indicates concentration of the outcome variable on the people of higher socioeconomic groups or individuals. A value of zero indicates no association between the outcome variable and socioeconomic position, i.e. total equity.

THE MEASUREMENT OF ABSOLUTE HORIZONTAL EQUITY

Since absolute measures are not scale invariant, it is not possible to make direct comparisons between the use of care and the need for care variables which are measured on different scales. If studies where the need for care can be evaluated clinically on a case-by-case basis, this is however not an issue (Palència et al., 2013; Sözmen and Ünal, 2008). If the indicators for health care can be meaningfully combined the absolute horizontal equity can be estimated using the SII, for example.

THE CONNECTION BETWEEN INEQUITY INDICES

The inequity indices have connections. The absolute and the relative concentration indices are related, as shown above, $ACI = C \cdot \bar{y}$. Similarly, the absolute and the relative versions of the inequality indices (the SII and the RII) have a connection: $SII = RII \cdot \bar{y}$. Additionally, C and the RII are related as: $RII = \frac{C}{2\sigma_R^2}$ and the ACI and the SII are related as: $SII = \frac{ACI}{2\sigma_R^2}$ (Wagstaff et al., 1991).

3.5 THE UNCERTAINTY OF THE ESTIMATES OF THE INEQUITY INDICES

The uncertainty of the estimates is commonly quantified using a confidence interval that provides a means of assessing and reporting the uncertainty, since it is intuitively straightforward to interpret. The principal idea of the classical confidence intervals is to present the uncertainty that is related to results derived from data that are a randomly selected subset of a population. This uncertainty can originate from measurement error or sampling, for example. In general, the lower and upper limits of a confidence interval are calculated as:

Lower limit: $S-(1.96\cdot SE(S))$
Upper limit: $S+(1.96\cdot SE(S))$,

where S is the point estimate for a measure and SE(S) is the standard error for the estimate.

CONFIDENCE INTERVALS FOR THE CONCENTRATION INDEX

As Mackenbach and Kunst (1997) have stated, C has a practical limitation concerning the calculation of a confidence interval. The application of regression techniques to estimate C does not require distributional assumptions. On the other hand, if making statistical inferences regarding the uncertainty of C, the distributional assumptions need to hold. Thus, the classical standard error of the regression slope parameter is not directly applicable to C. For example, Wagstaff and van Doorslaer (2000) have suggested that serial correlation in the errors potentially causes biased standard errors; testing for serial correlation is recommended when making statistical inferences using the regression method. Kakwani et al. (1997) developed estimators of the standard error of C that take into account the serial correlation in the data applicable to survey data. These estimators do not, however, take into account the sampling variability of the outcome variable in question. O'Donnell et al. (2008) introduced a method for taking this into account. Previous studies of the uncertainty of C have mainly focused on developing statistical inference for sampled data from population surveys.

CONFIDENCE INTERVALS FOR THE RELATIVE INDEX OF INEQUALITY

The conventional approach to calculating the confidence intervals for the RII is to use the standard error of the regression estimate. If an assumption of an actual linear association between the outcome variable and the variable of the socioeconomic position is true, this is considered to be an appropriate approach. This holds for survey data, since these regression methods are developed for sampling purposes. Hayes and Berry (2002) developed a method of calculating confidence intervals for the RII for survey data. The method they introduce depends on two sources of sampling variability: the health outcome measure and the fitted regression line of health outcome on the socioeconomic group variable. Bootstrap methods to estimate the confidence intervals for the RII have been introduced for and applied to sample data (Sergeant and Firth, 2005).

CONFIDENCE INTERVALS FOR THE SLOPE INDEX OF INEQUALITY

If the linearity assumption holds for SII, it has been suggested that the confidence intervals for the SII can be estimated using the standard deviation of the estimated regression parameter (Cheng et al., 2008).

3.6 MEASURING REGIONAL DIFFERENCES IN SOCIOECONOMIC EQUITY

When studying regional differences in socioeconomic equity, the methods used should take into account the effect of variation in the population sizes in regions. Likewise, the possible dependence between regions should not be ignored. Also, varying age and socioeconomic structures in addition to different needs for health care must be taken into consideration.

The existing methodology of measuring regional differences in socioeconomic equity within a country while taking the dependence between regions into account is limited. If there are only two areas then basic measures, such as the mean level, proportions, or rates between socioeconomic groups can be used to study regional differences in equity. When the aim is to study more than two regions and especially if more than two socioeconomic groups are included in the comparison, such basic measures – convenient for pairwise comparisons – might prove difficult, since they will produce numerous values and ignore some of the information regarding the socioeconomic distribution.

The measures used to compare equity between regions have been rate ratios, odds ratios, and risk ratios of the socioeconomic groups. More complicated measures can also be used, for example, the concentration index (Lee and Jones, 2007).

3.7 MEASURING TRENDS IN SOCIOECONOMIC EQUITY

To study changes in socioeconomic equity over time in detail, disparity measures should be sensitive to two sources of change: change in the size of the socioeconomic groups and change in the level of the outcome indicator within each group (Harper and Lynch, 2005). The available methods for measuring trends in equity are mainly the same as those used to measure regional differences in equity: rate ratios, relative ratios, odds ratios and other regression methods, and concentration indices. Also, the same challenge applies regarding the multidimensionality of the information when socioeconomic position is categorised into more than two groups and the aim is to include all of the groups in the measurement.

3.8 REMARKS ON EARLIER METHODOLOGY

There are several conclusions that can be drawn from earlier research on measuring socioeconomic equity in health care. A considerable amount of research has been conducted on measuring socioeconomic equity. However, there are some gaps in the previous research. Firstly, the methodological work has mainly concentrated on equity in health or equity in health care resources. In particular, the development and application of the concentration index has mainly been in the field of health care economics. Additionally, and even more importantly, the methods have been developed for survey data.

There is also a lack of theoretical and methodological research into the choice between absolute or relative measures of socioeconomic equity in health care. The research has basically focused on relative and absolute equity in health. Moreover, the question of measuring absolute socioeconomic equity in health care while taking the need for care into account and using register data has not been addressed in the literature. In particular, the use of proxy measures for the need for care induces challenges for estimating absolute horizontal equity.

The estimation of the uncertainty of C is not straightforward since the numeric value of C is based on an area between the concentration curve and the line of equity. The use of the regression method to estimate C requires no distributional assumptions to be met. But when considering the uncertainty of C, the estimation of confidence intervals from the regression model is not appropriate.

Lastly, there is limited existing methodology regarding the measurement of regional differences in socioeconomic equity within a country or for the study of trends in equity including several socioeconomic groups.

4 REGISTER DATA AS A SOURCE IN MEASURING SOCIOECONOMIC EQUITY IN HEALTH CARE

4.1 DATA SOURCES IN MEASURING EQUITY

The analysis of socioeconomic equity in health care and the conclusions drawn from the achieved results are basically dependent on the available data sources and the process of observing the data. The source of the data constrains what kind of a measure is conceivable, what can be measured, and in relation to what determinant. Thus, the source of the available data constrains what aspect of equity can be studied, what indicator of health care (and need for care) can be used, what statistical methods can be applied, what the population at risk is, i.e. to what group of people the results can be generalised, and how the results can be interpreted. If adequate information on both health care indicators and socioeconomic position is lacking or do not represent the target population comprehensively, measurement of equity is challenging. Selecting the indicators of health care is also fundamental for specifying the research question.

Survey and register data are two main sources of data in the field of health services research. Combining information gathered from both survey and register data is also possible. The choice as to whether to use either of these data types in a research project is not only based on scientific arguments: Cost and financing options are usually the deciding factors (Olsen, 2011). In relation to equity, probably the most important difference between survey and register data is the objectiveness of the information. Using objective administrative information on the use of or need for care enables the preservation of the comparability of the data between social groups, as well as between countries (Johnston et al., 2007). Allin et al. (2007) claim, however, that registers may provide less comprehensive data than survey data on socioeconomic position and health status.

However, in most studies on equity in health or health care – including methodological as well as substantial studies – survey data rather than register data have been used (O’Donnell et al., 2008). Among others, Wagstaff et al. (1991), Kakwani et al. (1997), Wagstaff and van Doorslaer (2000), Waters (2000), and d’Uva et al. (2009) have developed methods to measure equity using survey data. Some studies exist that compare equity results using individual-level and aggregated survey data (Kakwani and Podder, 1976; Kakwani et al., 1997), while empirical or methodological research using register data is sparse.

SURVEY DATA

In surveys information is received through questionnaires and interviews directly from the study population. A sample of respondents from a selected study population is chosen using a suitable sampling method. Household panel surveys have become more versatile and extensive over the two decades since national governments and organizations have invested increasingly resources in household surveys (O'Donnel, 2008).

It is an advantage that survey data allow conclusions to be drawn about inequity in health care use between individuals, since information about individuals who have not used health care, as well as those who have is included. It is also possible to ask the respondents questions and receive information, for example, on their own experience of treatment. As a drawback, survey data are prone to measurement and sampling error. Selection might cause unreliable estimates of the measured event. In addition, surveys often only include a small number of patients using specific procedures, for example. Thus, equity analyses are typically restricted to common health care use indicators, such as the use of any form of specialist care. If some members of the study population are inadequately represented, under-coverage exists. Obtaining representative samples of the most disadvantaged and advantaged population subgroups might be especially challenging (Bilheimer and Klein, 2010). Survey data often lacks objective information on health, diagnostics, use of services, or social status. Self-reported information may also be biased due to recall or report biases. The reliability of self-reported hospital visits is generally better than physician contacts (Barer et al., 1982). However, subjective answers received from national surveys asking 'How is your health?', for example, have been found to be a good predictor of people's future health care use and mortality (van Doorslaer et al., 2000 and 2004; van Doorslaer and Gerdtham, 2003; Idler and Benyamini, 1997).

Uncertainty of the equity estimates using survey data

Statistical procedures for confidence interval estimation using sample data account for sampling error as a source of uncertainty. Missing and incomplete data and other data errors, bias resulting from non-response, and poor data collection are not taken into account when estimating the confidence intervals.

4.2 REGISTER DATA

Register-based data provide another possible source of data for equity studies, and are typically secondary data, i.e. they have not been collected for the purposes of specific studies (Hearst and Hulley, 1988; Sund, 2003). The routine collection of administrative registers has increased due to rapid progress in advanced computer technology and has simplified data collection in many countries. The possibility to link data sets from different registers together through the use of unique personal identifiers has diversified studies further. Linking various administrative registers, such as population census data and vital statistics, to hospital registers allows for the study of socioeconomic equity in health care. Commonly, these datasets contain diagnoses and procedures based on the International Classification of Diseases (ICD), enabling selection of specific cases. Register data have been recognised as cost-effective and powerful sources of data for research purposes and have become the primary source of population data on health care use and access to care (Hall et al., 2005; Sund, 2012). The right to use administrative registers for scientific study purposes is combined with laws and rules to protect the privacy of citizens.

Register data can include large numbers of people, even total populations, rather than samples, thus enabling detailed and longitudinal statistics on subpopulations, regions, or specific cohorts in the whole country (Wallgren and Wallgren, 2007). However, the use of a representative sample of register data is also a possibility. Register data allow for the study of rare events and the examination of specific procedures in the total population or in certain disease groups. However, the validity of the data depends on the purpose for which they are used (Sorensen et al., 1996). Selection bias due to either non-response or the subjectivity of information poses a problem when using register-based data. Objective information on social conditions is also an advantage (Braaten et al., 2009; Olsen, 2011). As a drawback, administrative registers do not necessarily have data on all relevant variables. Moreover, for the variables of interest we may have to accept that we have only proxy data (Olsen, 2011). In the selection of patients, the use of procedure or diagnosis codes may cause problems in some cases (Sund, 2007). Although register data are generally of high quality and provide complete coverage (Gissler and Haukka, 2004; Keskimäki et al., 1997), the data are not without errors. As information systems can vary and collection of data is not consistent across countries, a lack of comparability may exist. In some cases or countries, coding of the diagnoses may even have questionable accuracy or the data might be out of date to some extent (Iezzoni, 2003).

The Nordic countries have for the most part collected national register data on social, demographic, environmental, and health data for many decades and in these countries, there has been an opportunity to use registers for research as well (Olsen, 2011). All European Union Member States gather mortality data and make them available for research, but not all countries collect mortality data linked with socioeconomic position. Finland offers very good possibilities to conduct register-based public health research, since the personal identification code system adopted in 1963 allows researchers to link administrative data from several databases reliably and easily. The Causes of Death statistics compiled by Statistics Finland collates information on deaths in Finland. These statistics are comprehensive due to the completeness of death registration, the process for expert review of disputed cases, and the high autopsy rate for deaths from suspicious and external causes (Lahti and Penttilä, 2001). In 2014, the autopsy rate was 23% for all deaths and 53% of those under 65 years of age (StatFin database, 2016).

In addition, the Finnish welfare and taxation systems have generated a large amount of reliable register data covering several decades. Finland has also one of the oldest individual-level registers on the use of hospital care in the world. The Care Register for Health Care (CRHC) (until 1993 the Hospital Discharge Register) has been intensively used in health services research and its quality has been generally considered good for end-point assessment for scientific study purposes (Sund, 2012). The CRHD covers all hospitals, both publicly and privately funded. In addition to inpatient care, it contains information on specialised outpatient care and day surgeries. Approximately 95% of hospital discharges and 90–95% of surgical procedures were recorded in the CRHC (Keskimäki and Aro, 1991; Salmela and Koistinen 1987). Since 2008, outpatient primary health care visits have also been collected in Finland. However, not until 2011 has the register covered all health care delivered. Both health care registers are maintained by the National Institute for Health and Welfare (THL). These registers include information on the patient's personal details, diagnoses, treatments and arrangement of the follow-up, and the unit providing the health care.

The CRHC includes only patients treated in hospital or in inpatient wards. Thus, it is not aimed for aetiological research or cannot be used for direct estimation of the incidence or the prevalence of certain diseases, but it captures the patients who receive health care. In Finland, administrative registers allow for studying the treatment of specific patient groups in some cases. It is possible to combine the datasets of the CRHC with registers of the Social Insurance Institution of Finland (SIIF) for medication use and special reimbursements for medicines and sickness allowances with diagnoses. This collection of information enables determining, for example, the diabetes population rather extensively.

To study equity in the use of a specific procedure or other indicator of health care among the total population, information on socioeconomic position and confounding factors of the total population is needed. In these cases, register data are commonly provided for research use in an aggregated form for privacy reasons, but also owing to the large amount of data and the lack of computational resources. Person years and the number of events of the total population form the study data, aggregated by socioeconomic position and other sociodemographic variables.

When using register data, evaluating the need for care is not always possible at the individual level and/or using direct measures of need, since information on the need for specific treatment is not usually available from the registers directly. However, linking various administrative registers to hospital registers allows for an evaluation of the need for care using medication use, morbidity, or mortality due to a specific cause of death as a proxy for ill-health (Vehko, 2010). Sometimes the only possibility to use such data for this purpose is to aggregate the data (which were originally individual-level) by variables characterising the need for care, such as gender, age, and socioeconomic position. The different metrics of the proxy indicator of the need for care and the indicator of the use of care should be taken into account when measuring horizontal equity. Using aggregated proxy indicators for the need for care do not provide the actual level of need for care but gives an approximation of the need at a comparative level (Keskimäki, 1997).

Summarising register data to an aggregate level may result in information loss. The fact that the data were aggregated must be taken into account in the analyses using weighted analyses or another appropriate method. Using aggregated data limits the number of study questions that can be answered and the range of statistical methods that can be employed.

Uncertainty of the equity estimates using register data

Estimation of the uncertainty in the indicator of interest using population-based data is complicated (Sørensen et al., 1996). The available estimators of the standard errors of the equity measures have been developed for survey data and do not describe the uncertainty in register data. There are several sources of errors that can affect the uncertainty (Sund, 2003). The quality of the register data is one of the factors affecting the uncertainty. Deterioration of the quality of the data may have originated at the stage of registration due to varying practices and accuracy in the processes. Also, merging datasets from different registries and data handling can cause faults. Errors in the data may also result from mistakes in programming and in variable coding.

4.3 OUTCOMES IN STUDYING EQUITY IN HEALTH CARE USING REGISTER DATA

To study the chosen aspect of equity there needs to be an appropriate indicator of health care. The starting point is to define the study question: What is to be observed and scrutinised? As noted earlier, register data have not been collected for the purposes of specific studies, denoting that the researcher does not have an opportunity to influence the registration of the data or their content at the data collection or study phase.

In Finland, register data on the use of hospital services provide excellent opportunities for studying health care due to good quality data and features of the health care system. Access to hospital care is somewhat more dependent on the characteristics of the health care system than is the use of primary care (Keskimäki, 1997). In non-emergency cases, the patient needs a referral to the hospital from a physician (general practitioner or private specialist). Thus, the patient is more dependent on the system and the physician's actions than he or she is when using primary health care services. Moreover, studying hospital services is more convenient than studying outpatient care due to incoherence in the information systems and the shortcomings of the outpatient register data, at least until recently. The ability to link hospital data with register data on socioeconomic information allows for the study of equity in health care.

The remainder of this chapter introduces the ways in which socioeconomic equity in health care has been studied using register data in Finland and elsewhere from the perspective of outcomes. Only studies where socioeconomic position is measured at the individual-level are included. Mental health services are excluded from this examination due to the different nature of mental disorders and somatic diseases and the organisation of health services. The association of socioeconomic position with mental disorders is more complex than with somatic diseases in that they are intertwined. Also, studies on health care costs and expenditure and the dispensing of drugs are not the focus of this thesis.

The choice of the variables for the use of health care depends obviously on the availability. The selected variables must have established practices in coding the diagnoses or procedures. Physicians may have varying practices in their diagnoses and similar conditions may be coded differently. Additionally, the chosen event must be sufficiently common so that there are enough cases for the analyses. It is also essential that the need for care can be evaluated, since morbidity varies considerably between socioeconomic groups. Need for revascularisation is assessed in many studies using register information in relation to an underlying disease requiring specific treatment. Usually it is preferred to restrict the study to specific procedures or indicators for practical reasons and to arrive at a more straightforward interpretation of the results. Keskimäki et al. (1995), however, studied socioeconomic differences in short-term hospitalisations in Finland by measuring overall annual risk of hospitalisation, discharge rate, and inpatient days according to need, which was assessed using mortality and morbidity as a proxy for need. Another study from Finland (Manderbacka et al., 2014) examined the annual risk of hospitalisations of somatic specialist care by income group. They also studied equity separately in surgical and non-surgical admissions. Manderbacka et al. (2015) also investigated equity in overall somatic specialised care in Finland. This kind of overall examination gives a broad picture of equity in hospital care but equity also needs to be examined in more specific patient groups so as to be able to take into account the need for care.

SURGICAL OPERATIONS

Systematic inequities in access to treatment are also likely to be reflected in common surgical procedure rates. Surgical procedures are good examples in evaluating equity since they are rather stable and common. Keskimäki et al. (1996) and Manderbacka et al. (2014) studied socioeconomic differences in the rates of nine common surgical procedures in Finland using hospital register data linked to census data. Another Finnish study used similar setting and measured equity in seven common elective procedures (Manderbacka et al., 2009). The need for care was not taken into account in these studies. Luoto et al. (1997) examined socioeconomic variation in hysterectomy by several indications for the treatment in Finland. Monstad et al. (2014) detected socioeconomic equity in waiting times for elective primary hip replacement operations in Norway. Socioeconomic inequity in hip replacement was also the measured outcome in a study of five European countries, covering a part of these countries (Cookson et al., 2015). Smirthwaite et al. (2016) analysed equity in waiting times for cataract surgery in Sweden.

Coronary revascularisations

Use of coronary revascularisations (percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG)) is also a good indication of hospital services. Ischaemic heart disease (IHD) is a common disease and invasive treatment is shown to improve the quality of life. In non-emergency cases, the patient and the health care professional make the decision together to perform a coronary revascularisation. Earlier studies suggest that a significant factor behind socioeconomic differences in coronary revascularisations might be the supply of services.

The need for coronary revascularisation varies by several factors such as age, gender, socioeconomic position, area of residence, and severity of disease (Black et al., 1995; Manson-Siddle and Robinson, 1998). Earlier studies have examined patients with acute myocardial infarction (AMI), (Hetemaa et al., 2004; Rosvall et al., 2008) and patients with unstable angina pectoris (AP) (Haglund et al., 2004) or both AMI and AP (Hetemaa et al., 2006). Measuring equity in revascularisations among all coronary heart disease patients is more complex, and a few studies have used IHD mortality as a proxy for need (Hetemaa et al., 2003). Keskimäki et al. (1997) evaluated socioeconomic differences in the utilisation of CABG and compared their use to two need indicators: mortality from and risk of hospitalisation due to IHD.

Vehko et al. (2010) observed all incident IHD patients and studied socioeconomic differences in access to first cardiac operation.

Only a few studies have examined age differences in socioeconomic equity in the treatment of IHD. Keskimäki et al. (1997) studied age differences between occupational classes in the use of CABG in 1988 in Finland. Another study from Finland used a similar setting and social class indicator and investigated age differences in the use of CABGs in 1988 and in the use of both CABGs and PCIs in 1996 (Hetemaa et al., 2003). Thus, there is an obvious lack of recent studies on age differences in socioeconomic equity in coronary revascularisations using register data with socioeconomic position measured at an individual level.

MORTALITY AMENABLE TO HEALTH CARE INTERVENTIONS

Amenable mortality – or causes of death that should be avoided in the presence of timely and effective health care interventions – represents an alternative measure of quality of health care (Nolte and McKee, 2004). These amenable deaths are an indication of potential weaknesses in health care that can then be the focus of more in-depth investigation. This approach attempts to identify possible differences and weaknesses in parts of the health care system. It is not meant to be a definite measure of quality, but rather, an indirect measure of the quality and performance of the health care system. This indicator was first proposed by Rutstein et al. (1976). The list of causes of death that are considered amenable has since been adapted and modified in many studies (e.g. Nolte and McKee, 2004; Tobias and Yeh, 2009). The selection of causes focuses on conditions for which effective clinical interventions exist in people aged younger than 75 years (a general age limit). Age limits vary for some diseases, taking into account the fact that health systems may not be able to contribute substantially to survival above or below a certain age.

Furthermore, Simonato et al. (1998) classified causes of deaths into three groups of conditions that cause amenable deaths according to the place and timing of the intervention to which each of the conditions is responsive: 1) primary prevention, 2) secondary prevention (early detection and treatment), and 3) tertiary prevention (improved treatment and medical care). This categorisation allows for a separate examination of the performance of primary and specialised health care, which is its strength, since register data on primary health care is usually not comprehensive enough for research purposes in Finland, at least at the present moment.

This approach has been used mainly in studying time trends, regional differences, gender differences, and socioeconomic differences (Mackenbach et al., 1990; Westerling, 1992; Westerling, 1993; Westerling and Rosen, 2002; Westerling, 2003). Time trend studies can be used to compare changes between amenable and non-amenable deaths as a pointer for influencing improvements in health care (e.g. Nolte and McKee, 2011; Simonato et al., 1998). Regional differences may reflect the availability of health services and differences in effectiveness between regions or countries (e.g. Charlton et al. 1983; Manuel and Mao, 2002; Plug et al., 2012; Poikolainen and Eskola, 1988; Schoenbaum et al., 2011). Monitoring socioeconomic differences in amenable mortality, on the other hand, can provide useful information on changes in socioeconomic differentials in health care and in effectiveness (Schwarz and Pamuk, 2008). It has been used in several studies measuring socioeconomic equity (e.g. McCallum et al., 2013; Poikolainen and Eskola, 1995; Stirbu et al., 2010; Westerling et al., 1996; Wood et al., 1999).

Amenable mortality has also been used to study trends in socioeconomic inequity in health care. Only one of these studies (Schwarz and Pamuk, 2008) — using relative equity measures and socioeconomic position measured at the individual level — has been from elsewhere than Finland (Manderbacka et al., 2014b; McCallum et al., 2013). Trends in socioeconomic differences in amenable mortality have also been studied in absolute terms and socioeconomic position measured at the individual level (Marshall et al., 1993; Schwarz and Pamuk, 2008; Tobias and Yeh, 2009).

This indicator is powerful compared to analysing merely the use of health care. It can (indirectly) capture those who did not receive health care at all or whose treatment was inadequate. As a limitation, this indicator does not take the changes in morbidity or differences between socioeconomic groups (or other population groups) into account. However, inequities in the use of and access to health care may have an influence on the incidence of subsequent disease. Additionally, some of the amenable causes are such that deaths from these conditions do not occur at all or only rarely, at least in Finland.

4.4 RESULTS ON SOCIOECONOMIC EQUITY IN HEALTH CARE

EQUITY IN REVASCULARISATIONS

There is a large body of research since the 1990s on socioeconomic equity in revascularisations. The results have generally been consistent: the higher the socioeconomic position the larger the likelihood of revascularisation. Keskimäki et al. (1997) and Hetemaa et al. (2003) found significant inequities in CABG favouring the higher socioeconomic groups among both genders in 1988 in Finland. Hetemaa showed that the inequities (in both CABG and PTCA) diminished somewhat up to 1996, but remained significant. Further, Hetemaa et al. (2006) saw marked differences in revascularisations between socioeconomic groups among both genders in the period 1995–1998. Vehko et al. (2010) found that socioeconomic inequities in the first cardiac operations among CHD patients remained from 1995–1996 to 2001–2002 in Finland. Haglund et al. (2004) detected occupational inequities in access to CABG among men from 1991 to 2000 in Sweden, but did not find socioeconomic inequalities among women.

Some studies have investigated how the increasing resources have affected equity. Hetemaa et al. (2003) conclude that despite a substantial increase in coronary procedures, socioeconomic inequities diminished only somewhat between 1988 and 1996 in Finland. They also found that in regions where overall revascularisation rates are highest, the services were more equitably distributed across socioeconomic groups. Manson-Siddle et al. (1999) came to the same finding. Haglund et al. (2004) detected diminishing inequalities between occupational groups with increasing resources.

Keskimäki et al. (1997) detected somewhat higher inequity favouring persons in a higher social position among younger male patients compared to older male patients in the use of coronary artery bypass grafting when using IHD mortality as a proxy for need in 1988 in Finland. They also found slightly greater inequity favouring white collar employees among the older female patients. Hetemaa et al. (2003) observed, also in Finland, higher inequity (favouring white collar employees) in revascularisations when using IHD mortality as a proxy for need among younger patients compared to older patients among both genders in 1996.

EQUITY IN MORTALITY AMENABLE TO HEALTH CARE INTERVENTIONS

Results on socioeconomic differences in amenable mortality are similar. Marshall et al. (1993) observed strong and persisting social class gradients in mortality from causes of death amenable to medical intervention in 1975–1977 and 1985–1987 in New Zealand. Tobias and Yeh (2009) found significant but decreasing absolute differences between income groups in amenable mortality in the period 1981–2004 in New Zealand. Poikolainen and Eskola (1995) perceived occupational social class differences in amenable mortality in the period 1980–1986 in the City of Helsinki. McCallum et al. (2013) detected marked and increasing relative income differences in amenable mortality in the period 1992–2003 in Finland. The results of Lehikoinen et al. (2016) corroborated this finding, covering the period 1992–2008 in Finland. Manderbacka et al. (2014b) also found steepening income differences in Finland from 1992–2008 and discovered even worse outcomes among those in a poor labour market position or living alone. Westerling et al. (1996) observed large differences in avoidable mortality between occupational classes in the period 1986–1990 in Sweden. Wood et al. (1999) demonstrated a clear socioeconomic gradient in mortality from avoidable causes in British Columbian males. Schwarz and Pamuk (2008) found significant and increasing absolute and relative educational inequities in some amenable causes from 1981–1982 to 1991–1992 in Austria. Schwarz (2007) calculated relative inequities using the RII in 1991–1992 in Austria and found educational differences in amenable mortality.

Additionally, he estimated cause-specific contributions to absolute overall mortality differentials by selected groups of causes of death (neoplasms, circulatory, other, external causes). Stirbu et al. (2010) found educational inequalities in amenable mortality in all countries of Europe. For some countries, they had a long follow-up time (from 1990 to 2000) but for one country only from 1996 to 1997.

4.5 REMARKS ON EARLIER RESEARCH USING REGISTER DATA

Several conclusions can be drawn from earlier research on socioeconomic equity in health care using register data. Even though the vast majority of equity research in health care has utilised survey data, register studies have a strong status in this field. There are, however, several deficiencies to be addressed.

1) Developments in the methodology of equity have concentrated on survey data. In particular, the uncertainty of the equity estimates has been discussed only in studies concerning survey data.

2) Additionally, the existing methodology of studying trends in equity in health care by carefully utilising the socioeconomic distribution is not well developed.

3) Evaluation of the need for care in register studies is not straightforward. There are survey studies on absolute equity in health care than take the need for care into account, the need evaluated as self-perceived health status, or the presence of chronic disease (Palència et al., 2013; Sözmen et al., 2008). As noted earlier, self-reported health status is prone to reporting biases and the judgement of the need for care is not clinical. Thus, it is not fully clear how it actually matches the clinical need for care. In register studies the need for care is usually evaluated using morbidity indicators that are available at group-level and thus does not describe the actual individual need for care either. Additionally, in absolute differences a problem arises from the scale difference between the use and the need of care variables. This induces a challenge in measuring absolute equity in health care that takes the need for care into account using register data.

4) Cause-specific contributions to socioeconomic equity in health care in relative terms have not been estimated. Studies by Schwarz (2007) and the New Zealand Ministry of Health (Ministry of Health, 2010) have presented cause-specific contributions to socioeconomic inequities in amenable mortality in absolute terms. The study by the New Zealand

Ministry of Health, however, used socioeconomic position by small area deprivation level.

5) There is also an obvious lack of recent studies addressing age differences and regional differences in socioeconomic equity in access to coronary revascularisations using register data with socioeconomic position measured at the individual level.

6) There are only a few studies examining the effect of the increasing supply of coronary care on socioeconomic equity taking the need into account, although the increase in the PCIs have been vast in many countries.

7) Hetemaa et al. (2003) compared socioeconomic equity in coronary operations in 1988 and 1996 taking the need for care into account. Vehko et al. (2010) assessed socioeconomic equity in first cardiac operation among CHD patients in 1995–1996 and in 2001–2002. Haglund et al. (2004) studied differences between high-grade non-manual and unskilled manual workers in access to CABG for those treated for IHD in Sweden between 1991 and 2000. Apart from these studies, there are no studies on trends in socioeconomic equity in coronary care that take the need for care into account using register data in which socioeconomic position is measured at the individual level.

8) Only a few studies have examined trends in socioeconomic inequity in amenable mortality using relative measures. The used measures in studies examining trends in equity in amenable mortality have been rather traditional. The shortage of these ‘traditional’ measures is that they do not exploit the socioeconomic distribution comprehensively in the analyses. For example, the concentration index has not been utilised in any study.

Registers provide an excellent source of data for equity research and usage of register data will increase in the future. However, improved statistical approaches are needed to draw more accurate estimates of equity and to exploit register data more carefully.

5 AIMS

This thesis aims to utilise register data in measuring socioeconomic equity in health care. This study sheds light on measuring equity from different angles and provides methodological tools to study equity in health care in more detail. The concentration index is used as a measure of equity throughout the thesis and developing the statistical methodology of this index to suit register data is the primary goal. At the same time, empirical results provide more timely and comprehensive information on the state of equity in the Finnish health care.

The specific study questions are:

1) How to compare regional differences in the distribution of health service utilisation in terms of socioeconomic equity while also taking into account dependence within these regions? (Study I)

2) How can trends in absolute and relative horizontal equity in health care be studied utilising the socioeconomic distribution comprehensively using register data? (Study II)

3) How can the uncertainty of the inequity measures be estimated using register data? (Study III)

4) How can the extent of and trends in socioeconomic equity in the effectiveness of health services be evaluated? How can the contribution of different levels of health care provision on equity in effectiveness be assessed? (Study IV)

A relative index of equity, the concentration index, is used in all of the studies as a measure of equity, but an absolute inequity index, the slope index of inequality, is also applied in Studies II and IV to study absolute inequities and the connections between these measures.

6 MATERIALS AND METHODS

6.1 DATA

This thesis applied two examples of health care outcomes in measuring socioeconomic equity in health care: the use of coronary revascularisations and mortality amenable to health care interventions. Study I and Study II used revascularisations as an empirical example of an outcome in utilising register data. In Study I, the setting was cross-sectional and in Study II it was longitudinal. Study III and Study IV had amenable mortality as an empirical example and the setting was longitudinal. The used datasets are summarised in Table 1.

The studies are based on linked register datasets. By means of the patients' unique personal identity numbers, data on revascularisations and amenable mortality were linked to the population Censuses and the Employment statistics of Statistics Finland for data on individual demographic and socioeconomic factors, including gender, age, income, and region of residence.

CORONARY REVASCULARISATIONS

In addition to lifestyle changes and medical therapy, IHD is treated with coronary revascularisations. The two primary methods of revascularisations are coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI). In PCI, the obstructed coronary is widened mechanically. An intracoronary stent is usually placed in the coronary after dilatation. CABG is more complex than PCI and involves redirecting the blood supply around the obstructed area to improve oxygen and blood flow to the heart.

Compiling the datasets

The study population comprised all resident Finnish men and women aged 45–84 years. The datasets on coronary revascularisations were based on register data on PCIs and CABGs. Information on revascularisations was obtained from the Care Register for Health Care (CRHC) from THL. According to the population registers, people living in institutions were excluded from the datasets. Such exclusions were mainly due to long-term inpatient care. For people registered as institutionalised, income information may be inadequate and not comparable with the general population (Keskimäki et al., 1995; Epland and Törmälehto, 2007).

The need for care

In Finland, there are large socioeconomic and regional differences in IHD morbidity and IHD mortality. Additionally, IHD morbidity is strongly dependent on age, which indicates large variations in the need for CHD treatment. Study II used IHD mortality and Study I used both IHD mortality and IHD incidence as proxies for relative differences in need for coronary intervention between age, income groups, and regions. The number of IHD deaths of the resident population in Finland was obtained from the Causes of Death statistics maintained by Statistics Finland.

Need for care was approximated separately for different age groups, income groups and regions. IHD incidence in the period 2001–2003 was specified using a composite indicator consisting of three specific indicators of IHD morbidity available at the individual level: (1) entitlement to elevated reimbursements for IHD medicines (information from the SIIF), or (2) hospitalisation due to AMI (information from the CRHC), or (3) IHD as an underlying cause of death. To compile the group of incident IHD patients, those with a prior history of IHD were excluded, i.e. patients entitled to special reimbursement for IHD medicines or patients who had an AMI in the period 1990–2000.

MORTALITY AMENABLE TO HEALTH CARE INTERVENTIONS

The concept of mortality amenable to health care interventions is based on the idea that certain deaths could be avoided if there had been more effective and timely health care interventions in place. The selection of causes of death considered amenable to health care focuses on conditions for which effective clinical interventions exist in people aged less than 75 years. Additionally, for some causes of deaths, lower age limits are defined. Amenable mortality provides some indication for the quality and performance of health care.

Compiling the datasets

The study population consisted of deaths amenable to health care interventions in Finland. By means of unique personal identity codes, the information on mortality came from the Causes of Death statistics compiled by Statistics Finland. In this thesis, an adaptation of classifications by Page et al. (2006) and Nolte and McKee (2008) was used (see Appendix A in the original publication of Study IV). Causes of death (as an underlying cause) were coded according to the ICD-9 for the period 1992–1996 and ICD-10 for the period 1996–2008. IHD was not included, as the precise contribution of health care to deaths or reduction of deaths from this condition cannot be defined. Additionally, deaths due to ‘accident or misadventure due to health care’ were not included since these deaths are not classified separately in the

Finnish Causes of Death statistics. However, those deaths represent a small fraction of all amenable mortality (Nolte and McKee, 2004).

Due to data protection regulations the research group received the data compiled from individual-level registers in tabulated form. Thus, the final data sets included records on deaths grouped by other variables including gender, year, family income, and age. In Study III, age was grouped from 1 to 4 years and then in five-year age bands.

In Study IV the categorisation used by Simonato et al. (1998) was modified and updated to estimate the contributions of levels of interventions to the overall equity. The main groups comprised here were causes of death attributable to specialised and primary care interventions. This refined categorisation allowed for studying the Finnish health care system in more detail. Treatable conditions were divided by the main site of a potentially effective intervention: specialised health care (SHC) and primary health care (PHC). PHC includes outpatient care administered by general practitioners, and it was further subdivided into three groups according to the timing of the interventions: (1) primary prevention, (2) early detection and treatment and (3) improved treatment and medical care. This grouping of the place and timing of potentially effective interventions is somewhat arbitrary but it is assumed that it has a descriptive value to indicate the sector of weaknesses in the health care system that is to be analysed further.

SOCIOECONOMIC POSITION

Disposable family income was used as an indicator for socioeconomic position in all studies. The family net income was adjusted for family size using the OECD modified equivalence scale (OECD, 1982). Information on income was obtained from annual Employment Statistics collected by Statistics Finland, based on tax administration data. The income record for the year before the studied event (revascularisation or death) was used. The income information was further grouped based on the annual Finnish income distribution. The same income limits were applied for men and women. Studies I, III, and IV used income categorised into 20 income groups by the fifth percentiles of the annual Finnish income distribution, and Study II used two categorisations: 5 and 20 income groups.

REGION

Study I used hospital districts, based on the administrative division of the Finnish hospital care system, as an indicator of the region of residence. One hospital district was excluded due to low numbers of events. The information on hospital district for the year before the revascularisation was used. Study II used University hospital district as the indicator of region.

POPULATION AT RISK

To estimate rates of revascularisations and amenable mortality, information on the population at risk was needed. Person years of the Finnish residents were received from Statistics Finland in tabulated form due to data protection regulations. Person years were aggregated by year, gender, age, income group, and region of residence using restrictions described in Table 1 (Study population, years, and age). Age was grouped in five-year age bands.

Table 1. *Summary of datasets Studies I-IV*

Study	Setting	Study population	Years	Age	Outcome	Need for care	Data manipulation
I	Cross-sectional study combining individual-level register data from the CRHC, population censuses, employment statistics, the Causes of Death Register, and statistics on reimbursements for medical expenses	Non-institutionalised Finnish residents	2001–2003	45-84	Coronary revascularisations (CABG and PCI)	IHD mortality and IHD incidence (those with a prior history (1990–2000) of IHD were excluded)	Individual-level data tabulated by gender, age and income groups, and hospital districts for analyses. Data from years 2001–2003 were pooled. Men and women analysed separately.
II	Longitudinal study combining individual-level register data from the CRHC, population censuses, employment statistics, and the Causes of Death Register	Non-institutionalised Finnish residents	1995–2010	45-84	Coronary revascularisations (CABG and PCI)	IHD mortality	Individual-level data tabulated by gender, year, age and income groups, University hospital district for analyses. Data was divided into two age groups (45–64 and 65–84) in some analyses. Men and women analysed separately.
III	Longitudinal study combining individual-level register data from population censuses, employment statistics, and the Causes of Death Register	Finnish residents	1996–2008	1-74	Mortality amenable to health care interventions (see Appendix A in the original publication of Study IV for causes of deaths)	–	Individual-level data tabulated by gender, year, age and income groups for analyses. Age was grouped from 1 to 4 years and then in five year age bands. Men and women analysed separately.
IV	Longitudinal study combining individual-level register data from population censuses, employment statistics, and the Causes of Death Register	Non-institutionalised Finnish residents	1992–2008	25-74	Mortality amenable to health care interventions divided into specialised health care and primary health care which was further subdivided into three groups	–	Individual-level data tabulated by gender, year, age and income groups for analyses. Men and women analysed separately.

6.2 STATISTICAL METHODS

Statistical analyses were based on multidimensional tabulations of the primary outcomes (revascularisations and amenable mortality) and other factors, including confounding variables. Men and women were studied separately because IHD morbidity, the use of revascularisations, and amenable mortality vary considerably between genders.

For some analyses, annual crude rates (per 100000 person years) in each age and gender groups were calculated for the outcome variables, revascularisations, and IHD mortality, and amenable mortality. Age-standardised rates (per 100000 person years, the direct method) using the European population as the standard were calculated by income quintiles and by 20 income groups. In Study I, III, and IV, the old version of the European standard population was used (Waterhouse et al., 1976) and in Study II the new version (Eurostat, 2013). Income quintiles were used in the preliminary analyses and in the graphical presentations and 20 income groups in more detailed analyses of socioeconomic equity.

The linear dependence between income and annual rates of the outcome variables were tested separately for each year by fitting a linear regression line across the outcome rates for the income groups. If the slope of the model significantly differed from zero, a linear dependence was interpreted to exist.

The statistical significance of the difference between two income group-specific rates of the outcome variables at a specific time and the change in the overall level of the outcome variables during specific years was tested using the rate ratio approach.

For more detailed analyses of socioeconomic disparity, equity was measured with inequity indices. As a relative measure C and as an absolute measure the SII was used. In these analyses, 20 income groups were applied.

Multilevel modelling was used in Study I. It is a regression-based analysis that takes the hierarchical structure of the data into account. In these analyses, 2-level model assuming random intercepts and slopes was applied, with income as the level 1 variable and region as the level 2 variable.

The statistical analyses were performed using SAS (SAS Institute Inc., Cary, NC, USA) software, versions 9.1, 9.2 and 9.3.

6.3 ETHICAL ISSUES

According to Finnish legislation, register data containing individual-level information allowing direct identification (e.g. personal identification code) can be provided for scientific purposes given that it is necessary for forming the data. However, data enabling direct identification needs to be removed from the data as soon as it is no longer necessary (Henkilötietolaki 22.4.1999/523). Ethical consent for the studies was given by the Research Ethics Committees of STAKES (National Research and Development Centre for Welfare and Health) or THL. The permissions to use the data for the project were given by each competent register authority. The linkages of the several datasets were performed by the competent authorities and the datasets received for research use were anonymised.

7 RESULTS

7.1 MULTILEVEL MODELLING OF REGIONAL VARIATION IN EQUITY

In Study I, the concentration index (C) was developed further to provide an equity measure to assess variations in socioeconomic inequities in the use of health services in relation to need in different regions.

The estimation of C is based on the concentration curves; Kakwani (1980) formalised this method to calculate it using linear regression. The horizontal inequity index HII is defined by comparing the distributions of health care and the need for care among socioeconomic groups and can be estimated as, $HII = C_m - C_n$, where C_m is the concentration index for health care and C_n is the concentration index for the need of care. When studying horizontal equity, the need for care should be properly taken into account, since the use of care and the need for care often vary widely between age and income groups. The method developed in this study takes this imbalance into account. This modified method is denoted by HII_m and is defined as:

$$HII_m = \left[2\sum_{g=1}^{G} \left(f_g R_g \frac{y_g}{y_g^*} \right) - 1 \right] - \left[2\sum_{g=1}^{G} \left(f_g R_g \frac{x_g}{x_g^*} \right) - 1 \right],$$

where y_g^* is the expected value of the health care variable in the g th SEG, x_g is the value of the need variable in the g th SEG and x_g^* is its expected value. Here y_g and x_g are actual values of these variables (i.e. number of events), not rates. The expected values y_g^* and x_g^* are calculated for the g th SEG using health care and need variable rates in each age group i as $y_g^* = \sum_{i=1}^{I} (Y_i py_{ig})$ and $x_g^* = \sum_{i=1}^{I} (X_i py_{ig})$, where Y_i is the observed rate of the health care use variable in the i th age group, X_i is the observed rate of the need variable and py_{ig} is the number of person years in the g th SEG and the i th age group. The expected number of health care events in the i th age group then equals the observed number of events in that age group. So, one assumption of this model is that the number of health care events is appropriate for each age group.

In many cases the use of care and the need for care also vary between regions. To also take this into account, the HII_m was defined separately for each region j as:

$$HII_{m.j} = \left[2\sum_{g=1}^{G} \left(f_{gj} R_{gj} \frac{y_{gj}}{y_{gj}^{*}} \right) - 1 \right] - \left[2\sum_{g=1}^{G} \left(f_{gj} R_{gj} \frac{x_{gj}}{x_{gj}^{*}} \right) - 1 \right].$$

Now $\sum_{g=1}^{G} y_{gj}^{*} = \sum_{g=1}^{G} y_{gj}$ and $\sum_{g=1}^{G} x_{gj}^{*} = \sum_{g=1}^{G} x_{gj}$, i.e. the total number of expected health care events equals the total number of observed events in each region, and the same applies for the total number of the need variable. Additionally, it is assumed that in region j the expected number of health care and need events in the i th age group equals the observed number of events in that age group.

Next, the regression-based approach to calculate C was extended to calculate concentration indices for different regions using multilevel regression modelling. This allows for modelling the variance of regional horizontal inequity indices between regions. The $HII_{m.j}$ for different regions can now be estimated with one multilevel regression model as:

$$\left[2\sigma_{R_j}^{2} \left(\frac{y_{gj}}{y_{gj}^{*}} - \frac{x_{gj}}{x_{gj}^{*}} \right) \right] f_{gj} = (\beta_0 + u_{0j}) f_{gj} + (\beta_1 + u_{1j}) R_{gj} f_{gj} + e_{gj},$$

where $\sigma_{R_j}^{2}$ is the weighted variance of the rank R_{gj}, defined for region j as $\sigma_{R_j}^{2} = \sum_{g=1}^{G} f_{gj} \left(R_{gj} - \frac{1}{2} \right)^{2}$, and f_{gj} are the population shares for the g th SEG in region j. In this random coefficients model, the estimates of $(\beta_1 + u_{1j})$ are equal to the $HII_{m.j}$. Here β_1 is a fixed effect parameter and estimates the mean of the modified horizontal inequity indices and u_{1j} are random coefficients estimating the deviances from the mean for different regions. Population groups defined by income are the level 1 units and regions are at level 2 in the multilevel model.

The β_0 in the model is a fixed effect parameter and estimates the mean of the intercepts and u_{0j} are random coefficients estimating the deviances from the mean of the intercepts for different regions. These parameters are essential for the model but are not used to calculate the horizontal inequity indices.

Coefficients u_{0j} and u_{1j} are assumed to follow a multivariate Normal distribution with mean 0 and a covariance matrix Ω_u which has three components: var(u_{0j})=$\sigma_{u_0}^{2}$, var(u_{1j})=$\sigma_{u_1}^{2}$ and cov(u_{0j}, u_{1j})=$\sigma_{u_{01}}$. The variance $\sigma_{u_0}^{2}$ indicates the variation of regions around the mean intercept and $\sigma_{u_1}^{2}$ is the variance of the deviations u_{1j} from the mean inequity index β_1. As such $\sigma_{u_1}^{2}$ is the variance of the inequity indices of regions around β_1.

Empirical examples and equity results

A total of 26642 PCIs and CABGs were performed on patients aged 45–84 in Finland in the period 2001–2003. Over 70% of these procedures were on men. During the study period, the annual population at risk averaged 2091617 person years (of which 47% were men). Across the study areas, the equivalent number of persons varied from 9117 to 86787 for men and 10017 to 116321 for women. The overall 3-year revascularisation rate (per 100 000 person years) was 653 (men) and 224 (women) in the period 2001–2003. Between areas, these rates varied from 412 to 892 for men and from 125 to 344 for women.

For men, the HII for the whole of Finland estimated using a multilevel model was 0.089 (95% CI 0.076–0.102) when IHD incidence was used as a proxy for need and 0.208 (0.186–0.231) using IHD mortality as a proxy for need. For women, the indices were 0.049 (0.026–0.072) and 0.129 (0.097–0.161) respectively. Since the values of the HII were positive and significantly greater than zero, clear evidence of inequity in the use of revascularisations favouring the better off in 2001–2003 in Finland was found. The results were firm among both genders and regardless of which measure (IHD incidence or IHD mortality) was used to approximate the need for care. Coronary interventions were more equitably distributed between income groups for women than for men. There was little correlation between horizontal inequity indices for men and women, which may reflect gender differences in service provision. Furthermore, this study detected minor differences in inequity between regions, particularly in men.

Additionally, correlation coefficients between the overall area revascularisation rate and the rate ratio of the lowest income quintile compared with the highest were not significant (r=0.369 men; r=0.095 women), indicating insignificant association between high provision and socioeconomic equity between regions.

7.2 TRENDS OF RELATIVE AND ABSOLUTE SOCIOECONOMIC EQUITY

The evaluation of horizontal equity in health care using register data is not straightforward in cases where the need for care cannot be assessed clinically on a case-by-case basis. In register studies, it is common to use proxy measures that are at an aggregated level to take the need for care into account. In these cases, the use of care and the need for care variables are measured on different metrics.

Relative horizontal equity is not sensitive to possible differences between the scales of the use and the need variables. Pure scale difference exists when there is direct information available on the need for care whereas difference between metrics occurs in the case of indirect evaluation of the need for care.

The numerical solution for the scale and metrics difference is the same for both cases. But the interpretation of the results is somewhat different. Using proxy indicators for the need for care gives indirect estimates for horizontal equity.

The existing methods for measuring absolute differences do not provide solutions for evaluating absolute inequity numerically in health care taking the need for care into account using register data and proxy variables for the need for care. Study II proposes a non-numerical approach to evaluate absolute horizontal equity. Due to differences in metrics or scales of the use and need variables, this approach compares the tendency of equity and do not try to give numerical values for equity. In this approach, absolute differences are estimated separately in the use of health care and in the need for care indicators using an absolute equity measure. Differences in the use of care favouring the lower socioeconomic groups (i.e. people with lower socioeconomic position would use more health services) is denoted as 'LOW' and differences favouring the better-off as 'HIGH'. Differences in the need for care favouring the lower socioeconomic groups (i.e. people with lower socioeconomic position are in less need of health services) is denoted similarly as 'LOW' and vice versa. It is important to note that the need for care is evaluated using ill-health and thus a negative value of an absolute measure for the need for care variable means 'HIGH' -situation, whereas a negative value of an absolute measure for the use of care variable indicates a 'LOW' -situation. All possible situations are illustrated in Table 2.

Table 2. *Absolute horizontal equity in health care*

Case no.	Differences in use of care favouring		Differences in need for care favouring		Absolute horizontal equity
1	NO	+	NO	=	EQUAL
2	NO	+	LOW	=	INEQUITY PRO LOW
3	NO	+	HIGH	=	INEQUITY PRO HIGH
4	LOW	+	NO	=	INEQUITY PRO LOW
5	LOW	+	LOW	=	INEQUITY PRO LOW
6	LOW	+	HIGH	=	A
7	HIGH	+	NO	=	INEQUITY PRO HIGH
8	HIGH	+	LOW	=	B
9	HIGH	+	HIGH	=	INEQUITY PRO HIGH

Equity

A: If the value of an absolute inequity index for use is smaller than for need, i.e. |use| < |need| then PRO HIGH. If |use| > |need| then PRO LOW. If |use| = |need| then EQUAL.

B: If |use| < |need| then PRO LOW. If |use| > |need| then PRO HIGH. If |use| = |need| then EQUAL.

If the distributions are equal across socioeconomic groups in the use and the care variables (case no. 1), the evaluation of the absolute horizontal equity is unambiguous. In cases where differences are found in the distribution of the use or the need for care variable, the differences must be significant to approximate the absolute horizontal distribution as significantly inequitable (case nos 2-9).

In cases 6 and 8, the evaluation of the absolute horizontal equity depends on the situation, due to differences of the scales of the use and need variables. Additionally, absolute differences do not take into account the discrepancy between the levels of the use of care and the need for care. Thus, in cases where the overall levels are very different, the existence of inequity can be assessed but the magnitude of the inequity cannot be evaluated rationally.

Moreover, the means to evaluate trends in absolute horizontal equity was discussed by applying further the abovementioned non-numerical approach. This approach can be used to study whether the change in absolute trend has been favourable or not. Absolute differences in the use of health care and in the need for care are estimated separately using an absolute equity measure at the beginning of the follow-up and at the end of the follow-up. This approach describes how the absolute differences between the use and the need for care have changed. It is important to notice that this approach draws conclusions on absolute equity in health care, not for example equity in health.

The value for the use for care measured with the absolute equity measure at the beginning of the follow up is denoted as $use1$ and the value for the need for care at the beginning of the follow up is denoted as $need1$ and values at the end of the follow-up are denoted as $use2$ and $need2$.

Now,

If $|use1 - need1| = |use2 - need2|$, then the state of equity has not changed
If $|use1 - need1| < |use2 - need2|$, then inequity has increased
If $|use1 - need1| > |use2 - need2|$, then inequity has decreased

If $(use2 - need2) > 0$, then inequity exists favouring the better-off
If $(use2 - need2) > 0$, then inequity exists favouring the worse-off

Empirical example and equity results

In Study II, data on coronary revascularisations were used to empirically study changes in health care taking need into account. The total number of performed coronary revascularisations was 4103 among men and 1373 among women in 1995 in Finland. The majority of the performed interventions were CABGs. Resources for coronary interventions increased markedly and by 2010, the overall supply had nearly doubled and the share of PCIs accounted for over 70% of all revascularisations among both genders.

IHD mortality was used as a proxy for the need for coronary revascularisations in this Study. Figure 3 shows age-standardised rates (per 100000 person years) for revascularisations and IHD mortality in the period 1995–2010. During this period, IHD mortality rate declined substantially, whereas the revascularisation rate increased.

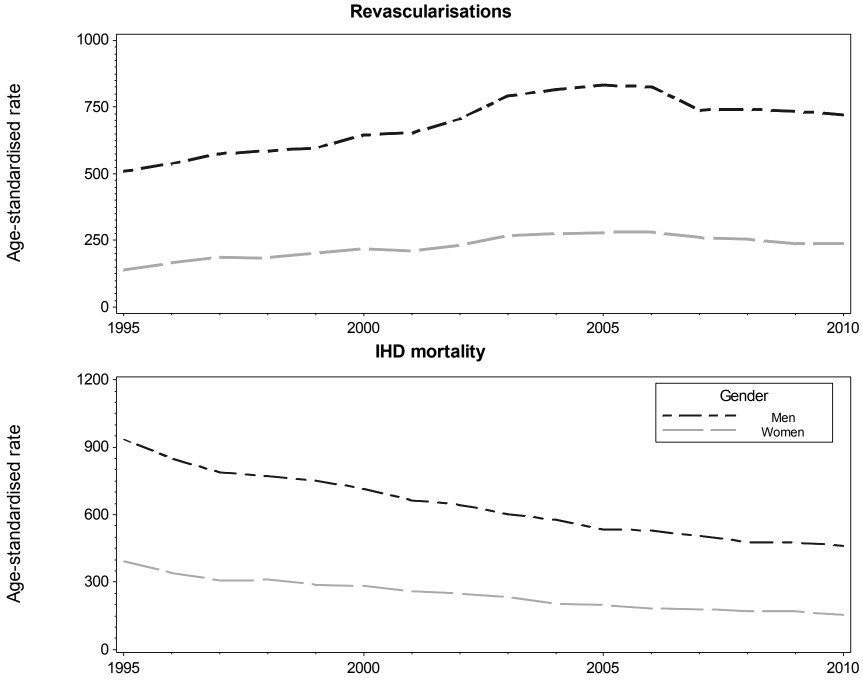


Figure 3 Age-standardised coronary revascularisation and ischaemic heart disease (IHD) mortality rates (per 100000 person years) in the period 1995–2010 in Finland

The change in revascularisation and IHD mortality rates was not, however, similar across income groups in the period 1995–2010 (Figure 4). To study the socioeconomic distribution of revascularisations and IHD mortality in more detail, C was used. In 1995, C for revascularisations was -0.00 (95% CI -0.02 to 0.01) among men, indicating an equal distribution and -0.03 (-0.07 to 0.00) among women, indicating minor differences favouring the low-income patients. There was a clear decreasing trend (p-values < 0.0001) and by 2010 C was -0.08 (-0.09 to -0.07) among men and -0.14 (-0.17 to -0.12) among women. In 1995, C for IHD mortality was -0.14 (-0.16 to -0.12) among men and -0.15 (-0.17 to -0.12) among women, indicating clear differences, with lower mortality among the better-off. Relative differences increased further (p-values for trend < 0.0001) over time and in 2010 C for IHD mortality was -0.26 (-0.28 to -0.24) among men and -0.25 (-0.28 to -0.21) among women.

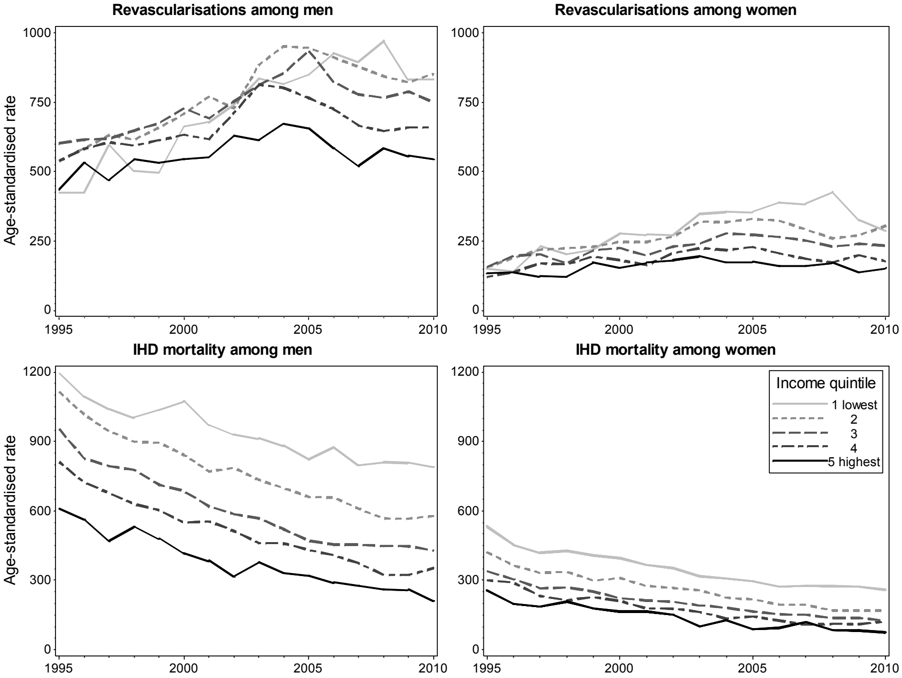


Figure 4 Age-standardised coronary revascularisations and ischaemic heart disease (IHD) mortality rates (per 100000 person years) by income quintile in the period 1995–2010 in Finland

In addition to income groups, the need for coronary interventions varies by gender, age, and region. This was taken into account when estimating relative equity, while the need for revascularisations was evaluated separately for each age and income group and region. This was carried through using the HII as a measure for relative horizontal equity and the method developed in Study I, which allowed us to study whether the varying levels of need between regions had an influence on equity at the national level. When using proxy indicators for the need for care, it is possible to compare distributions of the use of care and the need for care variables measured using different metrics and estimating relative horizontal equity using the HII. The confidence intervals for the HII were estimated using the approach developed in Study III and 20 income groups were used when estimating equity. In 1995, the HII was 0.15 (95% CI 0.12 to 0.18) among men, and 0.10 (0.06 to 0.15) among women. In 2010, the HII was 0.18 (0.16 to 0.21) among men and 0.12 (0.08 to 0.17) among women, but the trend was not significant.

Absolute differences in the use of coronary revascularisations and IHD mortality were estimated using the SII. The confidence intervals for the SII were estimated using the approach developed in Study III and 20 income groups were used in these analyses. Next, trends in absolute equity were evaluated. In 1995, the value of the SII for revascularisations was -12 (95% CI -64 to 39) among men and -30 (-58 to -1) among women. During the study period, the SII decreased significantly (p-values < 0.05), and in 2010 the SII was -340 (-395 to -283) among men and -195 (-226 to -163) among women. In 1995, the SII for IHD mortality was -760 (-860 to -657) among men and -318 (-368 to -266) among women, indicating evident inequity favouring the better-off. There was a slight improvement in absolute equity over time and in 2010 the SII was -681 (-738 to -623) among men and -211 (-241 to -179) among women. Among men the trend was not significant (p = 0.165), but among women it was significant (p-value < 0.0001). Now since $|use1 - need1| > |use2 - need2|$ among both genders, inequity has decreased. Since the changes in the absolute distributions of both the supply and the need for coronary care have favoured the low-income groups, it can be stated that the trend is good and absolute inequity has decreased, despite the lack of a meaningful numerical value for inequity.

In 1995, there were no age differences in relative equity in revascularisations when taking the need into account among women, but inequity increased significantly among younger age groups during the study period, resulting in significant age differences in equity among both genders. However, inequity remained at the same level in the older age groups between 1995 and 2010.

In 1995, there were clear age differences in absolute horizontal equity among both genders. The difference $|use1 - need1|$ was positive and markedly greater than zero in both age groups among men, indicating inequity favouring the better-off. Among women, the difference $|use1 - need1|$ was positive in both age groups but markedly greater than zero only in older age groups. During the study period, the absolute inequity decreased in both age groups, although the decrease was greater in older age groups, resulting in smaller differences between age groups in equity in 2010 among men. However, absolute horizontal inequity remained in both age groups in 2010 among men. Among women the decrease was significant in older age groups, resulting in smaller differences between age groups in equity in 2010. In younger age groups, the absolute equity remained at the same level.

7.3 THE CONFIDENCE INTERVALS FOR THE INEQUITY INDICES

Study III developed a method for assessing the uncertainty of the inequity measures using register data. The method was developed primarily for the concentration index but it is applied also to the HII and the SII. The approach was used to estimate the confidence intervals for the HII and the SII in Study II, but the implementation is introduced in this chapter.

This study developed five different Monte Carlo simulation techniques to estimate the confidence interval for C using aggregated register data. These simulation techniques differ from each other in distributional assumptions and in the phase of the simulation process. The biasing effect of a correlation between the rank ($R_g = \sum_{\gamma=1}^{g-1} f_\gamma + 0.5 f_g$) and the health care outcome variable (y_g) is avoided in these techniques because the standard error is not estimated from the regression model, but the uncertainty of C is simulated using the original data.

Technique 1 - MC

In this technique, a simple assumption of uncertainty around the dependent variable $2\sigma_R^2 (y_g / y)$ in equation $\left[2\sigma_R^2 \left(\frac{y_g}{y} \right) \right] f_g = \beta_0 f_g + \beta_1 R_g f_g + e_g$ is made. That uncertainty is accounted for by assuming $2\sigma_R^2 \frac{y_g}{y} \sim N(\mu_g, \sigma_g^2)$, where the mean μ_g is the observed value of $2\sigma_R^2 \frac{y_g}{y}$ from the data and the variance σ_g^2 is the observed value of $\left(2\sigma_R^2 \frac{y_g}{y\sqrt{n_g}} \right)^2$, with n_g being the number of health care events in the gth SEG. Next, C is re-estimated by replicating the regression estimation N times (for example 10 000 times) to account for the uncertainty. The lower and upper limits of the 95% confidence interval of C are obtained as the 2.5 and 97.5 percentiles of the distribution of the simulated slopes.

Technique 2 - BIN

In this technique, more assumptions are made and the MC technique is developed further to model the uncertainty in more detail. A requirement for independence of the error terms is not needed, since this method does not use errors estimated from a regression. It repeats the estimation of C by allowing some variability in the health outcome by SEGs and also in the total number of health care events. This technique can be used in the regression method in addition to the formula method to estimate C. The variability is approximated from the data with the following assumptions and steps:

1) The observed p_{ig} (the population size), the denominator of the rate, is held fixed in the simulation. This is based on the assumption that the information on age and person years in the registers is perfect.

2) The second assumption concerns the health care events, which are treated as being random. The number of events is allowed to vary due to the

fact that there is some error in the coding of the events. The observed total number of events in age group i is the sum over SEGs $\sum_{g=1}^{G} d_{ig} = D_i$.

3) The number of events is allowed to vary between SEGs within the age group. This is permitted because the income information presumably does not exactly measure the person's real wealth. It might not describe the real wealth level of a person since all assets are not recorded in the administrative registers. Income is obtained from multiple administrative sources and, in addition, may vary considerably even over a short period. The random variables X_{ig} indicate the simulated number of events in group ig. The X_{ig} follow a binomial distribution $X_{ig} \sim B(D_i, \rho_{ig})$. The denominator D_i is the same for all SEGs within the same age group. Probabilities ρ_{ig} (with the constraints that $\sum_{g=1}^{G} \rho_{ig} = 1$ and $0 \le \rho_{ig} \le 1$) are estimated from the observed data: $\rho_{ig} = {d_{ig}}\big/{D_i}$.

4) Simulation step 3) is repeated N times (for example 10 000 times), thus N is the number of desired sets of observations sampled from the distribution.

5) Next, N sets of age-adjusted rates are calculated using the simulated number of events, the observed person years at risk from the data set and the weights from the standard population.

6) Now N values of C are calculated using the regression or the formula method from the simulated data yielding a distribution of C. The 2.5 and 97.5 percentiles of this distribution comprise the 95% confidence intervals for the C.

Technique 3 - POIS

The third technique is a simulation approach equivalent to BIN except that the number of events in the step 3) follows a Poisson distribution $X_{ig} \sim Pois(\lambda_{ig})$, where the parameter λ_{ig} is the observed number of events in a group ig.

Technique 4 - MN

In the fourth simulation technique the total number of events within age group D_i is held fixed. The number of deaths is, however, allowed to vary between SEGs within each age group. The random variable X_{ig} follows a multinomial distribution with parameters D_i and ρ, and mean $E\{X_{ig}\} = D_i \rho_{ig}$ with the constraint that $\sum_{g=1}^{G} X_{ig} = D_i$. The probabilities $\rho_i = \{\rho_{i1}, \ldots, \rho_{iG}\}$ (with constraints $\sum_{g=1}^{G} \rho_{ig} = 1$ and $0 < \rho_{ig} \le 1$) are estimated from the observed data: $\rho_{ig} = {d_{ig}}/{D_i}$.

Technique 5 – MC-rate

The fifth model (denoted as *MC-rate*) assumes the age-adjusted rates follow normal distributions $y_g \sim N(y_g, \frac{y_g^2}{n_g})$, and both methods (regression and formula) can be used to estimate the confidence interval for C. C is re-estimated N times (for example 10000 times) to account for the uncertainty. The lower and upper limits of the 95% confidence interval of C are obtained as the 2.5 and 97.5 percentiles of the distribution of the simulated slopes.

Confidence interval for the HII

The confidence interval for the HII can be estimated by applying the introduced techniques and using the assumption

$$\text{var}(HII) = \text{var}(C_m + C_n) = \text{var}(C_m) + \text{var}(C_n) - 2\,\text{cov}(C_m, C_n).$$

Confidence interval for the SII

The confidence interval for the SII can be estimated following the same idea as estimating confidence interval for C using technique 5. Now age-adjusted rates follow normal distributions $y_g \sim N(y_g, \frac{y_g^2}{n_g})$. The SII is re-estimated by replicating the regression estimation $y_g f_g = \beta_0 f_g + \beta_1 R_g f_g + e_g$ N times (for example 10000 times) to account for the uncertainty. The lower and upper limits of the 95% confidence interval of the SII are obtained as the 2.5 and 97.5 percentiles of the distribution of the simulated slopes.

Empirical example

As an empirical example, register data on deaths amenable to health care interventions were used. In 1996, the total number of deaths considered amenable to health care interventions in Finland was 4087, of which 52% occurred among men. The number of amenable deaths decreased evenly during the follow-up (p-value for linear trend < 0.01) and by 2008 there were 3012 amenable deaths (53% among men). In 1996, the overall age-standardized rate per 100000 person years was 102 among men and 75 among women, and 60 and 50 respectively in 2008. The average annual population (person-years) at risk was 4789000 during the follow-up.

Equity in amenable mortality was estimated using C. Confidence intervals for C were calculated using the five simulation techniques developed in this study. All simulation techniques yielded very similar results in relation to the lengths of the confidence intervals of C. The differences between the lengths of the confidence intervals were on average 0.0113 (min 0.0005, max 0.0130) among men and 0.0244 (min 0.0094, max 0.0354) among women. Thus, the results were consistent irrespective of the approach used or the parametric assumptions. Neither simulating events or rates instead of the outcome variable in the formula method to estimate C, nor using Binomial, Multinomial or Poisson distributions, nor keeping mortality fixed within the age groups, had any effect on the length of the confidence intervals. The distribution of the simulated data in the POIS technique, however, was inherently skewed to the right due to the low mean values among the young age groups and the high-income groups, causing asymmetric confidence intervals.

The results of the simulation techniques were also compared to results using convenient regression carried out by applying procedures using a standard statistical software package. On average, the confidence intervals were over twice as wide with the regression method than with the simulation approaches. The average of the lengths of the intervals was 0.16 among men and 0.17 among women with the regression method and 0.07 among men and 0.08 among women with the MC technique. The correction for serial correlation did not have a notable effect on the length of the confidence interval; the average was 0.15 among both genders when the serial correlation was taken into account.

7.4 SOCIOECONOMIC EQUITY IN MORTALITY AMENABLE TO HEALTH CARE INTERVENTIONS

In Study IV an approach to assess socioeconomic equity in the effectiveness of health services was introduced. Amenable mortality is used as an indicator of health system performance. It captures premature deaths that should not occur in the presence of effective and timely health care.

Socioeconomic equity in amenable mortality was estimated using C and the SII. In these analyses, income was categorised into 20 income groups. To study the influence of specific categories of amenable mortality in more detail, a decomposition technique introduced by Clarke et al. (2003) was modified. This method allowed for estimating the contributions of the amenable mortality categories to the total inequity. The categories were classified according to the main place for a potentially effective intervention of the treatable conditions. Main categories were specialised health care (SHC) and primary health care (PHC). Socioeconomic inequity in amenable mortality was decomposed by SHC and PHC and contributions of these categories j to inequity were estimated. Now, the concentration index of the total amenable mortality is $C=\sum_{j=1}^{J} w_j C_j$, where $w_j = y_j / y$ is the weight estimated as the share of the total amenable mortality rate and C_j is the concentration index of category j. Hence C is a weighted average of the concentration indices of the subcategories. The category-specific contribution cb_j to the overall inequity C is then $cb_j = w_j C_j / C$.

Now since $C = SII \cdot 2\sigma_R^2 / y$, it can be seen that cb_j is equal to SII_j divided by the overall SII

$$cb_j = \frac{w_j C_j}{C} = \frac{y_j}{y} \cdot SII_j \cdot \frac{2\sigma_R^2}{y_j} \cdot \frac{1}{SII \cdot 2\sigma_R^2 / y} = \frac{SII_j}{SII}.$$

Equity results

In 1992, a total of 1965 deaths among men and 1884 among women aged 25–74 years were considered amenable to health care in Finland. By 2008, amenable mortality decreased and there were 1403 deaths among men and 1315 among women. In 1992, the overall age-standardised amenable mortality rate was 145 (95% CI 139 to 152) among men and 109 (104 to 114) among women. By 2008 the amenable mortality rate had decreased by 47% for men and 39% for women, while the equivalent decreases for the overall all-cause mortality rate were 34% and 31%. The ratio of amenable mortality rates in 1992 and 2008 was 1.87 (1.74 to 2.01) among men and 1.63 (1.52 to 1.76) among women.

In 1992, C for total amenable mortality was -0.14 (-0.16 to -0.11) among men and -0.10 (-0.13 to -0.07) among women, indicating marked inequity favouring higher income groups. By 2008, socioeconomic inequities in amenable mortality increased further and the corresponding indices were -0.25 (-0.28 to -0.22) and -0.19 (-0.23 to -0.15). The increasing trend in inequity between income groups during the study period was significant (p-value for the trend < 0.01) for both genders. C was significantly higher in mortality amenable to SHC than PHC. Confidence intervals were wider in SHC due to there being fewer cases. Trend analyses revealed significant growths (p-value < 0.01) in the absolute values of C in both PHC and in SHC.

In 1992, the SII for total amenable mortality was -116 (-139 to -92) among men and -68 (-87 to -49) among women. In 2008, the SII was -112 (-127 to -96) and -78 (-93 to -62). In women, a weak trend existed (p-value = 0.05) for increasing inequity but for men no such pattern appeared. Inequity in absolute terms was higher in mortality amenable to PHC than SHC, but the difference was not significant for men or women.

The relative contribution of categories ($cb_j = w_j C_j / C$) to the total inequity was varied somewhat during the years; it ranged from 51% to 74% among men and from 63% to 84% among women in PHC. In contrast, the contributions varied from 26% to 49% and from 16% to 37% in SHC. In PHC the trend was increasing and in SHC decreasing (p-value for the trend < 0.05) among both genders.

Next it was approximated what proportion of the amenable deaths needs to be transferred between the extreme socioeconomic groups to remove all inequity. To approximate this proportion the interpretation of C presented by Koolman and van Doorslaer (2004) was used. In SHC, this redistribution approximation (RD) was 17% in 1992 and 32% in 2008 among men. Among women RD was 17% and 37%. In PHC the proportions were markedly smaller, 8% in 1992 and 16% in 2008 among men and correspondingly 7% and 12% among women. These proportions indicate the hypothetical share of the amenable deaths that would need to be redistributed from the poorest to the most affluent groups to remove inequity.

8 DISCUSSION

8.1 OVERVIEW OF THE MAIN FINDINGS

STUDYING REGIONAL DIFFERENCES IN EQUITY IN HEALTH CARE

This study proposed a method to compare regional differences in the distribution of health service utilisation in terms of socioeconomic equity while simultaneously taking dependence within regions into account. The advantage of using multilevel modelling to estimate indices is to overcome the problems associated with random error in small regions. Additionally, it takes into account the effect of variation in the population sizes in regions. This method allows for varying age and socioeconomic structures in addition to different needs for health care. It is important to study regional differences in socioeconomic equity in health care, since regions can vary according to health care resources, population structures (such as socioeconomic position and age), and morbidities. Studying equity within a country without separation of the regional variation may not give an accurate enough picture of the state of equity.

Equity measures that can be used to study differences in health can also be applied to measuring equity in health care, although including the need for care in the evaluation imposes its own requirements for the measurement. Previous studies have compared equity between regions by calculating rate ratios or odds ratios of health or health care indicator in the lowest and in the highest socioeconomic groups by regions (Hetemaa et al., 2003; Hosseinpoor et al., 2005; Nolasco et al., 2015). The approaches comparing merely the extreme socioeconomic groups do not, however, exploit the whole socioeconomic distribution. These measures might also be inconvenient since they produce numerous values.

The shortage of the methodological studies on regional differences in equity in health and health care is presumably partly due to the fact that datasets including all the required information are available only in a few countries. Nonetheless, it is expected that the availability and the usage of register data in health studies will increase in the future. This will also in part influence the need for improved methods in measuring equity using register data. In Finland, the possibility to combine various administrative registers provides a good premise for studying equity in health care, since these registers cover admissions in public and private hospitals throughout the whole country.

The concentration index has also been used in one study to compare equity between regions (Hosseinpoor et al., 2005). The concentration index utilises the socioeconomic distribution more precisely. However, the dependence of the regions is not taken into account when estimating the concentration indices separately for each region.

The proposed method can be applied to many research questions where grouped data are used. In addition to register data, this method can be used with small modifications for samples of data sets and survey data. The method proposed in this study to evaluate regional differences in equity is invariant to the level of the use of care and to the level of the need for care for each age group as it does not make direct comparisons across age groups. Rather it makes a comparison of the relative differences in procedure rates in socioeconomic groups, adjusted for relative differences in need, averaged across age groups. This overcomes the problem of the use of care being higher (or lower) in the younger age groups while the need for care is higher (or lower) in the older age groups.

Comparing regional differences within a country and comparing countries do not necessarily require similar methods. While making comparisons between countries, there is no need to take into account dependence between countries and thus independent estimates are adequate. Additionally, the sizes of the countries do not create challenges in the estimation, whereas dividing a country into parts may results in small numbers within some regions. On the other hand, it is always relevant and straightforward to interpret the results from several regions from one country using register data due to the consistent data collection system and the organisation of the health care system. However, this method can be applied also to country comparisons, although the distributional assumptions underlying multilevel models mean that this method would be better suited to making comparisons between countries that share similarities.

Equity in revascularisations

Earlier research on socioeconomic equity in the use of revascularisations has generally come to the same conclusion: the higher the socioeconomic position the larger the likelihood of revascularisation. This tendency was found already during the times when CABG was the predominant procedure for IHD. A Swedish study, however, did not find occupational inequities in the use of CABG among women between 1991 and 2000 (Haglund et al., 2004).

The present study found clear evidence of inequity in the use of revascularisations favouring the better off in both genders in 2001–2003 in Finland. The results were apparent regardless of which measure (IHD incidence or IHD mortality) was used to approximate the need for care. Keskimäki et al. (1997) and Hetemaa et al. (2003) have reported similar results on the use of revascularisations earlier in Finland.

This study detected that revascularisations were more equitably distributed between socioeconomic groups for women than for men in 2001–2003, although Hetemaa et al. (2003) showed that in 1988 and 1996, inequities for both genders were almost equal in Finland. These results emphasise different trends in equity between men and women in Finland.

Earlier studies from Finland and England have suggested that in regions where overall revascularisation rates are highest, the services are more equitably distributed between socioeconomic groups (Hetemaa et al., 2003; Manson-Siddle et al., 1999). The results of the current study, however, did not corroborate this finding.

Differences in inequity in revascularisations in relation to need between regions in Finland were minor according to this study, especially in men.

TRENDS IN ABSOLUTE AND RELATIVE HORIZONTAL EQUITY

This study introduced a non-numerical approach to evaluate absolute horizontal socioeconomic equity in health care to fill the gap in the literature. The existing methods measuring absolute differences do not provide solutions for evaluating absolute inequity in health care while taking the need for care into account. Studying both absolute and relative socioeconomic equity in health care is important, as they commonly move in opposite directions when the overall trends in the health care indicators either increase or decrease.

Evaluating the need for health care is usually not easy. If the use of care cannot be evaluated clinically on a case-by-case basis, proxy indicators of need for care can be used that are measured on different metrics than the use of care. The current study, however, found a method for solving the challenge of different metrics between the use of care and the need for care. The numerical solution for the scale and metrics difference is the same for both cases, but the interpretation of the results differs somewhat. Using proxy indicators for the need for care gives indirect estimates for horizontal equity. Using proxy measures is sometimes the only way to evaluate horizontal equity in health care and thus the best estimate of the state of equity.

The HII provides a means to measure relative horizontal equity in a relatively straightforward manner by comparing distributions of the use and the need indicators (Moonesinghe and Beckles, 2015; Wagstaff and van Doorslaer, 1999). It follows that there is no need to combine these indicators in the same model but they are examined separately and a difference in the scale or the metrics is not an issue.

In absolute terms, estimating horizontal equity is more complex due to possible scale differences of the measures of the use of care and the need for care. This study proposed a way to evaluate absolute horizontal equity. Absolute differences are estimated separately in the use of health care and in the need for care indicators using an absolute equity measure, such as the SII or AC. This approach gives a non-numerical evaluation of state of equity.

Additionally, this study proposed a means to study both absolute and relative trends in horizontal equity in health care. This was done by applying further the non-numerical approach. It evaluates whether the change in the absolute trend has been favourable or not by comparing the change in the difference between the use of care and the need for care indicators during the follow-up.

Researchers have argued that when studying trends in socioeconomic equity (in health), disparity measures should be sensitive to two sources of change: change in the size of the socioeconomic groups and change in the level of the outcome indicator within each group (Harper and Lynch, 2005). However, even though relative equity measures are sensitive to the mean level of the outcome indicator, changes in the relative disparity do not give a comprehensive picture of the population health or health care burden of disparities over time without information also on the overall level of an indicator and change in it. At the same time, it is also necessary to study changes in absolute disparities.

This study proposes that 'more sophisticated' measures of equity (such as C and the SII) should be used when measuring trends in equity, since they are sensitive to changes in the sizes of the socioeconomic groups. Additionally, they summarise information considerably and thus enable taking into account several dimensions of information simultaneously.

Equity results

As an empirical example this study assessed absolute and relative trends in revascularisations while taking the need for care into account in the period 1995–2010 in Finland. IHD mortality was used as a proxy indicator for the need for care due to a lack of individual information on the need for care, which is often the case in register studies. Relative differences were estimated using C and absolute differences using the SII. The need for care was approximated separately for each age and socioeconomic group and region when studying relative differences and the multilevel method to estimate C presented in Study I was exploited to take into account regional variation. Men and women were studied separately. The use of revascularisations and IHD mortality are measured on different metrics, but as the distributions of these indicators across socioeconomic groups are examined separately using C, it is not an issue when estimating relative horizontal equity.

The results showed that relative differences in revascularisations (without taking the need into account) favouring low-income groups emerged among men and increased among women during the study period, indicating improved access among the low-income groups. In absolute terms, the income group distribution of revascularisations was equal in the beginning of the study period, although differences favouring the low-income groups emerged during the study period among both genders.

In IHD mortality the absolute and relative differences favoured the better-off throughout the study period. The common finding of different changes in absolute and relative disparities over time was seen in IHD mortality; absolute differences remained stable among men and decreased among women, while relative differences increased among both genders. The distinct trends occurred due to a clear decrease in IHD mortality in all socioeconomic groups.

Despite the large body of research on socioeconomic differences in the use of revascularisations, most studies have not examined time-trends in revascularisations even while the increase in the PCIs has been large in many countries. Hetemaa et al. (2003) concluded that despite a substantial increase in coronary procedures, socioeconomic inequities diminished only somewhat from 1988 to 1996 in Finland. Manson-Siddle and Robinson (1999) argue that increasing resources for tertiary cardiology without specific targeting may narrow inequity. Nevertheless, they recommend targeting resources to the deprived. Haglund et al. (2004) saw diminishing socioeconomic inequalities between occupational groups with increasing resources and highlight the importance of identifying patients with the highest need for care. The current study detected marked and persistent relative socioeconomic inequity in the use of revascularisations in relation to need favouring the better-off in the period 1995 to 2010 in Finland among both genders. In contrast to earlier research, this study found no decrease in relative inequity despite the increasing supply of revascularisations during the study years.

This study found that the changes in the absolute distributions of the both supply and the need for coronary care have favoured the low-income groups. Thus, it can be concluded that absolute inequity has decreased although it cannot be quantified numerically.

Keskimäki et al. (1997) detected somewhat higher inequity favouring persons in higher social positions among younger male patients (40-44) compared to older male patients (60-69) in the use of CABG in 1988 in Finland when using IHD mortality and annual risk of hospitalisation due to IHD as proxies for need. Hetemaa et al. (2003) also found higher inequity favouring white collar employees in revascularisations among younger male patients compared to older patients in 1996 in Finland when using IHD mortality as a proxy for need. This finding was corroborated also in this study, as clear inequity favouring the higher income groups in 1995 was seen, although this study used different age limits and statistical methods for assessing equity. Keskimäki et al. (1997) found greater inequity among older female patients (aged 55-69) compared to young female patients (aged 40-44) in 1988 while Hetemaa et al. (2003) had the same finding in 1996. The present study did not find age differences in equity among women in 1995 in Finland. Further, it was detected that relative inequity increased significantly among younger age groups, while inequity remained at the same level in the older age groups in the period 1995 to 2010, resulting in significant age differences in equity among both genders.

This study found clear age differences in absolute horizontal equity favouring the better-off among both genders in 1995. Among men the absolute inequity decreased in both age groups, although the decrease was greater in older age groups, resulting in smaller differences between age groups in equity in 2010. However, absolute horizontal inequity remained among men in both age groups in 2010. Among women the decrease was significant in older age groups, resulting in smaller differences between age groups in equity in 2010. In younger age groups the absolute equity remained at the same level.

MEASURING UNCERTAINTY OF THE INEQUITY INDICES USING REGISTER DATA

The purpose of this study was to develop statistical inferences on the inequity indices calculated from aggregated register data. Five different Monte Carlo simulation techniques were developed to estimate the confidence interval for C, the HII, and the SII. This fills a gap in the literature, as previous methodological studies concerning inequity indices have mainly used survey data and have not addressed the use of register data. The confidence intervals for estimates using sample data do not account for sources of uncertainty other than small sample sizes, sampling error, including missing and incomplete data and other data errors, bias resulting from non-response, and poor data collection.

Mackenbach and Kunst (1997) have noted that C has a practical limitation concerning calculating confidence intervals. The application of regression techniques for point estimation does not require distributional assumptions. On the other hand, if making statistical inferences regarding the uncertainty of C, the distributional assumptions need to hold. The standard error of the regression slope describes the variability of the estimate around the true slope parameter. It takes into account the error occurring in fitting a regression line to the observed data. Furthermore, using the linear regression method, the error is evaluated mainly based on the size of the error terms in the equation. Thus, if the relationship between the outcome variable and the rank variable is not linear across the socioeconomic groups, the error will be estimated as larger than if the relationship were linear. Therefore, the standard error of the regression slope parameter is not directly applicable to C.

Wagstaff and van Doorslaer (2000) have suggested that serial correlation in the errors potentially causes biased standard errors when estimating C. Kakwani et al. (1997) developed estimators of the standard error of C that take into account the serial correlation in the data applicable to survey data. These estimators do not, however, take into account the sampling variability of the outcome variable. O’Donnell et al. (2008) presented a method for taking this into account. An alternative way of computing probability intervals is through simulation; Bootstrap and jackknife techniques have been shown to be superior to asymptotic intervals both theoretically and in a variety of applications using inequity measures (Mills and Zandvakili, 1997;

Sergeant and Firth, 2006). Modarres et al. (2006) pointed out that using the regression method to estimate the standard error of the Gini coefficient yields standard errors that are too large due to serial correlation and they recommend using jackknife and bootstrapping methods. These simulation techniques overcome the problems of serial correlation or lack of linearity. These earlier studies on the uncertainty of the inequity indices have focused on developing statistical inference for survey data and in the field of health care economics.

This study presented approaches to estimate the uncertainty of the inequity indices using several different distributional assumptions and additionally these techniques differ from each other in the phase of the simulation process. The results using the different simulation techniques yielded very similar results in relation to the lengths of the confidence intervals for C. Thus, in that regard, all these techniques can be considered equally good. However, the usability of technique 5 (MC-rate) is probably the most straightforward and besides, this technique is very close to the technique of the estimating the confidence intervals for the SII. Nevertheless, the used technique should be decided on a case-by-case basis taking into account the specific datasets and underlying assumptions.

The presented simulation techniques have the advantage that the correlation between the rank and the outcome variable do not bias results since standard error is not estimated using the regression method. The possible correlation structure between the rank of socioeconomic groups and outcome variable remains approximately the same in the simulation replicates as in the original data. The similar results obtained using different assumptions also support the interpretation that serial correlation is not an issue in these techniques. Additionally, empirical illustrations in this study suggest that the difference between taking serial correlation into account and failing to do so when estimating the uncertainty of C is small, which is in line with earlier studies (Kakwani et al., 1997; Chen and Roy, 2009).

The results of the simulation techniques were also compared to results using convenient regression carried out by applying procedures using a standard statistical software package. On average, the confidence intervals were over twice as wide with the regression method than with the simulation approaches. This is caused by several factors. The confidence interval estimated using the regression method is evaluated based on the size of the error terms in the regression equation that is used to estimate C. Thus, it describes mainly the variability between the estimated slope parameter and the observed data. The number of observations is only the number of socioeconomic groups.

Thus, this study claims that the regression method estimates the uncertainty in C too conservatively for aggregated register data, since this method does not take into account the extensive data set underlying the points of the regression.

Estimation of the uncertainty in the indicator of interest using population-based data is not simple (Sørensen et al., 1996). Moreover, several factors can affect the uncertainty, which complicates this calculation. Even within Europe, the quality of register data can vary markedly between countries (Kunst, 1997). Countries also differ regarding data collection, practices, and recording information on death certificates, for instance. Thus, the uncertainty of the inequity estimates should be evaluated on a case-by-case basis.

Mills and Zandvakili (1997) have stated that inequity indices are nonlinear functions of a random variable (such as income), and so are not readily suitable for standard statistical methods. In the real world, the uncertainty of the data is, however, caused by other factors, and is neither due to the lack of a linear relationship between the health care variable and the rank nor due to outliers in a regression sense. Therefore, in relation to register data, the convenient regression method to calculate standard errors does not factor in any inaccuracy in the observed data. Simulation techniques have the disadvantage that they may be mathematically complex or require a considerable amount of computation resources. Nevertheless, the lack of predictability means that it is important to use appropriate methods despite their complexity.

EXTENT OF AND TRENDS IN SOCIOECONOMIC EQUITY IN AMENABLE MORTALITY

The primary goal of this study was to improve the means of evaluating socioeconomic equity in the effectiveness of health care using register-based data. This included developing approaches for studying trends in equity utilising the whole socioeconomic distribution. Equity in health care was assessed by measuring differences in amenable mortality across socioeconomic groups. Amenable mortality can be used as a tool for capturing the effectiveness of health care and inequity in it, providing further evidence of differences in health care performance between socioeconomic groups. The categorisation of a medical condition as amenable is based on a judgment about the effectiveness of interventions that might prevent death (Nolte and McKee, 2008). This study assigned causes of deaths to categories according to the time and site of the interventions. This allows the evaluation of the contribution of different sectors of health care systems to socioeconomic inequity in deaths that should have been avoided by effective and timely medical interventions.

Earlier studies have measured inequity in amenable mortality (or some groups of avoidable conditions) most commonly by comparing standardised rates between socioeconomic groups (e.g. Westerling et al., 1996; Wood et al., 1999; Simonato et al., 1998). James et al. (2007) calculated differences in age-standardised expected years of life lost between the lowest and the highest income quintiles. McCallum et al. (2013) and Manderbacka et al.

(2014b) estimated relative differences between income quintiles using Poisson risk ratios. Stirbu et al. (2010) used the RII, Tobias and Yeh (2009) used the SII, and Korda et al. (2007), Schwarz (2007) and Schwarz and Pamuk (2008) used both the RII and the SII as measures of equity. Lehikoinen et al. (2016) used C as a measure of equity.

C was used in this study as a relative measure of equity for several reasons related to its features: the graphical presentation of the concentration curve, the redistribution approximation, the decomposition of contributions, and providing a single, quantitative measure for the degree of inequity. Also, an absolute measure, the SII, was used to provide a comprehensive view of the state of equity in health care.

Only the reports by Schwarz (2007) and the New Zealand Ministry of Health (Ministry of Health, 2010) have presented cause-specific contributions to socioeconomic inequities in amenable mortality in absolute terms. This study evaluated the relative contributions of categories to the total inequity using a decomposition approach, which has been previously used to study income-related health inequalities based on survey data (Clarke et al., 2003). This method was modified in this study and it allowed for estimating the contributions of the amenable mortality categories to the total inequity. The categories were classified according to the main place for a potentially effective intervention of the treatable conditions, specialised health care (SHC) and primary health care (PHC). Additionally, the connection between absolute and relative contributions is shown; the contributions estimated using the decomposition method with C and the corresponding absolute contributions (using the SII) are equal.

Equity results

Register data on amenable deaths in Finland covering the period 1992–2008 was exploited as an empirical example on equity in the effectiveness of health care. Several studies have shown that amenable mortality has decreased (among others in Western Europe, Australia, Canada, and the USA) over the last decades irrespective of the starting levels of mortality (Charlton and Velez, 1986; Marshall et al., 1993; Humblet et al., 2000; Manuel and Mao, 2002; Westerling, 2003; Treurniet et al., 2004; Korda and Butler, 2006; Nolte and McKee, 2008). A corresponding finding emerged in this study.

However, despite the decline in amenable mortality, earlier results indicate that socioeconomic inequities in amenable mortality have persisted in many countries (Korda et al., 2007; Stirbu et al., 2010; Ministry of Health, 2010). Only one study has detected narrowing (but persistent) relative inequities in amenable mortality among New Zealand males from 1975–1977 to 1985–1987 (Marshall et al., 1993). Nolasco et al. (2009) found constant relative socioeconomic inequalities in preventable avoidable mortality in period 1996 to 2003 in Spain. Marshall et al. (1993) observed strong and persisting social class gradients in mortality from causes of death amenable to medical intervention in 1975–1977 and 1985–1987 in New Zealand. In contrast, Schwarz and Pamuk (2008) found significant and increasing relative educational inequities in some amenable causes from 1981–1982 to 1991–1992 in Austria. Korda et al. (2007) found that relative inequalities in amenable mortality for conditions that are treatable increased in the period 1986–2002 in Australia. Asaria et al. (2016) detected increasing relative inequalities from 2004–2005 to 2011–2012 in England. McCallum et al. (2013) saw marked and increasing relative income differences in amenable mortality in the period 1992–2003 in Finland. Lehikoinen et al. (2016) replicated this finding for the period 1992 to 2008 in Finland. Manderbacka et al. (2014b) also found steepening income differences in Finland for the same period 1992 to 2008 and discovered even worse outcomes among those in a poor labour market position or living alone. Further, this study showed a marked and increasing trend in relative socioeconomic inequity in the period 1992 to 2008 in Finland. The increasing trend was significant in both SHC and PHC, but inequity increased more in mortality amenable to SHC than to PHC and was markedly higher in mortality amenable to SHC.

James et al. (2007) observed a large reduction in socioeconomic gradients in amenable mortality in absolute terms in Canada in the period 1971 to 1996. Tobias and Yeh (2009) also found significant but decreasing absolute differences between income groups in amenable mortality in the period 1981–2004 in New Zealand among men but found no change among women. Korda and colleagues (2007) also detected narrowing but persistent absolute inequities in the period 1986 to 2002 in Australia. Asaria et al. (2016) saw the same phenomenon from 2004–2005 to 2011–2012 in England. Only Schwarz and Pamuk (2008) have found significant and increasing absolute educational inequities in some amenable causes from 1981–1982 to 1991–1992 in Austria. This study saw constant absolute inequity from 1992 to 2008 in Finland among men but a weak increasing trend among women. Inequity in absolute terms was higher in mortality amenable to PHC than SHC, but the difference was not significant.

Schwarz (2007) estimated cause-specific contributions to absolute overall mortality differentials by selected groups of causes of death (neoplasms, circulatory, other, external causes) in 1991–1992. This study estimated relative contributions of amenable categories to the total amenable inequity. The results indicate that the contribution of PHC interventions to the overall inequity in amenable mortality was more substantial. In PHC the trend in contribution was increasing and in SHC decreasing among both genders.

Thus, this study showed that although inequity in relative terms was more pronounced in SHC, the influence of primary health care on widening inequities was bigger in Finland, due to higher absolute rates of mortality amenable to PHC. In addition, the change in the contributions was statistically significant.

Additionally, it was approximated what proportion of the amenable deaths needs to be transferred between the extreme socioeconomic groups to remove all inequity. In SHC these proportions were clearly higher but gender differences were not detected.

Anderson et al. (2005) argue that health care interventions may have the same relative effect on mortality in different socioeconomic groups if there is adequate access to health care for the disadvantaged, and therefore health care does have an important role in reducing inequities. On the other hand, Nolte and McKee (2004) found evidence supporting the claim that health care can contribute to the reduction of health inequities. Moreover, Tobias and Yeh (2009) also stated that improvements in access to and quality of health care for the disadvantaged could reduce health inequities. The trends in inequities in amenable mortality detected in this study suggest that socioeconomic disparities in either access to or the quality of health care in Finland have increased.

8.2 METHODOLOGICAL CONSIDERATIONS

In Finland, register data in general are of high quality (Gissler and Haukka, 2004; Keskimäki and Aro, 1991; Mähönen et al., 1997; Pajunen et al., 2005; Rapola et al., 1997; Salmela and Koistinen, 1987; Teppo et al., 1994). Nearly all events are included in Finnish administrative registers according to earlier studies (Gissler and Shelley, 2002; Sund, 2012). Additionally, these registers cover information from several decades.

However, some variation may occur in the coverage and validity of some variables regardless of the quality of the data (Gissler and Haukka, 2004). Lahti and Penttilä (2001) studied the validity of death certificates in Finland and its effects on mortality statistics and concluded that the data are overall of good quality. Yet, variation exists in the under-reporting of some causes of deaths as the underlying cause of death and about 7% of certificates are not completed as instructed. Manderbacka et al. (2013) found that a large part of the decline in pneumonia mortality from 2000 to 2008 was explained by changes in coding practices. They reported also large regional variation in coding practices. Thus, changes in coding practices might affect some results concerning amenable mortality in this study. It is likely, however, that the impact of coding changes on inequity is small. This study found no evidence of discontinuity between ICD-9 and ICD-10 nor did a study by Janssen and Kunst (2004). One study also suggests that the official classification of maternal deaths in Finland is rather arbitrary and allows a lot of variation in the definition of a maternal death (Gissler et al., 1997). Nevertheless, the datasets used in this study can be evaluated as precise, as having good coverage of the requisite information, and also as allowing long follow-up periods, this being one of the strengths of this study.

Allin et al. (2007) claim that register data may provide less comprehensive data than survey data on socioeconomic position and health status. The use of register data as a source of information on socioeconomic position can be regarded, however, as a major strength. Income is a strong predictor of numerous health and health care outcomes and as an ordinal variable it is very useful and easily defined. In this thesis, disposable family income was used as the socioeconomic indicator. In the grouping of income, the family net income record was used, assuring minor bias in cases where income varied within the family. The ability to use a family-level income instead of an area-based indicator further strengthens the reliability of this study, since area-level indicators usually underestimate the point estimates of equity measures.

When studying the use of hospital services, the use of the CRHC is an advantage compared with survey data on health care use collected from individuals of the target population, since register data covers all performed procedures unlike survey data. Additionally, diagnoses and procedures are coded by health care professionals and thus for instance recall bias which is common in survey studies, is avoided.

The present study used aggregated register data due to privacy protection and technical limitations. One limitation of using aggregated data is the lack of possibility of making inferences from individual-level relationships. Generally, group-level correlations are larger than individual-level correlations. Thus, when drawing conclusions based on aggregated data, this must be taken into account to avoid ecological bias. However, the use of individual-level data could also be a limitation, since the use of simulation techniques can be applied to aggregated data only.

In this thesis, the use of aggregated data made it difficult to use good individual-level proxies for need, as well as, limiting the feasibible analytical approaches. Thus, since neither information on the severity of the diseases nor clinical indicators on the need for care were available, it can be regarded as a limitation. Sometimes it is possible to compile a very good and precise dataset from which the need for specific treatment can be evaluated individually using information on the severity of the disease. This is, however, quite uncommon in register studies since the data are collected for other purposes and the available data might not include suitable variables. Instead of an individual-level evaluation of the need for care, proxy measures for the need were used, which is quite common. Mortality is often used to approximate morbidity due to good availability of mortality data. The linkage of mortality information to the population registers is straightforward and mortality is simple to define. Mortality is a group-level indicator and gives an approximation of the need at a comparative level. Morbidity due to certain disease, measured as the incidence or prevalence for this disease, is another commonly used group level proxy indicator of the need for care. The information on morbidity is usually, however, more complicated to receive from the registers than mortality. The use of aggregated proxy measures needs to be taken into account when interpreting the results so that ecological bias does not occur. Some proxy measures might either under- or overestimate the need for care for some socioeconomic groups. Despite the limitations of the use of proxy measures, it is however better to use them than evalute purely the use of care if the aim is to measure socioeconomic equity, since the use of care usually varies considerably across socioeconomic groups due to marked differences in morbidity. Hence, the use of proxy measures gives indirect estimates of equity but they are usually the best estimate available.

Study I used both IHD mortality and IHD incidence as a proxy for the need for revascularisation. It was observed that equity estimates were notably higher using IHD mortality as a proxy for need than with IHD incidence as a proxy for need. This is because the social gradient in IHD mortality is much steeper than that for IHD incidence. Explanations for this are higher out-of-hospital and early (0-28 day) case-fatality among lower-income-group patients. Therefore, it might be the case that IHD mortality overestimated the need for revascularisation for lower income groups. However, it is also possible that the proxy measure of IHD incidence used in this study somewhat underestimated the socioeconomic gradient in 'true' IHD incidence because the worse off may be under-diagnosed or are diagnosed at a later stage when the disease is more severe. Nevertheless, (the proxy measure of) IHD incidence may have some advantages over IHD mortality as an estimate of the need for revascularisation since it involves several morbidity indicators some of which are less severe than IHD mortality. Also, both measures of the need for care gave quite similar results, indicating inequities in revascularisations.

In Study II, IHD mortality was used as a proxy for need for revascularisations since IHD incidence was not available for the study period. While it is a limitation to use only IHD mortality due to possible overestimation of socioeconomic differences in need, the use of mortality enabled us to estimate the need for care and also to estimate more accurately the development of equity in revascularisations.

The ecological bias due to proxy measures of the need for care was presumably negligible in these studies. The relationship between the use of revascularisations and the need for care was approximated in the same subgroups. Furthermore, these subgroups were categories according to several variables (gender, age, region, income).

The indicator of region of residence used in Study II was rather broad. The use of a more accurate indicator of region than university hospital district (5 hospital districts in Finland) was not possible due to low numbers of events in some categories inducing unreliable estimates. However, this division of regions represents appropriately the notable differences in IHD mortality between eastern and western Finland.

Earlier studies have shown that amenable mortality decreased at a faster pace than mortality from other causes in recent decades (Nolte and McKee, 2004; Nolte and McKee, 2008). Also, studies have shown that health care investments on vaccinations, antibiotics, and cardiovascular disease treatment have contributed to a decrease of mortality for specific diseases

(Cutler, 2004). These findings suggest that health care has influenced mortality. Also, a study by Heijink et al. (2013) suggested that healthcare spending growth was associated with a decrease in amenable mortality. The Finnish data on amenable mortality are comprehensive due to the completeness of death registration, the process for expert review of disputed cases, and the high autopsy rate for deaths from suspicious and external causes (Lahti and Penttilä, 2001). However, some wariness is required when interpreting the results on amenable mortality. While amenable mortality may be an appropriate indicator of health care performance and the quality of the mortality data is good, it is, however, an indirect indicator. The differences in the prevalence and incidence of some diseases between socioeconomic groups might have a certain effect on disparities in amenable mortality, but those differences could not be taken into account in this thesis. Nevertheless, inequities in the use of and access to health services may affect the incidence of subsequent disease.

Inequity indices that meet all the three minimal requirements imposed for equity measures were used as a measure of equity. This can be regarded as a methodological strength. This study focused on using C, although the SII, an absolute measure, was also used in the substudies. The strengths of using C and the SII are that they reflect health care inequities in the entire population by taking the slope of the socioeconomic gradient and the sizes of the socioeconomic groups into account. They summarise information considerably and thus enable taking into account several dimensions simultaneously, such as several socioeconomic groups, time, and regions. C was chosen as the primary measure due to several convenient features that it has: the redistribution approximation, the decomposition of contributions, and the graphical presentation of the concentration curve.

8.3 POLICY IMPLICATIONS

Monitoring equity in health care

In order to obtain extensive and precise knowledge of inequities, comprehensive methods to study equity are needed. The methods proposed in this thesis provide the means to study several aspects of equity in health care in detail. These methods can be exploited in register studies but can be partly used also in survey studies. While a specific interest has been to improve the methodology for studying equity in health care, at the same time these approaches were utilised in measuring equity in health and health economics. Thus, this thesis adds tools for measuring equity in health and health care that can be employed for research and evaluation purposes. The results and indicators on equity received using these methods can provide information for policy-makers at several levels and operational planners as well as health care professionals at the operational level. Regardless of focusing on the Finnish health care system and Finnish register data, these methods are also applicable more widely than in the Finnish context alone.

Finland is geographically rather a large country and the population in different regions vary by several factors. One of the main goals of the ongoing health and social services reform in Finland is to diminish regional differences in health care in addition to improving equity and effectiveness in health care. The demand for the collation of health care indicators is increasing also due to this reform. For the moment, the health care indicators collected on a regular basis do not cover the socioeconomic equity aspect. THL, Statistics Finland, Finnish university hospital districts, and OECD collect some quality indicators but at the moment there is no established corporate data available to enable long-term comparability of the data (Gissler et al., 2012; OECD, 2013). Additionally, there is only limited experience of using these quality indicators in regional-level comparisons. At the same time an amendment of the Act on Safe Use of Health and Social Data is planned by the Ministry of Social Affairs and Health. The change aims to improve the possibilities to utilise more efficiently Finnish register data, which is exceptionally comprehensive and of high quality. Primary goals for data registers include maintaining information security, ensuring standardised practices of the authorities, supporting policy making, and improving health and social services.

Consequently, one of the approaches introduced in this thesis responds to an evident urge to study and receive information on regional differences in socioeconomic equity. It takes into account the heterogeneity of Finland at several levels. Regions vary from each other in relation to population sizes, socioeconomic distributions, morbidity, and health care services. This approach can be applied to many research questions where grouped data are used. In addition to register data, samples of data sets and survey data can be used to study health variables, morbidity, and the use of health services with a little modification of the approach. The approach is particularly designed to study socioeconomic inequity in different regions, but it can also be used to compare countries.

The approach to study absolute and relative trends in equity in health care provides tools for assessing how changes in health care resources impact on equity. The approach to estimate the contribution of different sectors of health care systems to socioeconomic inequity also provides a means for evaluating effectiveness and quality of health care in the long run. At the moment, register data on outpatient services are not comprehensive enough for research purposes. This approach allows for studying indirectly also primary health care. Thus, these methods can be used when evaluating the impacts of health care reforms or reallocation of health care resources.

Monitoring equity in health care and changes in it requires more precise measures of equity as well as detailed information on indicators for health care. One of the goals of this thesis was to provide improved methods and more accurate measures of equity in health care using register data and to evaluate the uncertainty of these measures.

Implications for equity in health care

A major health policy goal in Finland is to reduce disparities in health and in access to and the quality of health care. Good health of the population and its equal distribution is a significant advantage relative to several socio-political targets as well as being central to human happiness and wellbeing. Ensuring equal access to health care can diminish disparities in health. Furthermore, better health of the whole population makes a remarkable contribution to economic progress, as a healthy population is more productive and spends less on health care. However, previous research has shown that socioeconomic inequities in health care in relation to the need for care do exist. This thesis corroborates this finding.

Although absolute inequity in the use of revascularisations somewhat decreased in Finland in the period 1995 to 2010, relative inequity did not decrease. These results indicate that more effective measures are needed to secure equity in coronary care. It seems that an untargeted increase in resources may not be sufficient to further decrease differences in the use of revascularisations. Instead, identifying patients with the highest need for care early and more specific targeting of resources especially to middle-aged low-income IHD patients is needed, since improvements in their cardiovascular health has been slower.

The trends in inequities in amenable mortality detected in this study suggest that socioeconomic disparities in either access to or quality of health care in Finland have increased. This finding should prompt a serious consideration of measures to improve equity in health care in Finland.

8.4 SUGGESTIONS FOR FUTURE RESEARCH

This study provided new methods to evaluate socioeconomic inequities in health care using register data. A couple of studies have already utilised these methods to study equity (Allik et al., 2016; Lehikoinen et al., 2016). There is still an obvious need for future research developing further these methods to study equity in health care.

This study used proxy measures for evaluating the need for care. IHD incidence presumably underestimates the need for revascularisations for lower socioeconomic groups while on the other hand IHD mortality may overestimate the need respectively. Improved indicators for the need for coronary care should therefore be developed. Additionally, the same need is to develop other need indicators for the need for care using register data that are not covered in this thesis. Moreover, the development of methods measuring absolute horizontal equity in more detail is also important. This includes question concerning combining indicators of the use of care and the need for care that are measured with different metrics. The development of these indicators and methods, however, require more possibilities to link several registers and to improve the content of these registers. Changing legislation, growing the amount of information, and improving information systems in the future will probably open up possibilities to carry out these developments. These changes will also allow developing novel ways of evaluating equity in health care in general.

Methods related to the analysis of large and complex datasets (*aka* the Big Data approach) will apparently become one of the new practices for analysing this growing mass of datasets. This approach will enable us to take into account the large numbers of factors influencing health care outcomes on different levels. This approach should be exploited in measuring equity in health care using register data from several sources. For instance, the Big Data approach could open options to use individual-level measures of the need for care.

This study gave information on several aspects of the state of equity in health care in the period 1992 to 2010 in Finland. These results should give a pointer for future research. More studies are needed to investigate how to diminish both absolute and relative socioeconomic differences in health care and to identify the most vulnerable patient groups. It is also highly important to examine the extent of the needed re-allocation of health care resources and how to target these services at specific patient groups to improve equity.

9 CONCLUSIONS

Equity is a major goal in health policy in several countries; however, this goal has not been fully achieved. Socioeconomic position is strongly associated with morbidity and the use of health care according to need. In order to achieve an equitable distribution of health care between socioeconomic groups, better understanding of inequities in the use of health care is needed. This requires improved methods to study equity from several aspects, more precise measures of equity, as well as indicators of the use of care and the need for care.

This thesis developed a method for comparing regional differences in socioeconomic equity in health care while simultaneously taking into account dependence within regions. The advantage of this method is that it overcomes the problems associated with random error in small regions. Additionally, it takes into account the effect of variation in population sizes by age and socioeconomic position in regions, in addition to different need demands for health care. The proposed method may be used to identify effective and ineffective health service practices by examining their impact on socioeconomic inequities in the delivery of services whilst taking the need for care into account. To omit the use of models taking the dependence between regions into account may overemphasise regional differences and therefore this approach is recommended in multi-comparisons.

Studying both absolute and relative socioeconomic equity is crucial as they commonly move in opposite directions when the overall trends in health care indicators either increase or decrease. The existing methods for measuring absolute differences do not provide solutions for evaluating absolute inequity in health care while taking the need for care into account. This thesis proposed a non-numerical method to evaluate absolute horizontal socioeconomic equity in health care.

Furthermore, methods to evaluate the uncertainty of the inequity indices were developed. These methods take into account the nature of the population data, since previous studies assessing equity have used survey data and have not addressed the use of register data. Evaluation of the uncertainty of the equity measures ensures that comparisons at different levels (between hospitals, areas, countries, in time) are meaningful.

Finally, an improved method to study socioeconomic equity in the amenable mortality using register data was introduced. This method allows for studying the trend in equity while utilising the whole socioeconomic distribution. It uses amenable mortality as an indicator of health care performance. In this method, causes of deaths are assigned into categories according to the time and site of the interventions, which allows for the indicative estimation of the contribution of different sectors of health care systems to socioeconomic inequity in deaths that should have been avoided by effective and timely medical interventions.

Socioeconomic equity in health care was studied from several viewpoints using comprehensive register data from the period 1995–2010 in Finland. Results which were obtained by means of these developed methods showed that inequity in health care favouring the higher socioeconomic groups exists throughout the study period and corroborated the findings of earlier studies (for instance, Manderbacka et al., 2009; van Doorslaer et al., 2006).

Definite evidence of inequity in the use of revascularisations favouring the better-off among both genders in the period 2001–2003 in Finland was found. The results were clear regardless of which measure (IHD incidence or IHD mortality) was used to approximate the need for care. Especially among men, differences in inequity between regions were minor.

Moreover, marked and persistent relative socioeconomic inequity in the use of revascularisations favouring the better-off among both genders in the period 1995 to 2010 in Finland was discovered. In these analyses, IHD mortality was used as a proxy for need. Contradictory to previous studies, no decreasing relative inequity was detected despite the increasing supply of revascularisations during the study years. The results also suggest that absolute inequity has decreased although it cannot be quantified numerically.

Increasing and marked socioeconomic inequities in relative terms among deaths amenable to specialised and primary health care in the period 1992 to 2008 in Finland was found in the thesis. In deaths amenable to specialised health care, inequity was greater but the influence of primary health care on widening inequities was more substantial. These results suggest that socioeconomic disparities in either access to or quality of health care in Finland have increased.

In absolute terms, major socioeconomic inequity in amenable mortality has remained relatively stable. The differences between changes in absolute and relative inequities are due to the fact that absolute differences in amenable mortality between socioeconomic groups have changed little, but as mortality rates have declined the relative differences have increased. The increases in inequities in relative terms seen in this study reflect the fact that the proportional reduction in mortality amenable to health care has been smaller in low income groups compared with high income groups. This finding evidently reiterates the need to examine both relative and absolute differences when trying to understand the complex patterns of inequity trends.

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