Socioeconomic inequalities in health in Europe
Studies of middle-aged and older populations with a special focus on the role of smoking

Sociaal-economische verschillen in gezondheid in Europa
Studies naar populaties van middelbare leeftijd en ouderen, met speciale aandacht voor de bijdrage van roken

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Part I

Introduction

1

General introduction

1.1 Introduction

It has often been shown that those who are worse off in terms of wealth, knowledge and power are also worse off in terms of health. To the extent that such socioeconomic inequalities in health are not the result of genetic predisposition (solely) but reflect societal processes that are outside of an individual's personal reach, yet are partly modifiable from a societal level, these can be considered as being unfair. Evidence favours a role of social determination of health and illness. For instance, some social characteristics of early life, which is a time when informed and competent choices cannot yet be made by the individual, affect the health of the individual in adult life.[1] Further evidence for social determination is that after controlling for individual level risk factors, living in a deprived neighbourhood is associated with ill health.[2] Insofar as societal processes such as these are indeed modifiable they point toward a major opportunity for public health policy and practice to improve the population's health.

Research on socioeconomic inequalities in health has progressed over the past few decades and has moved from describing and identifying the problem towards explaining such inequalities, and is currently moving from explaining towards developing interventions to reduce health inequalities. Inequalities in health have been found to exist in all countries for which data are available, indicating that there is probably a general law relating lower socioeconomic status to worse health. But with recognizing the possible universality of the problem comes the realisation that there are still great 'gaps' in our knowledge of this problem. Most studies that have described, and provided explanations for, socioeconomic inequalities in health in developed countries have done so for young adult and middle-aged populations.[e.g. 3-6] Furthermore, most research on this topic is from northern European countries. However cross-country comparisons of the magnitude of socioeconomic inequalities in health suggest that results for one country are not necessarily generalisable to other countries.[3, 5-8]

This thesis reports on an international comparative study of health inequalities in Europe. Its distinctive characteristics are a focus on elderly people and on the contribution of smoking to socioeconomic inequalities in health.

1.2 Socioeconomic health inequalities among older populations

1.2.1 Smaller or larger health inequalities in old age?

Probably one of the most important gaps in the research on socioeconomic inequalities in health has been the neglect of older populations in this research up to some years ago. In the report on the Independent Inquiry on Inequalities and Health (1998) it is stated that because of the lack of routinely collected reliable data there are particular problems with monitoring inequalities in health and its determinants in older people.[9] The burden of disability, as well as mortality, lies heaviest on older men and women in the population. However until several years ago it was not known whether inequalities in mortality should be expected to persist into old age.[10] House et al. (1990) developed the theory of the social stratification of aging and health.[11,12] This theory states that levels of health become increasingly differentiated by socioeconomic status over the adult life course, until later old age when some combination of social and biological factors reduces socioeconomic inequalities in health again. It is necessary to determine whether health inequalities exist among older people, because even if inequalities were found to be small in relative terms, they would point toward a large burden of excess health problems in absolute numbers.

According to a recently conducted review of the area, studies covering this topic were heterogeneous in several respects, such as age and gender coverage, socioeconomic measure used, study design, and the summary measure of inequality used.[13] Generally however, these studies show that socioeconomic inequalities in old age exist, but that the magnitude depends on the indicator of socioeconomic status that is used, on the age group and gender that is studied, on the country for which they are examined, and on the health outcome that is used.

It should be acknowledged that the image of old age as fraught with disablement and need for care is not necessarily an accurate one. Heterogeneity in wellbeing and in physiologic and cognitive characteristics is large among the elderly[14] and in contrast to those older men and women who experience great functional decline and early death are those who continue living in relatively good health. Nevertheless, there can be no doubt that older people are in many ways the most vulnerable in society. Important life events such as functional decline, disease, relocation into institutional living and bereavement are most common in older age groups. Together with an increased need for social support because of physiologic and cognitive decline comes an increased risk of loss of social support through bereavement and relocation. It is likely that those who are worst off in terms of socioeconomic standing have to face those problems in a disproportionate amount. Empirical evidence shows that the poorer elderly do have worse health than the richer.[e.g. 15-20] Determining the nature and magnitude of inequalities in health among the elderly, and providing clues and recommendations for ways of reducing the burden of ill health among disadvantaged elderly should therefore be a priority in this field of research.

1.2.2 Describing or explaining socioeconomic inequalities in health?

An important question is how to contribute to research on socioeconomic inequalities among older people. Such research can be either descriptive, explanatory, or both. Already an important amount of descriptive information has been generated on inequalities in health among older populations. Inequalities in mortality have been observed for a number of countries, including the UK,[10,15,21] Finland,[22-24] Sweden.[25] The Netherlands,[19,20] the United States,[26,27] and Israel.[28] In addition, socioeconomic inequalities in self-reported health, disability and functional decline have also been reported.[17-19,29,30] In spite of the information that has already been generated there is at present still a need for a descriptive contribution in addition to an explanatory one. Most studies are from northern European countries and from the United States. Exceptions to this general rule are the studies of Zimmer and Liang that demonstrated inequalities in health among older people from several Asian societies.[31-33] It only remains to be seen whether these research findings can be generalized to describe the situation in other European countries for which little or no information has yet been published, and it is likely that they are not. Important differences in the nature of socioeconomic health inequalities have been observed between countries from different parts of Europe for middle-aged people.[6,34] In fact the relationship of each indicator of socioeconomic position to health should be expected to be different between countries because of differences in the contextual factors that shape the distribution and health impact of these indicators across the population.

Several studies have been performed with the aim of providing explanations for some of the observed inequalities. For instance, Breeze et al. (1999) reported that people who were socially downwardly mobile earlier in their life course carried a higher risk of mortality at old age than did those who were socially stable.[35] Martelin (1994) observed that among older Finnish people, causes of death with diverse etiological background were all more common among those with lower socioeconomic position.[36] Among Dutch elderly people, the main cardiovascular risk factors could only explain a small part of the association of socioeconomic status with stroke and aortic calcification.[20] Finally, some studies have described the dynamics behind socioeconomic inequalities in the prevalence of disability. Melzer et al. (2001) found for instance that it was especially inequalities in the incidence of disability that contributed to educational inequalities in the prevalence of mobility disability.[37] These are valuable findings, but they illustrate the diversity and the vastness of the area that needs to be covered by explanatory research.

In conclusion, at present there is a need for both describing and explaining inequalities in health among older people. A study that succeeds at incorporating elements of both can therefore be of great value.

1.2.3 Issues relating to the study of socioeconomic inequalities among older populations

The most obvious point of departure for describing inequalities in health among older men and women is the question: how large are socioeconomic inequalities in health among those populations? Answering this question is not straightforward. Two important reasons can be forwarded for this. Firstly, measuring socioeconomic status of older men and women is sometimes difficult. A descriptive approach should encompass several measures of socioeconomic status and relate these to health, identifying specific relationships of each of these measures with health. Secondly, the concept of health is notoriously broad and elusive. Although death is not a direct indicator of an individual's health, mortality is a powerful measure of the health status of a population. Measuring inequalities in mortality is therefore one way of describing health inequalities within populations. But death is most often preceded by years of living with reduced physical functioning and disability. Focusing only on mortality would mask inequalities in this important aspect of health. Therefore a description of socioeconomic inequalities in health among older people will need to pay attention to mortality as well as morbidity and disability.

Mortality as a health measure has its advantages, such as its objectivity, and the fact that it can be broken down into specific causes, which facilitates the discussion of explanations of inequalities. The objectivity of mortality is in contrast to self-reports of health that may be influenced by differential reporting behaviour between social groups, or populations with different cultural background. Measures of self-reported morbidity, or self-reported general health, have the advantage that they can reveal important aspects of health that mortality measures cannot. Self-rated health, which is one such measure, is found to be a multidimensional concept, reflecting the physical health aspects of respondents, but also aspects of functional well being and coping.[38,39] The measure can be used with confidence because it has shown to be predictive of mortality, and loss of function or independency, and to have good construct validity and good test-retest reliability.[38,40,41] On the other hand, because of its essentially subjective nature, self-rated health, and other measures of self-reported morbidity may be difficult to compare between different age groups, genders, or countries.[42,43]

Besides asking people to rate their general health, it is often relevant to assess their functioning in daily life more specifically. People's functioning in daily life can also be measured by self-reports, for instance by asking for problems that people may encounter while performing specific physical tasks. As long as the questions adequately and unambiguously describe the task that is asked for, these self-reports may be less sensitive to cultural differences in interpretation and rating than self-assessed health is. However, in addition to using self-reports, clinicians and researchers can measure the daily functioning of people by asking them to actually perform specific tasks. Researchers and clinicians often use such tests of performance to determine the level of physical functioning (in addition to, or instead of self-reported measures), because they have some important benefits over self-reported measures of functioning[1]. Either way, assessing the functioning of people in certain aspects of daily life

[1] For instance, the face validity of the task is clear, whereas that of self-reported measures can be compromised when the description of the task being assessed is unclear. Performance tests are also easily reproduced, and they are sensitive to subtle changes in functioning. They are also less influenced by cognitive functioning and by culture, language and education.[44]

specifically is important, because their level of functioning, and their ability to remain independent of others in their daily life strongly influences their quality of living, especially that of older people.[44, 45]

From the description of the (dis-) advantages of mortality and morbidity indicators above it follows that these measures can be regarded as being complementary to a certain extent. It is of importance to understand morbidity and mortality not as separate characteristics of populations, but as characteristics that are interconnected and that influence the occurrence of each other. This may be illustrated by the concept of mortality selection. Men and women who are frailer will be less likely to make it into older age. What this means is that those men and women who do make it into old age can be considered as being 'survivors'. This mechanism of 'mortality selection' is related sometimes to the finding that inequalities in health decrease with increasing age,[46] because the frail men and women of lower socioeconomic groups may die earlier than those of higher socioeconomic groups, causing inequalities among older ages to be smaller.

Once socioeconomic inequalities in health among older populations have been described further, how can a study contribute to explaining these inequalities? Firstly, splitting up a generic indicator of population health like mortality and studying inequalities in cause specific mortality may provide valuable clues about explanation of inequalities in health. An evidence base can be created for etiological inferences of inequalities in health by determining which causes of death do show large inequalities, and which causes of death do not. Another example of how to contribute to the explanation of inequalities in health is studying inequalities in disability within a longitudinal perspective, rather than a cross-sectional one, and determining the dynamics of incidence, recovery and mortality and how these dynamics 'determine' inequalities in the prevalence of disability. Such an approach has been followed by other studies before. These studies observed that education was related mostly to incidence of disability, and less to recovery.[37,47,48] A third possible way of contributing to explanation of inequalities in health among older populations is by investigating how more proximate determinants of health are distributed over the socioeconomic strata. One powerful determinant of health that has played an important role in shaping the health of today's older people in many countries is smoking. By estimating the role that smoking plays in socioeconomic inequalities in health it is perhaps possible that an important part of these inequalities can be explained.

1.3 The contribution of smoking to socioeconomic inequalities in health

Unhealthy life styles take a prominent place in the pathways linking socioeconomic status to health.[49-51] Of the health damaging behaviours, smoking contributes most to the burden of disease in developed countries, i.e. it is the single most important cause for loss of DALY's experienced throughout the developed world.[52] This life style factor is of great interest for research on socioeconomic inequalities in health because the diffusion of smoking has been shown to occur differentially over time between lower and higher socioeconomic groups.[53-54]

Smoking in western societies is often described as being an epidemic.[55] The higher socioeconomic groups are the first to pick up the habit of smoking, followed only a few decades later by the lower socioeconomic groups.

After some decades the higher socioeconomic groups are also the first to quit smoking, or to take up smoking less than the lower socioeconomic groups. Therefore, in the later stages of the smoking epidemic, the lower socioeconomic groups become more and more disadvantaged in terms of smoking. Most northern European countries already have reached the stage of increasing disadvantage of the lower socioeconomic groups.[54] It is likely therefore that smoking can explain a considerable part of socioeconomic inequalities in mortality among men and women of many European countries, and that smoking should receive due attention in an attempt to explain socioeconomic inequalities in health; also among older men and women.

A previous study on the contribution of 'material' and behavioural factors to socioeconomic inequalities in health found that behavioural factors, including smoking, independently contributed about 25-29% to educational inequalities in mortality in the Netherlands, and that another 23-28% of educational inequalities in mortality was explained by behavioural factors dependent on material factors.[56] In a study among adult Finnish men and women, cardiovascular risk factors, such as a.o. smoking, were associated with about half of the excess mortality among men of lower social classes.[57] There is also evidence that the effect of cultural and psychosocial factors on socioeconomic inequalities in health, such as e.g. locus of control and hostility, partly runs through behavioural factors, including smoking.[58,59]

However it is of further interest still to study socioeconomic inequalities in smoking among several generations of men and women in order to assess the progression of the smoking epidemic among lower and higher socioeconomic groups. Examining the contribution of smoking within an international perspective is of additional interest, because findings of smoking in different European countries suggest that the smoking epidemic is less advanced in southern parts of Europe than it is in northern parts.[53,54]

1.4 This thesis

This thesis combines descriptive and explanatory approaches to contribute to a better understanding of socioeconomic inequalities in health. The aim of the study is to determine the magnitude of socioeconomic inequalities in health among middle-aged and older men and women within Europe, and to contribute to the explanation of socioeconomic inequalities in health through estimating the contribution of smoking to these inequalities.

1.4.1 An international approach

There have been a number of studies indicating that socioeconomic inequalities in mortality persist into old age.[10,20-28] Also morbidity inequalities have often been demonstrated among older men and women.[17-19,29,30,37] However, these findings are mostly based upon data from countries in northern parts of Europe. Because previous cross-country comparisons found important differences between countries in socioeconomic health inequalities among middle-aged men and women, there is reason to expect that results applying to one country, for instance a northern European one, can not immediately be generalized to another, e.g. southern European, country. A distinctive element of the present study is that inequalities in health are studied in older populations from different parts of Europe. As will be explained in more detail later, this study includes data from thirteen European countries.

There are several potential benefits of international comparative research. The first, and perhaps most obvious one, is benchmarking. The results for one country can be compared with those of other countries to inform judgements about the magnitude of inequalities in that country, and the urgency of the problem of inequalities in health in that country. A second benefit is that cross-country comparisons can help with explaining inequalities in health. Differences between countries in the size and pattern of health inequalities can be of help in generating hypotheses on possible determinants, and can be used for testing such hypotheses if the social distribution of these determinants is known in these countries. A third potential benefit is that of informing policy makers about the effectiveness of interventions and policies to reduce inequalities in health. One example of an important finding of previous cross-country comparisons may serve to underline this point. It was reported by Mackenbach et al. (1997) that European countries with more egalitarian economic, social and health care policies had not achieved smaller inequalities in health.[5] A similar finding was reported by Lahelma and Arber (1994), who found larger inequalities in the egalitarian Nordic countries than in the UK, which has a more liberal welfare system.[60] This suggests that new approaches will have to be developed to these health inequalities effectively.

1.4.2 Research questions

In conclusion, three distinctive elements characterize this study. From an international perspective, socioeconomic inequalities among older men and women in mortality and morbidity are estimated. Furthermore, socioeconomic inequalities in one of the most important determinants of health, i.e. smoking, are estimated. The specific research questions of the study are as follows:

1. What is the magnitude of socioeconomic inequalities in mortality among middle-aged and older men and women of Western European countries? What is the contribution of specific causes of death to these socioeconomic inequalities in mortality? Can variations be observed between countries?
2. What is the magnitude of socioeconomic inequalities in self-assessed poor health and disability among older European men and women? Can socioeconomic inequalities also be observed in the incidence of disability and/or the recovery from disability? Does the mechanism of mortality selection in early old age reduce socioeconomic inequalities in health in later life?
3. What is the magnitude of socioeconomic inequalities in smoking among several generations of European men and women? How much do these inequalities in smoking contribute to inequalities in mortality in Europe? Can variations be observed between countries in the magnitude of inequalities in smoking and in the contribution of smoking to inequalities in mortality?

1.4.3 Structure of the thesis

This thesis is divided into five parts. The first part of the thesis consists of the first two chapters. This introduction is chapter 1 and it introduces the study and its general aim. The theoretical framework of the study is described, and the specific research questions are introduced. In chapter 2 the data and the methods of the study are introduced.

Inequalities related to mortality are the focus of the second part of the thesis. Chapter 3 gives an overview of socioeconomic inequalities in mortality in Europe, and shows how inequalities in mortality are patterned over several generations. Chapter 4 aims to explain inequalities in total mortality by showing the contribution of inequalities in specific causes of death to inequalities in total mortality.

The third part of the thesis consists of descriptive and explanatory analyses of socioeconomic inequalities in morbidity and disability. Chapter 5 gives an overview of socioeconomic inequalities in self-reported morbidity among the elderly in Europe. Chapter 6 shows whether socioeconomic inequalities in the incidence and recovery of self-reported and of performance-based disability can be demonstrated in addition to socioeconomic inequalities in prevalence. Chapter 7 describes an investigation into the implications of mortality selection occurring at younger ages for inequalities in health at older ages.

The focus of the fourth part of the thesis is smoking. An overview of inequalities in smoking is given in chapter 8. This is followed by an examination of the respective relationships of education and income to smoking in chapter 9. Chapters 10 and 11 estimate how much inequalities in smoking have contributed to inequalities in total mortality and inequalities in COPD mortality in Europe.

The fifth and final part of the thesis consists of a general discussion of the findings of the study.

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2

Data and methods of the study

2.1 Description of the data

Three different types of data sets are used in the study, with data from 13 different European countries. For this study the countries of interest are the countries of the European Union (until 1998), Norway and Switzerland. Eastern European countries are not taken into account. Table 1 lists for each country what data are available. All the data included in this study cover periods within the 1990s.

2.1.1 All-cause and cause-specific mortality data

Mortality data are used to answer the first research question about the magnitude of inequalities in mortality and the contribution of specific causes of death to these inequalities, and the third research question. Information on smoking related causes of death, such as lung cancer and COPD, are analyzed to estimate the contribution of smoking to socioeconomic inequalities in mortality.

The mortality data for this study have been derived from population census linked vital registries. Census linked vital registry data combine information on the number of deaths occurring in a given period of follow up after the census within socioeconomic subgroups of the population (derived from the vital registries), with information on the number of persons at risk within those subgroups (derived from the population census).[1] The information on socioeconomic status is derived from the population census. Data from such sources have been derived from a number of European populations, i.e. all the populations for which such data are available. Table 2 shows the populations for which data are obtained, the follow-up periods that are covered by these data, and the number of person years at risk of the total population (aged 30 years and older). All mortality data are aggregated according to sex, age and socioeconomic group.

Table 1: Overview of the data that are used in the study

Health (behaviour) indicator	Finland	Norway	Denmark	U.K.	Ireland	Netherlands	Belgium	Germany	France	Austria	Switzerland	Italy	Spain	Greece
All-cause mortality	National mortality data; 1991-1995; ages 30+	National mortality data; 1990-1995; ages 30+	National mortality data; 1991-1995; ages 30-69	ONS Longitudinal study; 1991-1996; ages 30+			National mortality data; 1991-1995; ages 30+		National mortality data; 1990-1994; ages 45-79	National mortality data; 1991-1992; ages 30+	National mortality data; 1991-1995; ages 30+	Urban mortality data from Turin; 1991-1996; ages 30+	Urban mortality data from Barcelona; 1992-1996; ages 30+. Region of Madrid; 1996-1997; ages 30+	
Cause-specific mortality	idem	idem	idem	idem			idem			idem	idem	idem	idem	
Self-reported morbidity			ECHP; 1994; ages 60+	ECHP; 1994; ages 60+	ECHP; 1994; ages 60+	ECHP; 1994; ages 60+	ECHP; 1994; ages 60+	ECHP; 1994; ages 60+		ECHP; 1994; ages 60+		ECHP; 1994; ages 60+	ECHP; 1994; ages 60+	ECHP; 1994; ages 60+
Disability						LASA; 1992-1999; ages 55-85						ILSA; 1992-1995; ages 65-84		
Current daily smoking	ECHP; 1998; ages 16+		ECHP; 1998; ages 16+	ECHP; 1998; ages 16+	ECHP; 1998; ages 16+		ECHP; 1998; ages 16+	ECHP; 1998; ages 16+		ECHP; 1998; ages 16+		ECHP; 1998; ages 16+	ECHP; 1998; ages 16+	ECHP; 1998; ages 16+
Ever daily smoking	idem		idem		idem		idem			idem		idem	idem	idem

Table 2: Populations for which mortality data have been included in the study

Country/Region	Follow-up period	Number of person years at risk	
		Men	Women
Finland	1991-1995	6,758,254	7,690,004
Norway	1990-1995	5,592,620	6,031,051
Denmark	1991-1995	7,035,378	7,677,538
England/ Wales	1991-1996	796,618	894,517
Belgium	1991-1995	13,047,398	14,587,998
France	1990-1994	1,432,641	1,192,537
Switzerland	1991-1995	5,673,634	6,747,784
Austria	1991-1992	2,092,646	2,459,625
Turin (city of)	1991-1996	1,276,242	1,532,675
Barcelona (city of)	1992-1996	2,263,963	2,798,811
Madrid (region of)	1996-1997	2,047,072	2,398,763

Data from Finland, Norway, Belgium and Austria comprise the total national populations of those aged 30 years and older. Data from Denmark and France comprise the national populations of those aged 30-74 years and 40-79 years respectively. The English and Welsh data are a nationally representative sample of 1% of the total English and Welsh population. The Swiss data include all those living in the predominantly German speaking parts of the country, and covers about 70% of the total Swiss population. Data from Turin and from Barcelona comprise the urban populations, and data from Madrid comprise the whole region of Madrid. For all the above-mentioned populations, with the exception of France, information on cause-specific mortality is acquired in addition to information on total mortality (all causes). Causes of death that were included were amongst others: ischaemic heart disease and stroke, specific cancers, COPD, and external causes of death. Information on educational level was available for each of the populations, and information on housing tenure for most, whereas information on income (of elderly people) was available only for a few populations. Therefore data on income were not included in the study.

2.1.2 Self-reported morbidity and smoking; the European Community Household Panel

The data of the European Community Household Panel (ECHP) are analyzed in this study for providing answers to the second and the third research questions. More specifically, analyses of the morbidity data that are available from this panel will provide answers to the question if socioeconomic inequalities in morbidity can be demonstrated among older men and women of

European countries. The ECHP also contains information on smoking that is used to estimate the magnitude of socioeconomic inequalities in smoking in European countries.

The ECHP is a social survey that is carried out in the member states of the European Community.[2] It is a survey of households and of individuals, which has as one of its main goals the generating of data that are comparable across countries. The target population of the ECHP consists of all individuals living in the European Union in private households (institutionalized are excluded). The first wave of data covered the year 1994, and included data for about 60.000 households and about 130.000 individuals living in private households in the then twelve member states of the European Union[1]. To warrant the comparability of the survey data, Eurostat, the statistical bureau of the European Community, has designed a blueprint questionnaire that is adopted in each of the countries. The data are representative both cross-sectionally and longitudinally.[2] For the purposes of this study the data of the ECHP are analyzed cross-sectionally.

Much effort has been put into acquiring comparable data sets for all countries, but some differences between countries in the methodology and the acquired response remain. The sampling frames and procedures are not completely standardized across countries. In each country a National Data Collection Unit (usually National Statistical Institutes) carries out the sampling but each national unit relies on its own methodologies for doing so. Sampling frames are the population registers in some countries, or a sample created from the latest populations census in others.

The ECHP contains information on several indicators of socioeconomic position, and some information on self-reported health. In this study the association between socioeconomic status and self-reported morbidity is determined for data of the first wave (1994). Interviewed individuals are asked how they would rate their health in general, on a five point scale, ranging from 'very good', 'good', 'fair', 'bad', to 'very bad'. They were also asked whether or not they felt

[1] The countries included then were: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and the UK.

that they were hampered in their daily activities by any physical or mental health problem, due to an illness or an injury. Finally they were asked to indicate whether or not they felt that they had to cut down in the things he or she normally does around the house due to a physical or a mental health problem, an illness or an injury. These three questions are used in this study to represent self-reported morbidity.

Data on smoking are also present in the ECHP, but questions on smoking are included only starting from the fifth wave of the survey (1998). Therefore the analyses with smoking and socioeconomic status are performed with data of this wave, in contrast to the analyses of self-reported morbidity. Interviewed individuals are asked whether they smoke daily, smoke occasionally, used to smoke daily, used to smoke occasionally, or never smoke.

2.1.3 Disability; the Italian Longitudinal Study on Aging, and the Longitudinal Aging Study Amsterdam

Analyses of the data from the Italian Longitudinal Study on Aging (ILSA) and the Longitudinal Aging Study Amsterdam (LASA) will provide answers to the second research question. Specifically these analyses will determine the magnitude of socioeconomic inequalities in the prevalence of, the incidence of and the recovery from disability. Both these studies include self-reported and the performance-based measures of disability, and these will both be included in the analyses.

The ILSA is a population-based study of the health status of older men and women from Italy, comprising data from persons of 65 years of age until 84 years of age.[3] As its main objectives the ILSA has studying the prevalence and the incidence of common chronic conditions in the older population, and identifying associated risks and protective factors. The data are representative for the Italian source population. At baseline, in 1992, a sex and age stratified sample of 5462 persons were randomly drawn from eight municipal registries from different parts of the country. One follow-up was conducted in the year 1995. Data from both baseline and the first follow-up are included in this study.

The Longitudinal Aging Study Amsterdam LASA is a longitudinal study covering older men and women in the Netherlands, aged between 55 and 85 years.[4] The central element of the LASA is the research into the autonomy of older men and women. Autonomy is defined in terms of physical, cognitive and emotional functioning. The first measurements were conducted among the 3200 men and women in 1992/1993. After that follow-ups were conducted in the years 1995/1996 and 1998/1999. These data are nationally representative. Data of baseline and the two follow-ups are included in the analyses of this study.

Both the ILSA and the LASA contain measurements of self-reported disability and disability assessed with performance tests. Because of the longitudinal structure of the studies, changes in disability can be assessed. In the present study socioeconomic inequalities in the prevalence of disability are determined, and additionally inequalities in the incidence and the recovery of disability.

Often disability is strictly defined as the expression of health problems in a social context.[5,6] Disability refers to people's ability to perform roles and activities in society. Measures of activities in daily living (ADL), functional limitations and performance-based measures of functional limitations are all defined as being disability measures in the present study. Thus, the definition of disability is used loosely here. Although limitations in ADL refer to serious dysfunction that likely also impair social functioning, measures of functional limitations on the other hand often concern basic physical actions that do not necessarily impair social functioning. In this study the term "disability" refers to either functional limitations or limitations in daily living activities without focusing strictly on the social context.

2.2 Methods of Analysis

2.2.1 The measuring of inequalities in health in this study

The measuring of socioeconomic inequalities in health can simply be conceptualized as consisting of: 1) the measurement of socioeconomic status, 2) the measuring and quantifying of health in different socioeconomic groups, and 3) comparing the quantified level of health between the socioeconomic groups. Several decisions need to be made during all three of these steps. Those decisions that are made in the present study are described in this section.

2.2.2 Determining the socioeconomic status of older persons

The relative position of a person within society is determined by several social attributes that can be to more or to a lesser extent be acquired in the course of one's life. For example, the relative position is determined by the educational level that someone has attained, it is determined by the occupation that he/she holds, by the income that is earned and by the social position of the spouse. These are arguably some of the most important attributes that determine someone's social position, or socioeconomic status. However, some of these are more important than others during different stages of the life course and are sometimes more relevant for indicating either the position of men or for that of women. Research on socioeconomic inequalities in health should best acknowledge this and the choice of the indicator of socioeconomic position that is used should be explained on the basis of the characteristics of the population that is studied.

In this study three different indicators of socioeconomic status are used. One indicator that is of practical use for older persons is education. This is because of a number of reasons. Firstly, one's educational level is usually acquired fairly early in the life course. This makes it less likely that a lower level of education can be ascribed to an existing health problem (health selection effects).[7] Although this characteristic of education equally applies to younger persons, the older men and women are more likely to suffer health problems, and other indicators of socioeconomic status, such as income, are likely to be influenced by their level of health. Secondly, education equally applies to those inside of and outside of the workforce and can be distinguished also for women and older persons.[7] However, the distribution of education across older populations is often very skewed, which means that education may not have enough discriminatory power to capture the full range of social inequalities in health. Information on level of education is the most widely available in different European countries. For instance, it can be linked often to data from mortality registries (while income in most countries cannot). All analyses of this study will be performed with education as an indicator of socioeconomic status.

Another indicator of socioeconomic status that will be used in this study is the household's net income level. Net household income is an indicator of household position, and captures the position equally of men and of women. It is a measure of 'liquid' material resources. As such, income may be relevant in those cases where wealth is needed to buffer acute economic stress. On the other hand, the net household income can change rapidly from one period to the next (for instance due to bereavement or retirement) and does not have the same stability as educational level has. When it is measured at only one point in time the current net household income cannot convey the history and the development of socioeconomic position of a household over time, and these are highly relevant for the health status of older persons. Combining net household income data with a measure of educational level may to a certain extent balance this drawback. Information on the net household income is available in the ECHP.

The third measure of socioeconomic status that is used in this study is housing tenure. Although it is not one of the core indicators of socioeconomic status, it has been used in previous research and consistently shows a relationship with health.[8-10] This indicator may capture important aspects of the social position of older persons. It can be thought of as representing accumulated wealth over the life course. It refers to the standard of living of the household. Previous studies that reported on inequalities related to housing tenure were mostly from Britain and it will be of interest to find out in how far housing tenure is related to health in older men and women of other countries as well.

Occupational class is not included as an indicator of socioeconomic position in the present study. Although it is one of the core indicators of socioeconomic position in addition to income and education, this indicator is much more relevant when studying the relationship of social position with health in populations that are part of the workforce.[11] These are mostly limited to adult men before retirement age and also, but less so, to adult women. It is for this reason that occupational class is not included in this study as an indicator of socioeconomic position.

2.2.3 *Measuring health*

The relationship of socioeconomic status with mortality in this study, and the use of census linked mortality registries imply a longitudinal design; they imply a follow-up of the populations over several years after the census has taken place. Morbidity can also be studied cross-sectionally. Cross-sectional analyses have the advantage that the statistical procedures are often relatively straightforward. They can be used to determine the association of an outcome variable with an exposure variable at a given point in time, but leave mostly no room for causal inferences. From a descriptive point of view cross-sectional analyses suffice to answer parts of the research questions of this study. It need not take more than determining the association of socioeconomic status with morbidity in a prevalence study to describe the existence and magnitude of inequalities in morbidity. That is why the data of the ECHP are analyzed cross-sectionally in this study.

One disadvantage of cross-sectional analyses is that the time sequence of exposure and outcome measures cannot be determined. This means that in theory, ill health may have preceded low socioeconomic status and may even have caused it. Although this is less likely to be the case when education is the indicator of socioeconomic position, because it is acquired early in the life course and mostly remains stable throughout; income is generally a much more variable exposure. Therefore, for more explanatory analyses of inequalities in morbidity a cross-sectional approach will not suffice.

In the present study longitudinal data are used therefore to determine the dynamics of incidence, recovery and mortality; factors that determine the duration of morbidity, and hence determine the observed prevalence of morbidity. With the analyses of data of the two longitudinal studies on disability it is determined whether educational status influences disability through incidence, through recovery and/or through mortality.

In the ECHP self-reported morbidity is determined by several questions about the health status of the interviewed individual. In the analyses of this study the answer categories of these questions are dichotomized and each individual subject is either categorized as having self-reported morbidity (e.g. less than self-reported good health) or not (e.g. self-reported good or excellent health). Dichotomizing into good and poor health obviously compresses the amount of available information because the initial five-and three-scale answering categories are not taken into account. However, the advantage of such dichotomy is the simplicity of calculating, interpreting and comparing the health status of, and between, the socioeconomic groups (using logistic regression).

Besides generating a measure of disability that is simple to interpret and to compare, there is an additional reason for dichotomizing the data from the disability measures in longitudinal studies. In such studies dichotomizing the disability measures allows for the analyses of the inequalities in transitions from one disability state to the other. It will be much more complex to determine and compare transitions from one disability state to another if there were more than two, and the samples of both longitudinal studies are also most likely too small to carry out such analyses.

One issue that needs to be discussed is the method of age standardizing that is employed in this study. Age standardization ensures that differences in the magnitude of morbidity or mortality in different populations are not due to differences in the age distribution of these populations. In this study two methods of standardizing for age are used; i.e. direct standardization and age-adjustment in regression analyses. Direct standardization is applied to the measurement of mortality and morbidity rates by applying the age distribution of a reference population (for instance the standard population of a European country) to the index populations under study. The rates that are thus acquired specify what rate of morbidity or mortality one would expect in a population with an age distribution as specified by the chosen reference population, in combination with the specific rates observed in the index population. In addition in this study the relationship of socioeconomic status with health is modeled via regression models. By including a categorical variable specifying 'age' into the regression models these risk ratios are adjusted for age. This method also ensures that differences in the age distribution between populations do not influence the observed risk ratios. Because both methods are based on slightly different approaches the results obtained may not be completely consistent. By the calculation of the rates, the rates are weighed according to the age distribution of a reference population, while in the regression analyses the weights are derived from the index populations under study. However, in practice the results are usually largely in agreement.

2.2.4 *Comparing the health status between socioeconomic groups*

Comparing the standardized prevalence or incidence/mortality rates of the groups could in theory be enough for deciding in which of the socioeconomic groups the burden of ill health or of mortality is the highest. Standardized rates are informative of the quantity of the problem of ill health, and are used mostly in descriptive studies.[12] However, comparing the magnitude of ill health in different subgroups would benefit from a quantification of the difference between these groups. Such quantification is needed to inform judgments about how large inequalities in health really are; or how strong the effect of socioeconomic status on health is. That is why in this study inequalities are expressed in summary measures that allow for such judgments. These summary measures quantify the difference between the magnitude of morbidity, disability, mortality or smoking in one group as compared to the other.

Several types of summary measures can be distinguished. For instance, the difference between groups can be estimated in relative, or in absolute terms and they can be expressed by simple summary measures or by more sophisticated ones. In this study differences between socioeconomic groups are expressed by means of all of these possible measures; i.e. in absolute and relative terms, and by means of simple measures but also sometimes using more sophisticated measures. This is because these measures provide information that can be regarded as being complementary to each other in order to determine the magnitude of inequalities in health and to compare these between countries or socioeconomic indicators. A short introduction to each of the measures that are used in this study is given below.

Socioeconomic inequalities are most often expressed in relative terms, by means of rate ratios, odds ratios or more sophisticated relative measures such as the relative index of inequality (RII). Relative measures are mostly based on a ratio of an absolute effect, and the reason why they are often preferred as the main outcome measure is probably because they put the absolute effect into perspective.[13] An absolute measure of effect by itself does not reveal how strong the effect of education on mortality is. On the other hand, relative inequalities in themselves do not convey the relevance of these inequalities for the population. A twofold higher level of mortality from a small cause of death can be considered of less relevance than a twofold higher level of mortality from a large cause of death. If such is the case, absolute measures complement the information that is obtained through relative measures. The distinction between relative and absolute measures is important when studying socioeconomic inequalities in old age, because it has often been stated that relative socioeconomic inequalities in mortality among older men and women are smaller as compared to inequalities among younger age groups. In absolute terms however, because mortality is much higher at old age, the absolute socioeconomic differences are much larger.

Both absolute and relative measures of effect can be roughly divided into simple measures and sophisticated measures. Generally, the more sophisticated a measure, the more information it takes into account, but also, the harder it is to interpret. Prevalence ratios, mortality ratios or prevalence odds ratios comparing low versus high socioeconomic groups are examples of simple measures. The absolute version of such simple relative measures is the prevalence or mortality rate difference. These measures take only the information of two socioeconomic groups into account, are therefore often easy to interpret, but also may leave important information untouched. The two groups that are compared when using these measures should be chosen with care, so as not to ignore most of the population by comparing only the two extremes of the socioeconomic dimension, but also not to be so broad that the real extent of health inequalities is underestimated.[14] In this study mostly simple measures are used, but in those cases where inequalities are compared between countries, socioeconomic indicators or age groups, a more sophisticated measure is used. This measure is the RII. The RII is a regression-based index that has the advantage that it takes information of all socioeconomic groups into account. In doing so it quantifies how a specific outcome varies according to the position of the socioeconomic groups within the whole socioeconomic hierarchy.[15]

When using binary data, such as is done in this study for morbidity, smoking and disability, two choices of a simple relative measure of effect present themselves: the prevalence ratio or the prevalence odds ratio. Logistic regression of a dichotomous outcome variable against a measure of socioeconomic position results in odds ratios after a log-transformation of the coefficient. Because it is automatically generated with logistic regression analyses, the odds ratio may be the more often used relative measure of effect in cases of prevalence data from cross-sectional studies.[16] In cases where the prevalence of the outcome is rare this will not present any problems, because the odds ratio can be interpreted in those cases as a prevalence ratio. Only when the outcome becomes more common the odds ratio will be increasingly further removed from one than the prevalence ratio is, and the odds ratio cannot be interpreted as a prevalence ratio anymore. This does not imply that the odds ratio is in all cases inferior to the prevalence ratio. There are properties that sometimes make the odds ratio the most likely measure of choice. One of these is that this measure expresses the effect of an independent variable on an outcome regardless of the direction (positive or negative) in which the outcome variable is defined. For example, an outcome variable of self-reported morbidity can either be so constructed that a case signifies ill health, or such that a case signifies good health. A prevalence ratio in both cases mostly yields different results whereas an odds ratio does not. In this study mostly the odds ratio is used as the simple relative measure. The exception is chapter 6 where inequalities in disability are expressed in prevalence ratios. Further explanation of the choice of prevalence ratios as the relative measures of effect as opposed to the odds ratio in those specific analyses is given in that chapter.

There are other summary measures that can be used to express the effect of socioeconomic status on health, that are not used in the present study. One of those is the 'population-attributable risk', or PAR. This measure gives an indication of the proportion of the incidence of a health condition within the population that is attributed to exposure to a given risk factor for that health condition within the population. With the PAR it would have been possible for instance to determine the proportion of lung cancer deaths in the population that can be attributed to exposure to lower socioeconomic status. In other words, it can express the proportionate reduction of the incidence of ill-health that would occur if everyone in the population would experience the rates of the highest socioeconomic group. Although this measure allows for attractive interpretation, using it in health inequalities research may be misleading because it can give an overestimated picture of the gains of reducing socioeconomic inequalities in health. On the other hand it has the advantage of taking the size of the exposed group into account, which the risk ratio does not. However in those cases where it is thought necessary to take the distribution of the population into account the RII is chosen, rather than the PAR, because the

PAR requires the arbitrary choice of a reference group, which may affect the comparability of this measure between populations.

2.2.5 *Explanatory methods*

Different analytical methods are used in the present study for explaining socioeconomic inequalities in health. Firstly, it is determined what share some important specific causes of death make to differentials in total mortality. This is done by determining the differences in rates of mortality between the higher and the lower socioeconomic group, and subsequently expressing the rate difference of a specific cause of death as a percentage of the total mortality rate difference. Through this method differences between countries and age groups in the probable explanations of mortality differentials can be insightfully demonstrated. Kunst et al. (1998) have used this method before in a study on socioeconomic inequalities in mortality.[17] The results of the method as it is applied in our study are described in chapter 4.

The multi-state life table is a second method used to provide explanations for the magnitude of inequalities in health occurring at older ages. The multi-state life table is an extension of the 'normal' life table. It does not only model the mortality experience of a population and its life expectancy, but it relates them to underlying transitions between the states of health, ill health and death.[18] The explanatory analyses that are described in chapter 7 consist of modeling the mortality rates with the multi-state life table technique to determine the effect of mortality selection in early old age on socioeconomic inequalities in health among the oldest ages.

One method that is often used to determine the contribution of smoking to mortality, but that has not been applied to socioeconomic inequalities in mortality before, is the method of Peto and Lopez (1992).[19] This method aims to quantify the contribution of smoking to the burden of mortality. The specific characteristics of this method are explained in chapters 10 and 11 of the thesis. The Peto-Lopez method is used in this study to determine the contribution that smoking made to mortality in lower and higher educational groups. In this way it is used to determine the contribution of smoking to inequalities in total mortality inequalities, and to inequalities in COPD mortality.

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Part II

Socioeconomic inequalities

in mortality

3

Socio-economic inequalities in mortality among the elderly in eleven European populations

Huisman M, Kunst AE, Andersen O, Bopp M, Borgan J-K, Borrell C, Costa G, Deboosere P, Desplanques G, Donkin A, Gadeyne S, Minder C, Regidor E, Spadea T, Valkonen T, Mackenbach J. Socio-economic inequalities in mortality among the elderly in eleven European populations. *J Epidemiol Community Health* 2004;55:895-904.

3.1 Summary

Introduction: This study aims to describe mortality inequalities related to level of education and housing tenure in eleven European populations. It describes the age pattern of not only relative, but also absolute, socio-economic inequalities in mortality in the elderly European population.

Data and Methods: Data from mortality registries linked with population census data of eleven countries and regions of Europe were acquired for the beginning of the 1990s. Level of education and housing tenure were used as indicators of socio-economic status. We classified these indicators into an internationally comparable categorisation. Relative socio-economic mortality inequalities were expressed in mortality rate ratios and in the relative index of inequality (RII). Differences in age standardised mortality rates between socio-economic strata were used to measure absolute mortality inequalities. The age range was 30 to over 90 years. Analyses were performed on the pooled European data, including all populations, and on the data of each of the populations separately. Populations included in the study were Finland, Norway, Denmark, England and Wales, Belgium, France, Austria, Switzerland, Barcelona, Madrid, and Turin.

Results: In Europe (all populations pooled) relative inequalities in mortality decreased with increasing age. A relation between socio-economic status and mortality was still present at the oldest ages (90+). Additionally we found that absolute educational differences in mortality rose to a peak at ages 90+. In some of the populations, relative inequalities among elderly women were as large as among middle-aged women. International variations in the age pattern of socio-economic mortality inequalities were observed. The decline of relative educational inequalities was largest in Norway (men and women) and Austria (men), while relative educational inequalities did not decrease, or hardly decreased with age in England & Wales (men), Belgium, Switzerland, Austria and Turin (women).

Conclusions: Socio-economic inequalities in mortality among the elderly were found to persist among men and women in each country, in some cases at a similar magnitude as among the middle-aged. Mortality inequalities among elderly populations are an important public health problem in Europe.

3.2 Introduction

Socio-economic mortality inequalities among older ages have been less discussed as inequalities among younger age groups. However, literature on the topic is increasing and it seems that more researchers developed an interest in mortality inequalities related to socio-economic status in elderly populations. The lion's share of mortality occurs at old age and any amount of inequality in mortality points to a major source of potential to improve health in the population.

It has been consistently found that among adult populations, mortality at the lower end of the socio-economic strata is higher as mortality at the higher end.[1-4] Also among elderly populations, socio-economic mortality inequalities are found.[5-13] These inequalities often decrease with increasing age.[10-16] However, there are important reasons to determine socio-economic inequalities among elderly populations.

One reason is that most of what is known of socio-economic inequalities in mortality among the elderly stems from research in Northern European countries. The question remains as to whether the results from these studies are generalisable to other parts of Europe.

A second reason is that the use of every socio-economic indicator has its own specific problems when applied to elderly populations.[10] Education is considered to be an appropriate indicator of socio-economic status by some,[8] but the concept of socio-economic status is broader than education alone. There may yet be other indicators beside the traditional ones (occupation, income, and education) that are more adequate measures of socio-economic status for elderly populations. Housing tenure for instance is an indicator that is often used in research from the U.K..[6,17-19] Housing tenure as an indicator of socio-economic status may show substantial mortality inequalities in other countries as well.

Thirdly, when comparing the reported inequalities among the elderly with inequalities among the middle-aged in relative terms alone, the situation in absolute terms is overlooked. Relative inequalities may decrease with age, but absolute differences may not. Absolute differences are important as well, as they refer to the absolute numbers of avoidable deaths. In ageing populations, the number of avoidable deaths can exceed thousands even when relative inequalities can hardly be demonstrated.

This study aims to describe the age pattern of not only relative, but also absolute, mortality inequalities related to both level of education and housing tenure in Europe, using population data. Elderly populations are compared with middle-aged populations. In order to determine the generalisability of results that are found in one part to other parts of Europe, the study includes data from northern as well as central and southern parts of Europe.

3.3 Data and Methods

Population data from national, regional and urban longitudinal mortality studies were used. We used data on mortality from vital registries linked with data from population censuses. From these census linked mortality data we acquired the number of deaths and the number of person years at risk, by sex, five-year age-group (age specified at the start of the follow-up; with 30-34 as the youngest age-group and 90+ as the oldest group), level of education and housing tenure (the latter not present in all studies). These two measures of socio-economic status were validated for the population as part of the population census. The population censuses were carried out by national, regional and urban statistical bureaus. The countries and cities that are included in the study are listed in Table 1. Most studies covered the entire national, regional or urban population. The data for England/Wales, Norway and France were representative samples of the national populations. Swiss data was representative of the population in the predominantly German speaking cantons.

Table 1: Follow-up periods of the included populations and the number of person years at risk (ages 30+ years)

Country/Region	Follow-up period	Number of person years at risk	
		Men	Women
Finland	1991-1995	6,758,254	7,690,004
Norway	1990-1995	5,592,620	6,031,051
Denmark	1991-1995	7,035,378	7,677,538
England/Wales	1991-1996	796,618	894,517
Belgium	1991-1995	13,047,398	14,587,998
France	1990-1994	1,432,641	1,192,537
Switzerland	1991-1995	5,673,634	6,747,784
Austria	1991-1992	2,092,646	2,459,625
Turin (city of)	1991-1996	1,276,242	1,532,675
Barcelona (city of)	1992-1996	2,263,963	2,798,811
Madrid (region of)	1996-1997	2,047,072	2,398,763

The level of education was initially classified according to national categories of education. We reclassified these into three levels of education (1=low, 2=middle, 3=high), approximately corresponding with the following levels of the International Standard Classification of Education (ISCED): 0-2 (pre-primary, primary and lower secondary education), 3 (upper secondary education) and 4-6 (postsecondary education).[20] Percentage of missing information for education was large in Denmark (10%) but below 4% in all other populations. The resulting population distribution of the three levels of this classification is given in Table 2. For Switzerland applying the general classification proved difficult, as is apparent from the deviating distribution over the population. Educational data was not available for Denmark and France for ages older than 60-69 years and 70-79 years respectively.

Housing tenure was divided into the following three categories: owner-occupiers, tenants and institutionalised populations. The distribution of the population according to housing tenure is given in the third table. Tenants were specified as representing lower socio-economic status and owner-occupiers as higher status. The institutionalised were left out of analysis. Tenure data was not available for France for those older than 79 years.

Table 2: Distribution of the educational variable, middle-aged (50-59 years) and elderly (80-89 years) men and women

		Percentage of the **Male** population			Percentage of the **Female** population		
Country/City	Age	Low	Middle	High	Low	Middle	High
Finland	50-59	62.3	27.0	10.7	63.4	27.9	8.7
	80-89	82.2	11.1	6.6	86.6	9.1	4.3
Norway	50-59	80.7	9.2	10.1	87.3	8.1	4.6
	80-89	90.6	4.0	5.4	95.2	4.2	0.6
Denmark	50-59	70.0	16.0	14.0	71.0	19.0	10.0
	60-69	74.3	14.4	11.3	77.1	15.8	7.2
England/Wales	50-59	79.4	11.6	9.0	85.9	11.1	3.0
	80-89	89.0	5.4	5.7	93.3	5.3	1.3
Belgium	50-59	71.9	16.1	11.9	77.2	14.0	8.8
	80-89	87.7	6.2	6.2	93.1	3.9	3.0
France	50-59	80.1	8.1	11.8	81.9	10.0	8.1
	70-79	80.4	8.8	10.8	83.1	9.2	7.7
Switzerland	50-59	18.2	58.8	23.0	42.5	52.3	5.2
	80-89	38.5	49.2	12.3	68.8	29.2	2.0
Austria	50-59	79.9	10.8	9.3	79.0	16.6	4.4
	80-89	80.2	10.5	9.4	88.2	9.8	2.1
Turin	50-59	75.5	16.8	7.7	84.8	11.6	3.6
	80-89	83.2	8.8	8.0	92.2	6.5	1.3
Barcelona	50-59	72.2	11.6	16.2	81.6	7.4	8.7
	80-89	80.0	8.0	12.1	90.2	2.5	3.9
Madrid	50-59	67.6	14.1	18.3	81.1	9.6	9.3
	80-89	81.8	6.9	11.4	93.0	3.5	3.4
All Countries	50-59	67.4	19.7	13.0	74.1	19.0	6.9
	80-89	78.4	13.2	8.4	88.6	8.8	2.6

Note: All Countries = Denmark and France not included

Table 3: Distribution of the housing tenure variable, middle-aged (50-59 years) and elderly (80-89 years), men and women

		Percentage of the **Male** population			Percentage of the **Female** population		
Country/City	Age	Tenants	Owners	In an institution	Tenants	Owners	In an institution
Finland	50-59	13.7	83.6	0.5	13.9	84.2	0.3
	80-89	13.6	74.3	7.2	22.6	60.8	11.7
Norway	50-59	12.2	87.7	0.1	10.9	89.1	0.1
	80-89	25.6	71.9	2.5	32.6	63.7	3.7
Denmark	50-59	26.3	71.8	0.5	31.3	67.4	0.3
	80-89	40.7	47.6	8.5	30.2	52.9	13.3
England/Wales	50-59	16.6	67.8	0.5	18.3	68.1	0.5
	80-89	29.5	51.3	7.5	32.7	42.5	13.1
Belgium	50-59	21.3	73.8	0.4	21.4	74.1	0.4
	80-89	23.7	63.3	7.4	26.6	51.9	14.4
France	50-59	42.2	57.8	N.A.	39.7	60.3	N.A.
	70-79	36.3	63.7	N.A.	37.0	63.0	N.A.
Turin	50-59	36.9	59.4	0.4	35.6	60.4	1.0
	80-89	33.2	57.4	2.5	38.3	47.1	6.0
All Countries	50-59	29.2	67.4	0.4	28.2	68.9	0.4
	80-89	28.5	60.8	6.6	28.2	55.0	11.7

Note: N.A. = Not Available; All countries = France not included

We determined age-standardised mortality rates by gender, ten-year age group and education/housing tenure. The rates were standardised by five-year age groups by means of the direct method, with the population of the EU plus Norway of 1995 as the standard.[21] Absolute socio-economic differences were expressed as rate differences. These are the differences between the mortality rates of the groups with a lower socio-economic status (= level 1 of the general educational classification/tenants) with the mortality rates of the groups with a higher status (levels 2 and 3 of the general educational classification/owner occupiers). For Switzerland we combined levels 1 and 2 of the general educational variable instead of levels 2 and in order to compare about equally large groups for this country as for the other countries in the study.

With Poisson regression analyses we calculated two indicators of relative mortality inequalities, rate ratios and the relative index of inequality (RII). The rate ratios were controlled for age, and country in the case of analyses of pooled data. The combined middle and high educational categories (for Switzerland only the high educational category), and the house owners were specified as the reference groups. The RII was determined for level of education in order to control for the distribution of the population over the levels of education. This regression-based index contrasts the rate of mortality that is predicted for the lower end of the educational hierarchy to the rate of mortality at the higher end of the hierarchy into a ratio.[22] The use of the RII allows for a direct comparison of relative inequalities between countries. We used the SAS statistical package, version 6.12 to determine these relative measures.[23]

We created two pooled European data sets with country-specific weights assigned to the individual observations, so that the separate populations carried equal weight in the results of the European analyses. One set included all countries, with the exception of Denmark and France for which no information on education among elderly populations could be given. The other data set included all countries for which information was available on housing tenure, with the exception of France. The analyses for educational inequalities in Europe were performed on the first pooled data set, and analyses for inequalities related to housing tenure were performed on the second data set.

The rate ratios, RIIs and rate differences were determined for the separate countries and cities for the age groups 50-59 (middle-aged), 60-69, 70-79 and 80-89 (elderly populations), and for the pooled data for all age groups of ten years, ranging from ages 30-39 to 90+. The studies of Barcelona and Madrid were taken together in the analyses of separate countries to represent Spain. A former study showed that the size of inequalities in mortality in both cities was similar.[24]

3.4 Results

Mortality rates for European men and women for the age groups 30-39 to 90+ are plotted in Figures 1 and 2. For education, the mortality rates among high and low status groups increasingly diverged with older age (Figure 1). The rates for men and women showed a similar pattern. The rates for housing tenure initially showed a similar pattern as those of education, i.e. divergence with increasing age (Figure 2). At the oldest ages, however, the rates for tenure converged. The rates of female tenants were smaller than those of female owner-occupiers after age 80.

Figure 1: Age-pattern of mortality rates for Europe, men and women, related to education

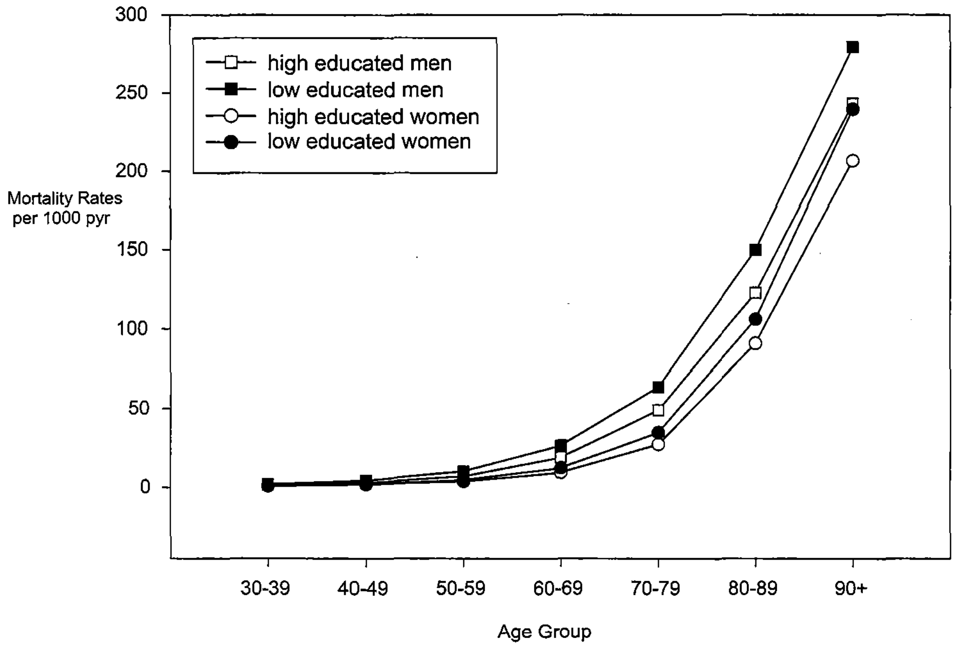


Figure 2: Age-pattern of mortality rates for Europe, men and women, related to housing tenure

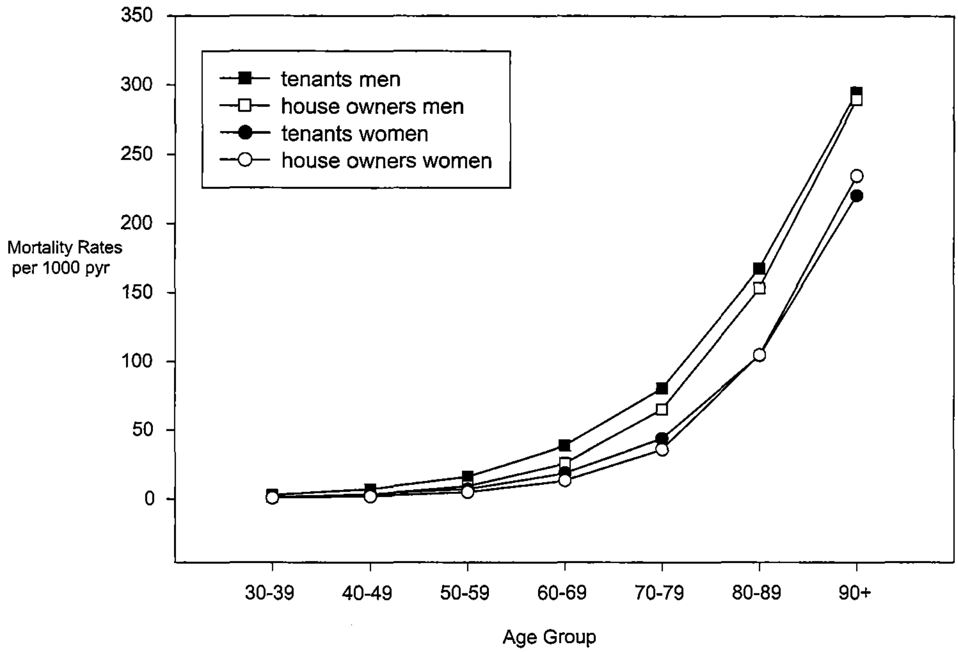


Table 4 shows rate ratios and rate differences per age group. Relative inequalities (rate ratios) decreased gradually with age, with the exception of educational inequalities among women. These were stable from ages 40-49 to 70-79. Educational inequalities among men and women persisted until the oldest ages, but inequalities related to tenure did not. Absolute educational differences increased consistently with increasing age among both sexes and were largest for the age group 90+. Absolute differences by tenure initially also increased with age, but decreased among the oldest old.

Table 4: The age-pattern of socio-economic mortality inequalities in Europe, by gender

	Indicator of inequality	Age-group						
		30-39	40-49	50-59	60-69	70-79	80-89	90+
Education								
Men	Rate Ratio	1.98	1.61	1.51	1.39	1.26	1.18	1.09
	(95% CI)	(1.88-2.07)	(1.56-1.67)	(1.47-1.55)	(1.37-1.42)	(1.24-1.28)	(1.16-1.20)	(1.02-1.15)
	Rate Difference	0.64	1.29	3.21	7.67	14.41	27.23	35.89
	Total Rate	1.74	3.75	9.36	25.24	60.95	145.65	273.63
Women	Rate Ratio	1.69	1.28	1.32	1.33	1.30	1.21	1.19
	(95% CI)	(1.57-1.81)	(1.22-1.34)	(1.26-1.37)	(1.29-1.37)	(1.27-1.34)	(1.18-1.24)	(1.13-1.25)
	Rate Difference	0.30	0.35	1.03	3.00	7.54	15.11	32.89
	Total Rate	0.84	1.99	4.45	11.98	34.29	104.81	237.10
Housing tenure								
Men	Rate Ratio	2.12	2.18	1.85	1.54	1.27	1.12	1.03
	(95% CI)	(2.05-2.18)	(2.13-2.23)	(1.82-1.88)	(1.53-1.57)	(1.26-1.29)	(1.11-1.13)	(0.99-1.07)
	Rate Difference	1.41	3.77	6.82	12.60	15.19	14.25	5.08
	Total Rate	1.81	4.01	10.33	28.00	68.04	156.20	290.81
Women	Rate Ratio	1.87	1.84	1.62	1.47	1.21	1.01	0.93
	(95% CI)	(1.79-1.95)	(1.79-1.90)	(1.58-1.66)	(1.45-1.49)	(1.20-1.23)	(0.99-1.02)	(0.91-0.96)
	Rate Difference	0.5	1.45	2.14	5.44	7.78	-0.53	-14.3
	Total Rate	0.92	2.32	5.42	14.46	37.95	104.93	230.69

Note: rates are given per 1,000 person years at risk. Rate Ratios are the ratio of the rate of the lower educated group with the rate of the combined middle and higher educated groups. Rate Differences are the difference between the rate of the lower educated group with the rate of the combined middle and higher educated groups.

Relative and absolute mortality inequalities for the separate populations are shown in Tables 5 and 6. Educational inequalities are given in Table 5. The populations are listed geographically from north to south. In this table, the results for each population are given for the middle-aged (ages 50-59) and elderly (ages 60-69, 70-79 and 80-89). Exceptions are Denmark and France for which the oldest age groups are 60-69 and 70-79 respectively.

Table 5: Absolute and relative educational inequalities in mortality among middle-aged and elderly men and women

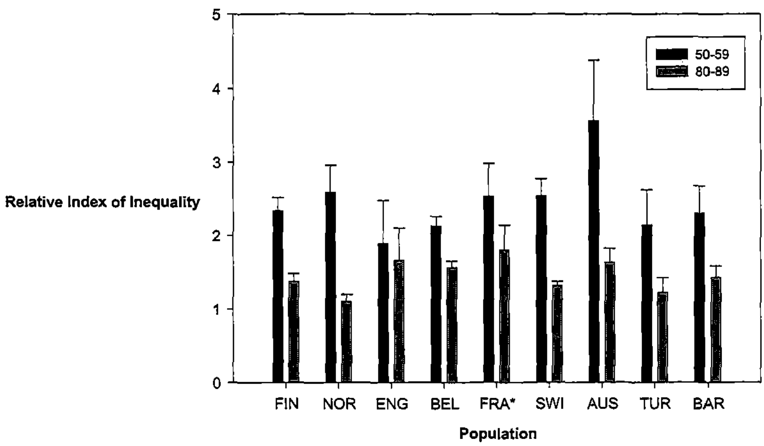
		MEN				WOMEN			
Country/ City	Age	RR	(95%-CI)	RD	TR†	RR	(95%-CI)	RD	TR†
Finland	50-59	1.49	(1.44-1.55)	4.45	11.79	1.42	(1.34-1.50)	1.53	4.65
	60-69	1.41	(1.37-1.45)	9.53	30.96	1.28	(1.24-1.34)	3.08	13.29
	70-79	1.25	(1.22-1.29)	15.36	73.21	1.24	(1.21-1.28)	8.54	42.59
	80-89	1.17	(1.13-1.21)	25.10	171.74	1.17	(1.14-1.21)	19.80	133.77
Norway	50-59	1.60	(1.50-1.71)	3.70	9.17	1.67	(1.50-1.87)	1.94	4.75
	60-69	1.41	(1.36-1.48)	7.92	25.95	1.36	(1.26-1.47)	3.40	12.58
	70-79	1.38	(1.33-1.43)	18.56	65.77	1.64	(1.54-1.75)	14.21	35.50
	80-89	1.05	(1.00-1.09)	7.68	160.84	1.12	(1.06-1.18)	11.34	108.06
Denmark	50-59	1.37	(1.31-1.42)	3.29	11.36	1.35	(1.28-1.42)	2.14	7.59
	60-69	1.28	(1.24-1.32)	7.05	30.28	1.26	(1.21-1.30)	3.97	18.45
England/ Wales	50-59	1.36	(1.19-1.56)	2.75	9.80	1.44	(1.15-1.80)	1.67	5.30
	60-69	1.61	(1.45-1.79)	11.18	27.99	1.53	(1.31-1.78)	5.93	16.72
	70-79	1.17	(1.08-1.28)	10.89	71.65	1.19	(1.07-1.33)	7.24	43.24
	80-89	1.28	(1.14-1.44)	38.17	161.33	1.07	(0.96-1.19)	7.67	116.10
Belgium	50-59	1.44	(1.40-1.49)	3.44	10.22	1.24	(1.19-1.30)	1.04	5.03
	60-69	1.38	(1.35-1.41)	8.10	27.68	1.34	(1.30-1.39)	3.39	12.72
	70-79	1.29	(1.27-1.32)	16.15	68.20	1.35	(1.31-1.39)	9.86	37.01
	80-89	1.24	(1.21-1.28)	34.13	169.54	1.26	(1.23-1.29)	24.76	118.76
France	50-59	1.58	(1.45-1.71)	3.24	8.40	1.08	(0.95-1.23)	0.29	3.45
	60-69	1.31	(1.21-1.41)	4.67	19.39	1.14	(1.00-1.29)	0.91	7.42
	70-79	1.36	(1.25-1.48)	11.25	42.45	1.22	(1.07-1.39)	3.04	20.65
Switzerland	50-59	1.62	(1.52-1.72)	3.24	7.81	1.29	(1.11-1.50)	0.94	3.89
	60-69	1.39	(1.34-1.45)	6.22	20.93	1.30	(1.16-1.45)	2.21	9.59
	70-79	1.30	(1.26-1.35)	12.81	52.38	1.28	(1.17-1.41)	5.97	27.56
	80-89	1.17	(1.12-1.21)	19.69	133.61	1.33	(1.22-1.44)	22.14	89.48
Austria	50-59	1.86	(1.68-2.06)	4.46	8.73	1.21	(1.07-1.37)	0.67	3.95
	60-69	1.56	(1.46-1.67)	8.53	21.95	1.30	(1.20-1.40)	2.38	10.03
	70-79	1.39	(1.31-1.47)	15.26	50.96	1.30	(1.23-1.38)	7.18	29.56
	80-89	1.27	(1.21-1.35)	31.24	138.68	1.39	(1.32-1.46)	29.78	102.66
Turin	50-59	1.45	(1.31-1.61)	2.84	8.35	1.14	(0.98-1.33)	0.50	4.14
	60-69	1.26	(1.18-1.34)	5.19	24.60	1.24	(1.11-1.38)	2.23	11.25
	70-79	1.17	(1.10-1.25)	9.27	59.34	1.32	(1.20-1.46)	8.05	31.72
	80-89	1.11	(1.03-1.20)	13.68	148.47	1.12	(1.03-1.22)	10.89	99.06
Barcelona & Madrid	50-59	1.46	(1.38-1.55)	2.64	7.59	1.29	(1.16-1.43)	0.74	3.00
	60-69	1.24	(1.19-1.29)	3.67	18.06	1.33	(1.22-1.44)	1.83	7.25
	70-79	1.17	(1.12-1.22)	6.37	40.48	1.35	(1.26-1.43)	5.44	20.52
	80-89	1.17	(1.12-1.22)	13.35	89.74	1.22	(1.15-1.29)	11.78	64.69

Note: RR=Rate Ratio. (95%-CI)=95% Confidence Interval. RD=Rate Difference. TR†=Total Rate. † The total rate represents the mortality rate of the total population. i.e. all educational groups together, given per 1000 person years at risk. Rate Ratios are the ratio of the rate of the lower educated group with the rate of the combined middle and higher educated groups. Rate Differences are the difference between the rate of the lower educated group with the rate of the combined middle and higher educated groups.

Among men, the relative inequalities (rate ratios) were lower among the elderly than among the middle-aged in all populations, with the exception of England and Wales, where the largest inequalities were observed at ages 60-69. A gradual decrease of relative educational inequalities among women in the older groups was only found for Finland. There was still a relationship between socio-economic status and mortality at older ages. Only in England and Wales (among the oldest women) could relative inequalities not be illustrated with statistical significance. Absolute differences were consistently higher among the elderly.

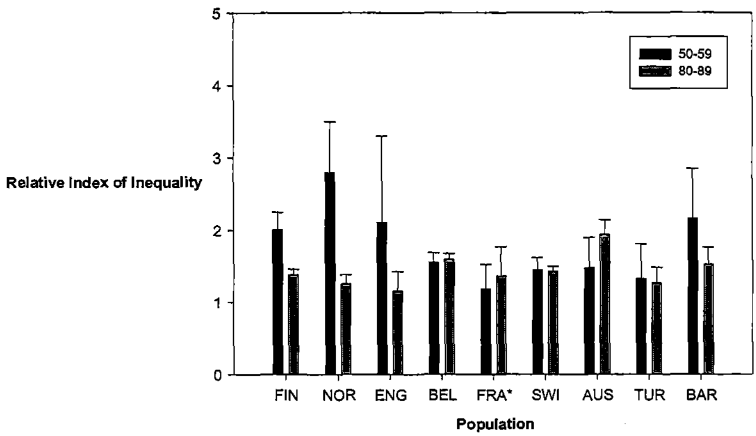
Differences between countries in the relative educational mortality inequalities are shown in the third and fourth figure. Variations in the extent of decrease of relative inequalities were found between populations. The decrease with age was large in Norway (men and women) and Austria (men). Smaller declines among women were also observed in Finland, England and Wales, and Barcelona and Madrid. In other populations the RIIs were similar or somewhat larger in the older age group.

Figure 3: The size of educational inequalities in mortality for middle-aged (50-59 years) and elderly (80-89 years) men



Note: * The oldest age group for France is 70-79. BAR = Barcelona & Madrid. The Relative Index of Inequality is a regression-based index that contrasts the rate of mortality that is predicted for the lower end of the educational hierarchy to the rate of mortality at the higher end of the hierarchy into a ratio.

Figure 4: The size of educational inequalities in mortality for middle-aged (50-59 years) and elderly (80-89 years) women



Note: * The oldest age group for France is 70-79. BAR = Barcelona & Madrid. The Relative Index of Inequality is a regression-based index that contrasts the rate of mortality that is predicted for the lower end of the educational hierarchy to the rate of mortality at the higher end of the hierarchy into a ratio.

Inequalities relating to housing tenure are shown in Table 6. Relative inequalities were consistently smaller among the oldest ages for all populations and both sexes. Among women these were statistically significant in Finland and Denmark only. The extent to which the inequalities declined differed between the populations. The peak in absolute differences was found in many populations at ages 70-79, rather than 80-89, which was in agreement with the finding for the pooled European population that absolute differences in mortality related to housing tenure declined at the oldest ages.

Table 6: Absolute and relative inequalities in mortality related to housing tenure among middle-aged and elderly men and women

		MEN			WOMEN		
Country/Region	Age	RR	(95%-CI)	RD	RR	(95%-CI)	RD
Finland	50-59	2.18	(2.09-2.26)	11.49	1.82	(1.71-1.94)	3.34
	60-69	1.90	(1.84-1.95)	23.96	1.73	(1.67-1.79)	8.50
	70-79	1.44	(1.40-1.48)	30.19	1.32	(1.29-1.35)	12.53
	80-89	1.20	(1.16-1.25)	28.96	1.05	(1.02-1.07)	4.70
Norway	50-59	1.65	(1.56-1.74)	5.42	1.13	(1.03-1.23)	0.60
	60-69	1.44	(1.39-1.49)	11.10	1.36	(1.30-1.42)	4.32
	70-79	1.16	(1.13-1.19)	10.87	1.15	(1.12-1.18)	5.46
	80-89	1.06	(1.03-1.09)	6.75	1.01	(0.99-1.03)	1.23
Denmark	50-59	2.15	(2.08-2.22)	10.12	1.72	(1.66-1.79)	4.49
	60-69	1.64	(1.60-1.67)	15.96	1.47	(1.43-1.51)	7.17
	70-79	1.36	(1.34-1.39)	22.35	1.33	(1.30-1.36)	11.44
	80-89	1.21	(1.18-1.24)	27.97	1.13	(1.10-1.15)	11.50
England/Wales	50-59	2.02	(1.80-2.27)	8.07	1.93	(1.66-2.26)	4.06
	60-69	1.65	(1.53-1.77)	14.81	1.58	(1.46-1.72)	8.20
	70-79	1.29	(1.21-1.37)	18.51	1.36	(1.28-1.45)	13.54
	80-89	1.17	(1.08-1.27)	20.01	1.01	(0.94-1.07)	0.38
Belgium	50-59	1.65	(1.61-1.70)	5.68	1.60	(1.54-1.66)	2.58
	60-69	1.44	(1.41-1.46)	10.78	1.43	(1.40-1.47)	4.83
	70-79	1.22	(1.20-1.24)	14.40	1.12	(1.10-1.14)	4.40
	80-89	1.08	(1.05-1.10)	11.19	0.92	(0.91-0.94)	-8.53
France	50-59	1.34	(1.27-1.42)	2.49	1.20	(1.09-1.32)	0.63
	60-69	1.27	(1.20-1.34)	4.69	1.25	(1.14-1.37)	1.68
	70-79	1.12	(1.05-1.19)	4.88	1.09	(0.99-1.19)	1.70
Turin	50-59	1.38	(1.27-1.49)	2.73	1.31	(1.17-1.46)	1.12
	60-69	1.37	(1.29-1.44)	7.95	1.33	(1.24-1.43)	3.29
	70-79	1.17	(1.11-1.23)	9.56	1.14	(1.08-1.20)	4.64
	80-89	1.06	(1.00-1.13)	6.86	1.01	(0.96-1.06)	0.22

Note: RR=Rate Ratio. (95%-CI)=95% Confidence Interval. RD=Rate Difference. Rate Ratios are the ratio of the rate of the lower educated group with the rate of the combined middle and higher educated groups. Rate Differences are the difference between the rate of the lower educated group with the rate of the combined middle and higher educated groups.

3.5 Discussion

This paper illustrated that not only absolute, but also relative socio-economic inequalities in mortality among the elderly persisted into old age and were considerable. Moreover we found that whereas relative socio-economic mortality inequalities generally decreased with age, absolute inequalities increased with age. Finally, we observed that the age pattern of relative inequalities differed between populations among women. A decrease in relative inequalities by education with rising age among women was not evident in many populations.

Some limitations of the study must be discussed. Because of differences in the organisation of national educational systems, we collapsed those into a broad general classification, consisting of three levels, with most of the population falling into the lowest category. We checked what influence the use of this broad classification had on the results. Using a more refined classification that was available for some of the populations we found that a further division of the levels of education resulted in slightly larger relative and absolute inequalities, but that the age patterns did not change.

The follow-up periods differed somewhat in length between studies. The studies for Austria and Madrid cover one and two years respectively, while other countries cover a period of four to five years. As a result the Austria and Madrid studies refer to a slightly younger population, which may have resulted in a small overestimate of relative mortality inequalities in these populations.

Furthermore, mortality rates may have changed during the follow-up periods due to, for instance, modifications in the organisation of health care programs. However, we do not expect that this has influenced the results to great extent, because the follow-up periods cover about 5 years and it is not likely that mortality rates have changed much in such a short time frame.

The results for housing tenure are probably influenced by the exclusion of institutionalised populations. One hypothesis is that the elderly who still rent a house are a selection of healthy people, because elderly tenants move more easily to institutions when they are faced with problems to live on their own. Research from England and Wales has shown that tenants have higher institutionalisation rates than owner-occupiers.[25] If tenants elsewhere also have a higher risk of becoming institutionalised when ill, this may explain the attenuation of mortality differences by housing tenure at 80+. The finding that inequalities attenuated more among women is in line with this explanation, since women are more likely to be institutionalised when disabled than men are. However, this is not likely to be the only explanation for the attenuation of the inequalities. In Norway, where the percentage of institutionalised is very low a large attenuation was observed.

Irrespective of the problem of institutionalisation mentioned above, housing tenure still acts as a conceptually complementary measure of socio-economic status to education. Conveniently, it is an indicator that is available in many countries. Housing tenure was strongly related to mortality among the middle-aged and among the early old age groups. We found that inequalities according to housing tenure were smaller as compared to educational inequalities only in the two oldest age groups. It appears that housing tenure is a useful indicator for both middle-aged and elderly populations, except the oldest old. Future research could address a 'four-corners' approach to socio-economic inequalities in mortality. Education and housing tenure may relate to different causal pathways and combining the two measures into one indicator may provide evidence of the relative importance of both pathways, as well as their combined effect.

Our results are comparable with the results of previous studies. Although a few studies did not report socio-economic inequalities among the elderly,[26-28] these were mostly epidemiological studies with small sample sizes.[9] Studies with larger samples did find that inequalities in health persist into old age, including studies that report on inequalities related to other socio-economic indicators than education and housing tenure, and studies based outside Europe.[5-13] An important contribution of the results of this overview is the finding that relative inequalities among the elderly were not consistently smaller than among younger age groups.

Furthermore, our study showed that absolute inequality measures reveal important information which relative measures alone cannot. We found that the absolute numbers of excess deaths among the lower socio-economic groups were considerable at old age. Therefore it cannot be concluded that inequalities among elderly populations are of lesser importance than at middle age.

This study showed that the age pattern of inequalities in mortality differed between countries. These findings raise the question as to why relative inequalities in mortality decreased with age in some countries, while in other countries they remained about stable, or increased, especially among women. One explanation is that a decrease is more unlikely among women in some populations because relative inequalities among the younger women are not large to begin with.

In fact, those populations that do show a decrease are those in which relative inequalities among younger women are almost as large as among men (Finland, Norway and England and Wales).

As the results of this study are related to different cohorts, they can hide different stories. An apparent decline among older generations could hide a surge in inequality among younger cohorts (for example women in Nordic countries). One factor possibly involved in this is smoking. Social inequalities in smoking vary strongly by age group, with larger inequalities observed among younger than among older generations.[29] This age-dependency of inequalities in smoking may have influenced the age-dependency of inequalities in mortality in many European populations, especially among male generations, which have had historically much higher lifetime exposure to smoking. International overviews have shown that strong age gradients in smoking inequalities, with smaller or even reverse gradients for the oldest cohorts, have persisted until the 1980s in most southern European populations.[29,30] In northern Europe in contrast, smoking has been more important in generating socio-economic inequalities among men. This may explain the somewhat more pronounced age-pattern among men in northern European populations.

Other risk factors for mortality should be considered as well. For example, alcohol abuse has been identified as an important cause of death among middle-aged men in northern Europe. A Finnish study showed that alcohol abuse contributed substantially to the large inequalities in mortality among middle-aged men, but much less so among older men.[31] Thus, the relatively strong age-gradient in relative inequalities in mortality in Finland is likely to be due in part to alcohol-related mortality. Even though alcohol-related mortality may have contributed as well to inequalities in mortality in more southern countries, these effects may have been spread more evenly over different age groups. Important is to note that, in contrast to the situation in southern countries, fatal alcohol abuse in northern Europe mainly takes the form of binge drinking leading to increased injuries and other actor causes of death that affect middle aged men in particular.[32]

Even though these explanations are tentative and require further exploration in future research, they serve to illustrate that many factors influence the age pattern of inequalities in mortality.

Given these multiple influences, it should be no surprise that this age pattern strongly varies between countries and between men and women.

This study provided evidence for persisting socio-economic inequalities in mortality among elderly populations in Europe. The large numbers of excess deaths that occur among the lower socio-economic groups are an important public health problem. Even when relative inequalities in future elderly European populations will not increase but remain as we observed, the absolute numbers of excess deaths will increase, as a result of the ageing of the population within these countries. There is as yet no indication that socio-economic inequalities in mortality among the elderly will become less. However, the variations in mortality inequalities that are observed between countries suggest that reducing inequalities is an achievable goal for elderly populations as well.

3.6 Acknowledgements

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4

Educational inequalities in cause-specific mortality: a study of middle-aged and older men and women in 8 Western European populations

Huisman M, Kunst AE, Bopp M, Borgan J-K, Borrell C, Costa G, Deboosere P, Gadeyne S, Glickman M, Marinacci C, Minder C, Regidor E, Valkonen T, Mackenbach J. Educational inequalities in cause-specific mortality: a study of middle-aged and older men and women in 8 Western European populations. (*Lancet*: in press).

4.1 Summary

Introduction: Previous studies of socioeconomic disparities in cause-of-death patterns have been limited in scope (single countries only, middle-aged people only, men only, and/or broad cause of death groups only). We assessed the contribution of specific causes of death to educational inequalities in mortality among middle-aged and older men and women in 8 Western European populations.

Data and Methods: We analysed data from longitudinal mortality studies by cause of death, covering periods between 1990 and 1997. More than 1 million deaths occurring in 51 million years of observation among men and women aged 45-59 years, 60-74 years and 75+ years were analysed.

Results: Among Western European men cardiovascular diseases accounted for 39% of overall mortality disparities, cancer for 24%, other diseases for 32% and external causes for 5%. Among women these contributions were 60%, 11%, 30%, and 0% respectively. The contributions of cerebrovascular disease, other cardiovascular diseases, pneumonia and COPD strongly increased by age, while those of cancer and external causes declined. While relative inequalities in total mortality were similar in all populations, we observed striking differences in the contribution of specific causes to these inequalities.

Conclusions: This study shows that there is an urgent need to widen the scope of explanatory research to include older populations, other diseases (e.g. cerebrovascular disease, COPD), and populations from different parts of Europe. Effective interventions should be developed and implemented to reduce exposure to cardiovascular risk factors in lower educational groups. All countries may benefit from international exchange of experiences with such interventions.

4.2 Introduction

Variations in cause-of-death patterns between socioeconomic groups provide valuable clues for the explanation of health disparities, because they point to the specific mechanisms relating low socioeconomic position to ill health. Most studies of socioeconomic variations in cause-of-death patterns have so far been conducted in single countries,[1-3] and international comparisons have been limited to periods preceding the 1990s,[4,5] or to single groups of specific causes of death only, such as cardiovascular mortality.[6,7] Some of these international-comparative studies yielded important results. A study conducted by Kunst et al. showed that during the 1980s the contribution of broad cause-of-death groups to occupational inequalities in overall mortality among middle-aged men varied strongly between Northern European and Southern European countries.[4]

In the present study we expand on previous international studies by using the most recent data available on mortality by cause of death for a broad range of male and female populations from various geographical areas in Western Europe. We distinguish detailed causes of death and, because the burden of mortality is highest among elderly people, we include data on older populations, which have not received attention in earlier studies.

The inclusion of information for older age groups may provide important new insights. Recently we observed that differences in overall mortality by educational level persist into old age in European populations among both men and women.[8] This indicates that these age groups should receive due attention in explanatory research. Because different causes of death are important in different age groups, it can be expected that those causes that contribute mostly to educational inequalities in overall mortality differ between older and middle-aged populations. Our over-all aim was to broaden the scope of the evidence-base for European public health policies.[9,10]

4.3 Data and methods

4.3.1 Data

Data from longitudinal mortality studies that were based on linkage of vital registries to population censuses were acquired for the following European populations: Finland, Norway, England and Wales, Belgium, Switzerland, Austria, Turin, Barcelona and Madrid. All data comprised the total national, regional (Madrid) and urban (Turin and Barcelona) populations, except for England and Wales, where the data cover a representative sample of 1% of the English and Welsh population, and for Switzerland, where the data cover all Swiss nationals living in the German speaking parts of the country. Urban and regional data for populations from Italy and Spain were used, because national data were not available for these countries. Linkage of mortality data with the census was close to 100% for all populations, with the exception of Madrid, where linkage was obtained for 70% of the population. There was no variation by education in the percentage of obtained linkage in this population. Data from Barcelona and Madrid were pooled for the analyses reported in this paper, because both are urban populations from Spain. We analysed a total of 1,281,272 deaths occurring in 51,710,855 person years at risk (appendix table 1).

The classification of the underlying cause of death occurred according to WHO guidelines in all of the populations. Deaths were classified according to ICD-8, and later ICD-10 in Switzerland, and according to ICD-9 in the other populations. We decided to include the four large standard groups of causes of death that together account for all mortality (cardiovascular diseases, neoplasm's, other diseases and external causes), and then within these groups selected the largest specific causes of death for further analysis.

Age was measured at the start of follow-up. We included data for the ages of 45 years and older. We distinguished between the middle-aged, those of early old age, and the oldest ages, by dividing the age range into the following age groups: 45-59, 60-74 and 75+ years. It was expected that the cause-of-death patterns would show important differences between these groups.

4.3.2 Indicator of socioeconomic position

Level of education was used as indicator of socioeconomic position. This was measured in the population censuses. We reclassified the national education data into two broad groups, approximately corresponding with the following levels of the International Standard Classification of Education (ISCED): 0-3 (pre-primary, primary and lower secondary education; labelled 'lower'), and 4-6 (upper secondary education and post-secondary education; labelled 'higher'). This is a meaningful cut-off point that could readily be made with the available data. Information on education was missing in less than 4% of the population in all countries. The proportion of 'lower' educated men was between 66% and 84% of the total male population, and that of 'lower' educated women was between 71% and 96% of the total female population (appendix table 2).

4.3.3 Data analyses

We determined relative inequalities in mortality by calculating the ratio of the mortality rates of the lower to the higher educational groups. These calculations were done with Poisson regression analysis, in which we regressed the number of deaths (against an offset of the natural log of the person-years at risk) on the level of education, separately for each broad age group and gender. A categorical variable was included in the regression models, signifying five-year age group, in order to control for age. We also calculated absolute differences in mortality, separately for each broad age group and gender. These were calculated by subtracting the age-adjusted rate of the higher educational group from that of the lower group. The contribution of a specific cause of death to educational differences in overall mortality was determined by expressing the rate difference of that cause as a percentage of the rate difference of total mortality.

The mortality rates were age-standardised according to the direct method, with the pooled population of the European Union plus Norway of 1995 as the standard, using age groups of five years. Analyses for Western Europe as a whole were performed on a combined data set that included data of all populations but in which weights were applied to equalise the sample sizes of the individual countries. Those countries with the largest samples therefore received the smallest weights.

4.3.4 *Role of the funding source*

This study was funded by the European Union. The European Union had no role in the study design, in the collection and analyses of the data, in the writing of the paper, or in the decision to submit the paper for publication.

4.4 Results

4.4.1 *Middle-aged and older European men*

Results of the pooled analyses for men are shown in Table 1. Detailed results can be found in appendix Table 3. These results may be interpreted as approximately representing the situation in Western Europe as a whole, perhaps with the exception of rural populations in the South. For total mortality as well as for all specific causes of death (with the exception of prostate cancer) rate ratios are above 1.00, indicating higher mortality in the lower as compared to the higher educational groups. Among men of all ages above 45 years, the highest rate ratios are found for COPD, stomach cancer and lung cancer. The highest rate differences are observed for ischemic heart disease, lung cancer and COPD. Rate ratios usually decline with age, but in most cases remain elevated into the highest age-group. Among men aged 75 and older, rate ratios are still remarkably high for stomach cancer, lung cancer and COPD. Rate differences usually increase strongly with age, indicating that educational inequalities in mortality among the elderly are of considerable public health importance.

Table 2 shows the contribution of specific causes of death to differences in total mortality by educational group for Western European men. Among men of all ages ischemic heart disease, lung cancer, COPD, other cardiovascular diseases and cerebrovascular disease make the largest contributions. Cardiovascular diseases contribute 39%, cancer 24%, "other diseases" 32% and external causes 5%. The contributions of cerebrovascular disease, other cardiovascular diseases, pneumonia and COPD rise with age, while the contributions of cancers and external causes decline with age.

Table 1: Educational inequalities in cause specific mortality in Western Europe, early to mid 1990s, by age. Men

Cause of death	45-59		60-74		75+		All ages 45+	
	RR (95%-CI)	RD	RR (95%-CI)	RD	RR (95%-CI)	RD	RR (95%-CI)	RD
Cardiovascular	**1.51 (1.45-1.57)**	**97**	**1.32 (1.29-1.35)**	**346**	**1.18 (1.15-1.20)**	**886**	**1.27 (1.25-1.29)**	**315**
IHD	1.51 (1.43-1.58)	60	1.32 (1.28-1.36)	193	1.14 (1.10-1.18)	312	1.27 (1.25-1.30)	148
Cerebrovascular	1.56 (1.40-1.74)	15	1.40 (1.32-1.48)	77	1.21 (1.16-1.26)	264	1.30 (1.25-1.34)	78
Other Circulatory	1.49 (1.37-1.61)	22	1.27 (1.21-1.33)	76	1.21 (1.16-1.26)	309	1.25 (1.22-1.29)	89
Cancer	**1.46 (1.40-1.52)**	**92**	**1.31 (1.27-1.34)**	**256**	**1.15 (1.12-1.18)**	**326**	**1.29 (1.26-1.31)**	**189**
Stomach Cancer	1.69 (1.43-2.00)	7	1.71 (1.53-1.92)	30	1.64 (1.43-1.88)	71	1.68 (1.55-1.81)	25
Lung Cancer	1.89 (1.76-2.03)	49	1.65 (1.58-1.74)	152	1.44 (1.33-1.55)	168	1.66 (1.61-1.72)	106
Colorectal Cancer	1.06 (0.95-1.19)	2	1.16 (1.08-1.26)	18	1.14 (1.04-1.24)	45	1.13 (1.08-1.19)	15
Prostate Cancer	1.07 (0.87-1.31)	0	0.94 (0.87-1.01)	-9	0.97 (0.91-1.04)	-21	0.96 (0.92-1.01)	-6
Other Cancer	1.32 (1.25-1.39)	34	1.19 (1.14-1.23)	65	1.09 (1.03-1.14)	66	1.19 (1.15-1.22)	50
Other Diseases	**1.76 (1.66-1.86)**	**73**	**1.54 (1.49-1.60)**	**234**	**1.31 (1.27-1.35)**	**838**	**1.47 (1.44-1.51)**	**255**
COPD	2.78 (1.27-3.39)	12	2.16 (1.99-2.35)	97	1.77 (1.64-1.91)	335	2.00 (1.89-2.11)	95
Pneumonia	2.31 (1.81-2.94)	6	1.77 (1.57-2.00)	33	1.30 (1.21-1.39)	202	1.45 (1.37-1.54)	47
Other	1.65 (1.56-1.75)	55	1.36 (1.30-1.42)	104	1.21 (1.16-1.25)	300	1.36 (1.32-1.39)	113
External Causes	1.50 (1.40-1.60)	29	1.35 (1.25-1.47)	30	1.26 (1.15-1.37)	78	1.37 (1.31-1.43)	37
Total Mortality	*1.54 (1.49-1.56)*	*290*	*1.36 (1.34-1.38)*	*867*	*1.21 (1.19-1.22)*	*2127*	*1.32 (1.31-1.33)*	*796*

RR = Rate Ratio (mortality rate in lower educational group expressed as a proportion of mortality rate in higher educational group).

RD = Rate Difference (mortality rate in lower educational group minus mortality rate in higher educational group, expressed as deaths per 100,000 person-years at risk).

(95%-CI) = 95% Confidence Interval.

IHD = Ischemic Heart Disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: These analyses were done on a pooled dataset that included data from 8 Western European populations. After weighting to equalise sample sizes between populations, this dataset comprised 304,410 deaths occurring among 11,030,032 person-years at risk. All mortality rates were age-adjusted (using 5-year age-groups). Rate Ratios and Rate Differences compared mortality rates among those with education corresponding approximately to pre-primary, primary or lower secondary level with mortality rates among those with education corresponding approximately to upper secondary and post-secondary level. Underlying data can be found in appendix table 3. Due to rounding, the cause specific RDs may not exactly add up to the RD of total mortality in some cases.

Table 2: Contribution (in %) of specific causes of death to the difference between lower and higher educational groups in total mortality. Western Europe, early to mid 1990s, by age. Men

Cause of death	45-59	60-74	75+	All ages 45+
Cardiovascular	**33.5**	**39.9**	**41.6**	**39.5**
IHD	20.6	22.3	14.7	18.6
Cerebrovascular	5.1	8.9	12.4	9.7
Other Cardiovascular	7.7	8.8	14.5	11.1
Cancer	**31.6**	**29.6**	**15.3**	**23.8**
Lung Cancer	17.1	17.6	7.9	13.3
Other Cancer	14.5	12.0	7.4	10.5
Other Diseases	**25.1**	**27.0**	**39.4**	**32.0**
COPD	4.3	11.2	15.8	12.0
Pneumonia	1.9	3.8	9.5	5.9
Other	18.8	12.0	14.1	14.1
External Causes	**9.9**	**3.4**	**3.7**	**4.7**
Total Mortality	**100**	**100**	**100**	**100**

IHD = Ischemic heart disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: Contributions of specific causes of death were calculated by expressing the Rate Differences for these causes of death (as presented in the columns of table 1) as a percentage of the Rate Difference for total mortality (as presented in the final row of table 1). Due to rounding, the percentages of specific causes may in some cases not add up to 100.0 % exactly. The note to table 1 also applies to table 2.

4.4.2 Middle-aged and older European women

Results of the pooled analyses for women are shown in Table 3. Detailed results can be found in appendix Table 4. Relative inequalities in mortality among women are of similar magnitude as those among men, as indicated by the rate ratio for total mortality. Among women of all ages, mortality is higher for most specific causes of death in the lower than in the higher educational groups, with the exceptions of breast cancer and external causes. The highest rate ratios are observed for stomach cancer, ischemic heart disease, and COPD. Absolute inequalities in mortality, as indicated by rate differences, are much smaller among women than among men. The highest rate differences are found for ischemic heart disease, other cardiovascular diseases and cerebrovascular disease.

Table 3: Educational inequalities in cause specific mortality in Western Europe, early to mid 1990s, by age. Women

Cause of death	45-59		60-74		75+		All ages 45+	
	RR (95%-CI)	RD	RR (95%-CI)	RD	RR (95%-CI)	RD	RR (95%-CI)	RD
Cardiovascular	**1.74 (1.60-1.90)**	**36**	**1.56 (1.50-1.63)**	**243**	**1.26 (1.23-1.29)**	**994**	**1.35 (1.33-1.38)**	**266**
IHD	1.98 (1.71-2.28)	17	1.66 (1.56-1.76)	128	1.26 (1.21-1.31)	322	1.41 (1.36-1.45)	107
Cerebrovascular	1.61 (1.37-1.88)	9	1.43 (1.33-1.54)	48	1.26 (1.21-1.32)	300	1.31 (1.27-1.36)	70
Other Circulatory	1.60 (1.38-1.87)	9	1.54 (1.43-1.67)	67	1.27 (1.22-1.32)	372	1.34 (1.29-1.38)	88
Cancer	**1.08 (1.03-1.13)**	**18**	**1.09 (1.05-1.13)**	**51**	**1.10 (1.05-1.14)**	**122**	**1.10 (1.07-1.12)**	**47**
Stomach Cancer	1.47 (1.12-1.92)	2	1.43 (1.20-1.70)	9	1.69 (1.42-2.00)	46	1.54 (1.38-1.72)	12
Lung Cancer	1.50 (1.28-1.75)	10	1.26 (1.13-1.42)	15	0.91 (0.79-1.04)	-7	1.21 (1.12-1.31)	8
Colorectal Cancer	1.05 (0.91-1.23)	1	1.07 (0.97-1.19)	6	1.12 (1.01-1.24)	23	1.09 (1.02-1.17)	6
Breast Cancer	0.89 (0.81-0.96)	-7	0.84 (0.78-0.91)	-16	1.01 (0.91-1.12)	10	0.89 (0.85-0.94)	-7
Other Cancer	1.14 (1.06-1.22)	11	1.14 (1.08-1.19)	38	1.08 (1.03-1.14)	51	1.12 (1.09-1.16)	27
Other Diseases	**1.70 (1.56-1.86)**	**31**	**1.43 (1.35-1.50)**	**110**	**1.24 (1.20-1.28)**	**470**	**1.34 (1.30-1.37)**	**130**
COPD	2.84 (2.02-4.00)	6	1.52 (1.32-1.76)	20	1.24 (1.10-1.40)	29	1.45 (1.33-1.59)	15
Pneumonia	2.49 (1.65-3.78)	3	1.48 (1.25-1.74)	13	1.26 (1.17-1.35)	119	1.31 (1.23-1.40)	25
Other	1.58 (1.44-1.74)	21	1.40 (1.32-1.49)	77	1.24 (1.19-1.29)	322	1.33 (1.29-1.37)	90
External Causes	**1.06 (0.94-1.20)**	**0**	**0.99 (0.88-1.12)**	**-1**	**1.04 (0.94-1.14)**	**3**	**1.00 (0.94-1.06)**	**0**
Total Mortality	***1.28 (1.23-1.33)***	***84***	***1.32 (1.29-1.35)***	***404***	***1.22 (1.20-1.24)***	***1588***	***1.26 (1.25-1.28)***	***442***

RR = Rate Ratio (mortality rate in lower educational group expressed as a proportion of mortality rate in higher educational group).

RD = Rate Difference (mortality rate in lower educational group minus mortality rate in higher educational group, expressed as deaths per 100,000 person-years at risk).

(95%-CI) = 95% Confidence Interval.

IHD = Ischemic Heart Disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: These analyses were done on a pooled dataset that included data from 8 Western European populations. After weighting to equalise sample sizes between populations, this dataset comprised 322,122 deaths occurring among 13,725,757 person-years at risk. All mortality rates were age-adjusted (using 5-year age-groups). Rate Ratios and Rate Differences compared mortality rates among those with education corresponding approximately to pre-primary, primary or lower secondary level with mortality rates among those with education corresponding approximately to upper secondary and post-secondary level. Underlying data can be found in appendix table 4. Due to rounding, the cause specific RDs may not exactly add up to the RD of total mortality in some cases.

Table 4: Contribution (in %) of specific causes of death to the difference between lower and higher educational groups in total mortality. Western Europe, early to mid 1990s, by age. Women

Cause of death	45-59	60-74	75+	All ages 45+
Cardiovascular	**42.5**	**60.3**	**62.6**	**60.1**
IHD	20.7	31.6	20.3	24.3
Cerebrovascular	10.7	12.0	18.9	15.8
Other Cardiovascular	11.1	16.7	23.4	19.9
Cancer	**21.0**	**12.7**	**7.7**	**10.5**
Breast Cancer	-7.8	-4.0	0.6	-1.7
Other Cancer	28.7	16.7	7.1	12.2
Other Diseases	**36.3**	**27.2**	**29.6**	**29.4**
COPD	7.5	5.0	1.8	3.3
Pneumonia	3.7	3.2	7.5	5.7
Other	25.1	19.1	20.3	20.3
External Causes	**0.1**	**-0.2**	**0.2**	**0.0**
Total Mortality	**100**	**100**	**100**	**100**

IHD = Ischemic Heart Disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: Contributions of specific causes of death were calculated by expressing the Rate Differences for these causes of death (as presented in the columns of table 1) as a percentage of the Rate Difference for total mortality (as presented in the final row of table 3). Due to rounding, the percentages of specific causes may in some cases not add up to 100.0 % exactly. The note to table 3 also applies to table 4.

The contributions of specific causes of death to educational differences in total mortality for women are shown in Table 4. Among women of all ages cardiovascular diseases contributed 60%, cancer 11%, "other diseases" 30% and external causes 0% -- a pattern distinctly different from that among men. The larger contribution of cardiovascular diseases among women is based on larger shares for each of the three specific causes (ischemic heart disease, cerebrovascular disease, other cardiovascular disease). Breast cancer contributes negatively, due to the fact that mortality is higher among higher educated women. The contributions of cerebrovascular disease, other cardiovascular diseases, and pneumonia strongly increase by age among women, and those of cancer and COPD decrease by age.

4.4.3 Differences between Western European populations

Table 5 shows that the rate ratios for total mortality are not very different between European populations. On the other hand, rate differences are substantially different and tend to be smaller in southern European populations. Among men rate differences are largest for England and Wales, followed by Belgium, Austria and Finland. Among women rate differences are largest in Belgium, followed by Austria, Finland and Norway.

Table 5; Educational inequalities in total mortality in 8 Western European populations. Early to mid 1990s, ages 45+, by gender

Population	MEN		WOMEN	
	RR (95%-CI)	RD	RR (95%-CI)	RD
Finland	1.33 (1.31-1.35)	1005	1.24 (1.22-1.26)	542
Norway	1.36 (1.33-1.39)	947	1.27 (1.24-1.31)	520
England/Wales	1.35 (1.28-1.42)	1052	1.22 (1.14-1.30)	435
Belgium	1.34 (1.33-1.36)	1020	1.29 (1.27-1.31)	577
Austria	1.43 (1.38-1.47)	1007	1.32 (1.28-1.36)	545
Switzerland	1.33 (1.30-1.36)	737	1.27 (1.21-1.33)	401
Turin	1.22 (1.18-1.27)	581	1.20 (1.15-1.26)	378
Barcelona & Madrid	1.24 (1.21-1.27)	540	1.27 (1.22-1.31)	311

RR = Rate Ratio (mortality rate in lower educational group expressed as a proportion of mortality rate in higher educational group).

RD = Rate Difference (mortality rate in lower educational group minus mortality rate in higher educational group, expressed as deaths per 100,000 person-years at risk).

(95%-CI) = 95% Confidence Interval.

Note: These analyses were done on separate datasets for each of 8 Western European populations. All age-groups above the age of 45, and all causes of death were pooled. All mortality rates were age-adjusted (using 5-year age-groups). Rate Ratios and Rate Differences compared mortality rates among those with education corresponding approximately to pre-primary, primary, or lower secondary level with mortality rates among those with education corresponding approximately to upper secondary and post-secondary level.

Contributions of specific causes of death for different populations are shown in Tables 6 (men) and 7 (women). Among men there are striking differences in the contribution of ischemic heart disease: this is between 30 and 40% in Northern European populations (Finland, Norway, England and Wales), smaller in Switzerland, Belgium, Austria and Barcelona/Madrid, and negative in Turin. The smaller share of ischemic heart disease in the Central and Southern European populations is compensated by larger shares for other diseases such as cerebrovascular disease (particularly in Turin), cancers, COPD and all other diseases".

Table 6: Contribution (in %) of specific causes of death to the difference between lower and higher educational groups in total mortality in 8 Western European populations. Early to mid 1990s, ages 45+. Men

Cause of death	Finland	Norway	England/ Wales	Belgium	Austria	Switzerland	Turin	Barcelona & Madrid
Cardiovascular	**50.0**	**52.5**	**47.5**	**27.6**	**46.1**	**42.5**	**19.7**	**13.5**
IHD	33.3	31.6	37.4	7.1	13.6	17.6	-8.3	2.8
Cerebrovascular	6.3	9.8	5.5	6.8	11.0	6.8	23.2	7.9
Other Cardiovascular	10.5	11.1	4.6	13.6	21.5	18.2	4.7	2.7
Cancer	**19.7**	**12.9**	**27.9**	**23.8**	**24.4**	**25.9**	**33.8**	**35.0**
Lung Cancer	12.3	6.6	13.6	17.2	11.1	12.6	19.9	11.0
Other Cancer	7.4	6.3	14.3	6.6	13.3	13.3	13.9	24.1
Other Diseases	**22.8**	**30.3**	**24.9**	**42.8**	**23.8**	**28.1**	**41.2**	**49.3**
COPD	8.4	8.3	11.1	16.0	5.5	10.3	16.3	17.0
Pneumonia	8.7	8.3	7.4	6.2	2.1	3.4	-0.5	3.5
Other	5.7	13.6	6.5	20.6	16.2	14.4	25.4	28.8
External Causes	**7.4**	**4.4**	**-0.3**	**5.9**	**5.8**	**3.5**	**5.3**	**2.2**
Total Mortality	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

IHD = Ischemic Heart Disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: Contributions of specific causes of death were calculated by expressing the Rate Differences for these causes of death as a percentage of the Rate Difference for total mortality (as presented in table 5). The note to table 5 also applies to table 6. Due to rounding, the percentages of specific causes of death may not exactly add up to 100.0 % in some cases.

Among women a similar geographical gradient for the contribution of ischemic heart disease is observed. Despite that, cardiovascular diseases as a group accounted for half or more of the excess mortality in all populations, due to larger contributions of cerebrovascular disease and/or other cardiovascular diseases in Central and Southern European populations. Breast cancer makes a negative contribution in all populations except England and Wales and Switzerland. In the latter countries, external causes contribute negatively to excess mortality in lower educational groups.

Table 7: Contribution (in %) of specific causes of death to the difference between lower and higher educational groups in total mortality in 8 Western European populations. Early to mid 1990s, ages 45+. Women

Cause of death	Finland	Norway	England/ Wales	Belgium	Austria	Switzerland	Turin	Barcelona & Madrid
Cardiovascular	**69.6**	**59.5**	**60.1**	**52.3**	**68.8**	**62.1**	**49.4**	**47.1**
IHD	41.1	29.8	41.0	14.9	22.2	23.1	1.1	11.6
Cerebrovascular	15.0	12.3	16.3	11.2	21.6	12.5	24.9	13.2
Other Cardiovascular	13.6	17.4	2.8	26.1	25.0	26.5	23.4	22.4
Cancer	**6.2**	**12.3**	**19.0**	**6.0**	**7.3**	**16.5**	**10.9**	**10.7**
Breast Cancer	-2.1	-2.4	0.2	-2.7	-2.0	1.3	-2.8	-2.2
Other Cancer	8.3	14.6	18.7	8.7	9.2	15.2	13.7	12.9
Other Diseases	**24.7**	**27.0**	**26.6**	**40.8**	**21.9**	**25.3**	**34.5**	**41.4**
COPD	1.7	4.7	5.3	4.6	2.2	2.4	2.3	3.1
Pneumonia	11.4	5.6	8.0	4.7	3.6	6.7	1.2	2.7
Other	11.7	16.8	13.3	31.6	16.2	16.3	31.0	35.6
External Causes	**-0.5**	**1.2**	**-5.6**	**1.0**	**2.0**	**-4.0**	**5.3**	**1.0**
Total Mortality	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

IHD = Ischemic Heart Disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: Contributions of specific causes of death were calculated by expressing the Rate Differences for these causes of death as a percentage of the Rate Difference for total mortality (as presented in table 5). The note to table 5 also applies to table 7. Due to rounding, the percentages of specific causes of death may not exactly add up to 100.0 % in some cases.

4.5 Discussion

Our study shows that educational differences in mortality persist into advanced age among both men and women in Western Europe. Cardiovascular diseases contribute most to these mortality differences: 2/5th among men, and 3/5th among women. Among men, the "top-5" of contributory specific causes consists of ischemic heart disease, lung cancer, COPD, other cardiovascular diseases, and cerebrovascular disease. Among women these are ischemic heart disease, other cardiovascular diseases, cerebrovascular disease, pneumonia and COPD. Relative inequalities in mortality decrease by age, while absolute inequalities increase strongly. At higher ages, the contribution of specific causes of death to excess mortality in the lower educational groups changes considerably, with cerebrovascular disease, other cardiovascular diseases, COPD (men only), and pneumonia becoming more important. Although relative inequalities in mortality were of similar magnitude in all populations, the pattern of cause of death contributions differed greatly between countries, and showed a North-South gradient for ischemic heart disease among both men and women.

4.5.1 *Evaluation of the data*

Using education as the indicator of socioeconomic position has several advantages. Firstly, unlike occupational class education allows classification of those who are outside the workforce. Among older men and, in many European countries, among women the latter constitute a large part of the population. Secondly, one's level of education is acquired early in life, which makes it unlikely that reverse causation accounts for the association between low socioeconomic position and ill-health.[11] Finally, level of education is an individual measure of socioeconomic position. Indicators based on household measures, such as household income, pose problems for international-comparative studies because of between-country differences in the definition of households. Also, part of the elderly population does not live in a private household.

Using education as a socioeconomic indicator also has a number of disadvantages. Individuals usually achieve their final level of education early in adult life, and their educational level may therefore not accurately indicate their current socioeconomic position. Grundy and Holt have suggested pairing level of education with a measure related to deprivation such as housing tenure for studies of socioeconomic inequalities in health including older people.[12] Because education may predominantly be linked to a cultural or behavioural pathway linking low socioeconomic position to ill health, and housing tenure to a material and psychosocial pathway, such a combination may provide a more comprehensive picture of variations in socioeconomic position. Information on housing tenure was not available for a number of populations, and we could therefore not construct such a combined indicator. We do not think, however, that using another socioeconomic indicator would lead to different results in terms of cause-of-death patterns. The analysis by Kunst et al. covered partly the same populations as our study, and whereas they used occupational class as their socioeconomic indicator, their results were quite similar to ours for the group (middle-aged men) that was included in both studies.[4]

The distribution of education over the populations was skewed, with large groups of lower educated and relatively small groups of higher educated. It might be argued that taking an "extreme" group as reference category may have led to an overestimation of educational inequalities in mortality. It is important to note, however, that this is not just a matter of measurement of educational level in this study, but that this reflects the real situation of educational attainment among older populations in Europe. That is, only a minority received an education beyond secondary level. Additionally, because the group of lower educated is heterogeneous in terms of educational level as well as in a wide range of other socioeconomic variables, one could also argue that the inequalities in mortality that we observed are likely to be underestimated, as compared to an analysis in which a more "extreme" lower educated group had been used. For the purpose of this study we strove for comparability between populations in terms of the educational distribution, and in the process had to sacrifice more detailed information. Nonetheless we succeeded in establishing an educational variable that showed significant inequalities in mortality.

Reliability of cause of death classification may decrease with age because the number of competing causes of death increases with age, making it more difficult for certifying doctors and coders to determine the underlying cause of death.[13,14] Among older people pneumonia usually occurs among those with other underlying chronic conditions, such as cardiovascular diseases and COPD,[15,16] and deaths ascribed to pneumonia may simply be misclassified. The contribution of this cause to mortality differences therefore requires further evaluation.

The degree of misclassification is not only dependent on age, but may also differ between countries because of differences in access to medical care and in certification and coding practices. Within Western Europe, cross-country differences in cause-of-death classification have been documented for several conditions.[17-20] Ischemic heart disease, for which we observed pronounced cross-country variations in contribution to excess mortality in lower educational groups, is one of the causes that is sensitive to misclassification. If doctors in Central and Southern European countries were to less often diagnose or certify ischemic heart disease than doctors in Northern European countries, this would result in a geographical gradient of the contribution of ischemic heart disease similar to the one we found. However, the pattern we observed is consistent with international studies on variations in the relationship of education with classical cardiovascular risk factors such as smoking,[21,22] diet[21,23,24] and obesity,[21] showing that inequalities in these risk factors are smaller, and sometimes even in the reversed direction, in southern parts of Europe. For example, a study of educational differences in smoking in different European countries around 1990 showed higher smoking rates in lower educated groups in the North of Europe, and absence of inequalities or higher smoking rates in the higher educated groups in the South of Europe.[22] This suggests that misclassification of causes of death cannot fully explain this marked North-South gradient, and that the latter is real.

The data that we used date from the 1990s, and represent the most recent data available for international comparisons (compilation of a more recent data set will have to await completion of follow-up after the censuses held around 2001). It is unlikely that mortality patterns have changed substantially since the 1990s, but it will be interesting to compare our results with those that may become available in the latter part of the first decade of the 21st century.

4.5.2 Comparison with former research

A study by Kunst et al. on the cause-of-death pattern of occupational inequalities in mortality compared middle-aged men of 11 Western European countries for the 1980s.[4] The scope of our study is considerably broader, as we also included older men and middle-aged and older women. In addition, our data cover the first half of the 1990s and refer to a partly different set of countries (data on socioeconomic inequalities in mortality in Belgium and Austria, included in our study, have almost never been reported in the international literature). We found a much more pronounced role of cardiovascular diseases other than ischemic heart disease, particularly cerebrovascular disease and other cardiovascular diseases. This is mainly because these causes are much more important for socioeconomic mortality differences among women, and among elderly people, than among middle-aged men. Exactly the opposite applies to external causes, whose role appears to be much smaller in our study than in that of Kunst et al. Other new findings relate to COPD, which now stands out as one of the main contributors, but was not included as a separate cause of death in their study. The findings of Kunst et al. concerning the North-South gradient in the contribution of ischemic heart disease, on the other hand, which was found to be related to patterns of cardiovascular risk factors in another paper,[6] were confirmed by our study that covered a much larger part of the total adult population. In the present study

Belgium and Austria fit into this gradient by occupying intermediate positions between Northern and Southern European countries.

4.5.3 *Interpretation*

While ischemic heart disease clearly is one of the most important contributors to socioeconomic differences in mortality, our results also emphasize the role of cerebrovascular disease and other cardiovascular diseases. An association between stroke mortality and socioeconomic status has been reported before by other studies,[25-28] but the size of the contribution to excess total mortality has not yet been documented so clearly. Further analyses showed that heart failure is the most important component of "other cardiovascular diseases". Most explanatory studies of socioeconomic differences in mortality have been done on ischemic heart disease.[See e.g. 29-32] Much less is known about the explanation of differences in cerebrovascular disease,[For some recent studies, see e.g. 26,27,33-35] or heart failure, while this is not likely to be exactly the same as for ischemic heart disease. Socioeconomic differences in prevalence, detection and/or treatment of hypertension could play a role,[36] as could adverse socioeconomic circumstances during childhood.[37,38] The latter are also suggested by the large relative inequalities in stomach cancer and COPD that we found, which are other causes of death that are strongly associated with childhood socioeconomic circumstances.[37,39] Further explanation of the inequalities in these causes of death should best adopt a life course approach, and look at disadvantage and its consequences across the life span.[37] Such explanatory studies could benefit from a comparative perspective, because generations with similar birth-years have gone through different socioeconomic trajectories in different European countries.

The increase in the contribution of cardiovascular diseases with increasing age was mirrored by a decrease in the contribution of cancer. The smaller share of lung cancer at older ages accounted for a large part of this decrease. In the oldest age-group, lower educated men and women have historically not been much more exposed to smoking than the higher educated, while the lower educated in younger cohorts have.[22,40] In future cohorts lung cancer will probably play an increasingly important role in socioeconomic inequalities in mortality, also for women, as smoking in Europe becomes more and more concentrated among the lower socioeconomic groups.[41] Among men COPD was another cause that accounted for a substantial part of the mortality differences. Barcelona/Madrid and Turin showed some of the largest contributions of COPD, and the contribution of lung cancer was also relatively large in these populations. These results indicate a strong effect of smoking in these populations which at first sight may seem implausible: data on smoking prevalence show that the smoking epidemic is far less advanced in Spain and Italy than in Northern European countries.[22,40,42,43] This discrepancy may possibly be explained by the fact that our data are for Barcelona, Madrid and Turin, and that the smoking epidemic is probably more advanced in these urbanized areas than in the rest of the country.

Educational inequalities in mortality are ubiquitous throughout Western Europe. Rate ratios are of largely similar magnitude for all countries, which can be interpreted as a powerful illustration of the importance of 'upstream' determinants for socioeconomic inequalities in mortality. Social stratification, and the resulting differences in access to resources such as knowledge, wealth and prestige, produces inequalities in life chances within populations regardless of their prevailing health risks and epidemiological characteristics. At the same time, however, similar rate ratios for total mortality often hide important differences between countries in cause-of-death patterns. More specific explanations of health inequalities, in terms of the specific determinants that mediate the effect of low socioeconomic position on mortality, are therefore likely to differ between populations. In consequence, results of explanatory research cannot be assumed to be generalisable from one population to the other, and all countries should to some extent invest in explanatory studies. This is not to say that countries cannot learn from each other, but they do all need to build up their own, partly particularistic, evidence-base for public health policy.

4.5.4 Policy implications

Reducing cardiovascular disease mortality among the lower education groups should clearly be an important public health priority throughout Western Europe. There is an urgent need to develop and implement effective interventions and policies to reduce exposure to cardiovascular risk factors (including smoking) in lower educational groups. Very few have been developed, let alone implemented, so far.[44] International exchange of experiences with interventions reaching the lower socioeconomic groups may be of benefit to all European countries. The European Union could play a key role in stimulating and facilitating such international collaboration.

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4.8 Appendix: Tables with basic information

Appendix table 1: Follow-up periods of the included countries and regions and number of person years at risk

Country/Region	Follow-up period	ICD coding	Number of deaths		Number of person years at risk	
			Men	**Women**	**Men**	**Women**
Finland	1991-1995	ICD 9	106,326	119,425	3,637,351	4,696,096
Norway	1990-1995	ICD 9	104,648	103,662	3,175,803	3,775,370
England/ Wales	1991-1996	ICD 9	14,610	16,048	480,387	573,234
Belgium	1991-1995	ICD 9	226,548	233,620	7,622,256	9,326,088
Austria	1991-1992	ICD 9	31,804	39,195	1,238,305	1,632,381
Switzerland	1991-1995	ICD 8-ICD 10	84,739	84,967	3,338,227	4,232,462
Turin	1991-1996	ICD 9	21,145	21,589	844,365	1,082,801
Barcelona (Spain)	1992-1996	ICD 9	34,775	34,870	1,478,362	1,947,329
Madrid (Spain)	1996-1997	ICD 9	19,646	17,797	1,167,401	1,462,637
Western Europe (pooled data)*			644,241	671,173	22,982,457	28,728,398

Note: * the number of deaths and the number of person years at risk of the individual populations received a weighted share in the pooled number of deaths and person years at risk.

Appendix table 2: Distribution of the educational variable over the populations, ages 45 and older, in percentages

		Ages 45-59 years		Ages 60-74 years		Ages 75+ years	
Sex	Country/City	Low	High	Low	High	Low	High
MEN	Finland	56	44	76	24	81	19
	Norway	78	22	87	13	91	9
	England & Wales	78	22	85	15	88	12
	Belgium	69	31	80	20	87	13
	Austria	78	22	78	22	79	21
	Switzerland	75	25	82	18	87	13
	Turin	72	28	79	21	83	17
	Barcelona	69	31	78	22	80	20
	Madrid	65	35	78	22	81	19
	All Countries	***70***	***30***	***80***	***20***	***84***	***16***
WOMEN	Finland	57	43	79	21	86	14
	Norway	85	15	93	7	95	5
	England & Wales	85	15	91	9	93	7
	Belgium	74	26	86	14	93	7
	Austria	76	24	81	19	87	13
	Switzerland	94	6	97	3	98	2
	Turin	82	18	88	12	92	8
	Barcelona	81	19	89	11	93	7
	Madrid	78	22	89	11	92	8
	All Countries	***77***	***23***	***87***	***13***	***92***	***8***

Appendix table 3: Age standardized cause specific mortality rates by level of education of Western European men, early to mid 1990s, by age.

Cause of death	45-59		60-74		75+		All ages 45+	
	Low	High	Low	High	Low	High	Low	High
Cardiovascular	**279**	**182**	**1,428**	**1,081**	**6,378**	**5,492**	**1,679**	**1,364**
IHD	176	116	819	626	2,555	2,243	793	644
Cerebrovascular	38	24	264	186	1,726	1,461	393	315
Other Cardiovascular	65	43	345	269	2,097	1,788	493	404
Cancer	**293**	**201**	**1,159**	**902**	**2,666**	**2,340**	**990**	**801**
Stomach Cancer	17	10	77	47	197	126	68	43
Lung Cancer	103	54	398	245	525	357	278	172
Colorectal Cancer	27	25	122	105	332	287	111	96
Prostate Cancer	9	9	115	123	622	643	147	153
Other Cancer	136	103	446	381	987	920	386	335
Other Diseases	**160**	**88**	**676**	**442**	**3,800**	**2,962**	**933**	**678**
COPD	19	7	184	86	739	404	195	100
Pneumonia	10	4	78	45	959	756	187	139
Other	131	77	415	311	2,102	1,802	551	438
External Causes	**84**	**56**	**110**	**80**	**409**	**330**	**145**	**108**
Total Mortality	***816***	***527***	***3,373***	***2,505***	***13,253***	***11,125***	***3,747***	***2,951***

IHD = Ischemic Heart Disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: These analyses were done on a pooled dataset that included data from 8 Western European populations. After weighting to equalise sample sizes between populations, this dataset comprised 304,410 deaths occurring among 11,030,032 person-years at risk. All mortality rates were age-adjusted (using 5-year age-groups). Due to rounding, the cause specific rates may not exactly add up to the rates of total mortality in some cases.

Appendix table 4: Age standardized cause specific mortality rates by level of education of Western European women, early to mid 1990s, by age

Cause of death	45-59		60-74		75+		All ages 45+	
	Low	High	Low	High	Low	High	Low	High
Cardiovascular	**82**	**46**	**675**	**431**	**5,119**	**4,125**	**1,108**	**843**
IHD	35	18	318	190	1,737	1,415	413	305
Cerebrovascular	22	13	172	124	1,537	1,237	322	251
Other Circulatory	24	15	185	118	1,844	1,472	374	286
Cancer	**196**	**178**	**566**	**515**	**1,281**	**1,159**	**505**	**458**
Stomach Cancer	7	5	30	21	105	59	31	20
Lung Cancer	24	14	71	56	87	94	51	42
Colorectal Cancer	19	18	70	65	214	191	69	63
Breast Cancer	54	60	97	113	184	175	90	97
Other Cancer	92	81	298	260	690	639	263	236
Other Diseases	**72**	**42**	**360**	**250**	**2,616**	**2,146**	**585**	**455**
COPD	9	3	57	36	186	157	55	40
Pneumonia	5	2	41	28	635	516	119	93
Other	58	37	262	185	1,795	1,473	411	321
External Causes	**27**	**27**	**46**	**47**	**271**	**269**	**73**	**73**
Total Mortality	***377***	***293***	***1,647***	***1,243***	***9,286***	***7,698***	***2,271***	***1,829***

IHD = Ischemic Heart Disease.

COPD = Chronic Obstructive Pulmonary Disease.

Note: These analyses were done on a pooled dataset that included data from 8 Western European populations. After weighting to equalise sample sizes between populations, this dataset comprised 322,122 deaths occurring among 13,725,757 person-years at risk. All mortality rates were age-adjusted (using 5-year age-groups). Due to rounding, the cause specific rates may not exactly add up to the rates of total mortality in some cases.

Part III

Socioeconomic inequalities

in morbidity

5

Socioeconomic inequalities in morbidity among the elderly; a European overview

Huisman M, Kunst AE, Mackenbach JP. Socioeconomic inequalities in morbidity among the elderly; a European overview. *Soc Sci Med* 2003; 57: 861-873.

5.1 Summary

Introduction: There is some evidence on socioeconomic inequality in morbidity among elderly people, but this evidence remains fragmentary. This study aims to give a comprehensive overview of educational and income inequalities in morbidity among the elderly of eleven European countries.

Data and Methods: Data from the first wave of 1994 of the European Community Household Panel were used. The study population comprised a total of 14,107 men and 17,243 women, divided into three age groups: 60-69, 70-79 and 80+. Three health indicators were used: self-assessed health, cut down in daily activities due to a physical or mental problem, and long-term disability.

Results: The results indicate that absolute and relative socioeconomic morbidity inequalities by education and income exist among the elderly in Europe, in all the countries in this study and all age groups, including the oldest old. Inequalities decline with age among women, but not always among men. Greece, Ireland, Italy and The Netherlands most often show large inequalities among men, and Greece, Ireland and Spain do so among women.

Conclusion: To conclude, inequalities in morbidity decrease with age, but a substantive part persists in old age. To improve the health of elderly people it is important that the material, social and cultural resources of the elderly are improved.

5.2 Introduction

The inverse effects of socioeconomic factors on mortality have been reported by a number of studies.[1,2] Lower levels of education, occupation and income are associated with higher levels of mortality, also among elderly people.[3-5] Until now, more studies focussed on mortality inequalities among the elderly than on morbidity inequalities. Morbidity however, is at least an equally important element of health. From the viewpoint of 'adding life to years', studying socioeconomic inequalities can give us clues about how much 'life' can still be added to the 'years' of elderly people that are in a socioeconomically disadvantaged position. In order to be able to reduce morbidity levels one has to identify the determinants of morbidity in old age. Socioeconomic determinants may be of key importance.

Breeze, Sloggett and Fletcher (1999a) studied the association of socioeconomic circumstances in old age with limiting long-term illness in a British sample and conclude that health inequalities do not completely disappear in very old age.[6] In agreement with these findings, Rahkonen and Takala (1998) reported that in a Finnish sample social class differences in self-assessed health and functional disability are still evident in later life.[7] Similarly, Dahl and Birkelund (1997) find in their study among Norwegian elderly that the egalitarian age pension policy of Norway does not succeed in eradicating health inequalities.[8] In the Netherlands, Broese van Groenou and Deeg (2000) also found that socio-economic inequalities in morbidity exist in old age.[9] Liao, McGee, Kaufman, Cao and Coopers (1999) observed differences in morbidity in the last years of life in the United States and came to the conclusion that deceased with higher socioeconomic status experienced lower levels of morbidity in their last years than did deceased with a lower socioeconomic status.[10] However, inequalities that are found among the elderly seem to be smaller compared to differences in morbidity among middle aged adults.

Despite an increasing number of studies, the evidence provided by the studies on morbidity among the elderly remains fragmentary. This study aims to provide a comprehensive overview of socioeconomic inequalities in self-reported morbidity among the elderly (age 60 and over) in the European Union. Several issues will be addressed in this study.

In the first place, previous studies are based on different indicators of socioeconomic status. Socioeconomic indicators that have alternately been used in the studies concerning morbidity in old age are amongst others: level of education, occupational class, or occupation before retirement, income and housing tenure. In a study on mortality among Finnish elderly Martelin (1994) suggested that no single measure proves comprehensive enough to portray the entire picture of socioeconomic position.[11] The elderly are a specific age group for which every single indicator has its own advantages and drawbacks. Education for instance has proved to be a highly relevant factor, but level of education of elderly people will show considerably skewed distributions. Income on the other hand sometimes shows an even stronger association with morbidity, however the nature of this association is less clear. Finally, occupational status is of less relevance since most elderly people have moved out of the working population long ago. Therefore, using a set of complementary measures seems to be the best option to indicate the socioeconomic status of elderly people. In this study, level of education and income will both be used as indicators of socioeconomic status.

The second issue is that of constructing age groups. At what age does midlife end and old age start? Some researchers begin counting old age from 55 years and older, while others start at 65. Obviously, concluding that inequalities in morbidity persist into old age has different implications when old age is considered to start at 65, rather than 55. Furthermore, when the minimum age is decided upon, the question arises whether the elderly should be treated as one homogeneous group or whether they should be divided in groups of early old age and the oldest old. Most studies use a division of two age groups or more, because the early old and the oldest old differ from each other in some respects. The oldest old are more likely to have higher levels of morbidity and have lower education or income than those who have just reached retirement age. Thus, constructing age groups is necessary to distinguish the just retired from the elderly whose age approaches the tenth decade. In the present study, we divided the elderly population into three age groups: age 60-69, 70-79 and 80+ years.

A third point has to be made, which is not so much a methodological issue, rather a logical step following from former research on the topic. All studies described the situation among the elderly in a single country. The logical step following from this is to compare the situation in a number of countries. An important reason for comparing the situations in several different countries is the possibility that inequalities in morbidity might not prove to be a general phenomenon but instead depend on the country in which they are studied. Indeed former studies on socioeconomic health inequalities among younger age groups lead us to expect that the pattern of inequalities differs greatly between countries.[12]

In sum, this study will provide a detailed overview of socioeconomic differences in morbidity among the elderly 1) by using two complementary indicators of socioeconomic status: level of education and net household income; 2) by including three age groups of elderly people; and 3) by performing simultaneous analysis of a large number of European countries. The overview will be given for men and women separately, because the situation will in all likelihood be different between men and women.

This approach will lead to answers to the following research questions: Do socioeconomic morbidity inequalities decrease with old age, and if so, do they persist to some extent? Does this differ between income and education? and Can variations between the countries in this study be demonstrated? These three research questions constitute the core of the study.

5.3 Data and Methods

5.3.1 Instrument

The data for the study have been derived from the first wave of the European Community Household Panel (ECHP).[13] The ECHP is a social survey, designed for the member states of the European Union, which uses a uniform design that allows for adaptation to national requirements. Through its longitudinal design it aims to represent the social dynamics in Europe, from 1994, the year of the first wave, throughout the period that is covered by the subsequent waves. In the first wave a sample of some 60,500 nationally representative households was interviewed in the then 12 member states. The total (all-age) samples per country vary from 2,000 to 14,000. The data is collected by National Statistical Institutes or research centres, while data checks, weightings and imputations are done centrally by Eurostat. The national survey questionnaires are based on a common blueprint questionnaire but are adapted to national requirements. The time and duration of data collection differs somewhat between the countries. All surveys are based on a non-stratified random sampling design. The target population is made up of all national private households. All persons in the panel households are individually interviewed. The data collection was carried out in most countries by paper-and-pencil interviewing, but in four countries (UK, The Netherlands, Portugal and Greece) by computer-assisted personal interviewing. Institutionalized people are not included.

5.3.2 Study population

Basic information on the study population can be found in Table 1. Overall there are more female than male respondents. Men and women are similarly distributed over the age groups. However we expect that a large number of women are excluded from the study population due to institutionalization. Of all men aged 60 or older, 56% (7,960 out of 14,107) falls into the 60-69 age group. For women the proportion is 51% (8,729 out of 17,243). For the 80+ groups the proportions are 12% of the men, 15% of the women. The response rates given in this table show that there is a large degree of non-response for some countries. Germany for instance has a response rate of 48%, only. Further information on non-response was not available, but potential effects of non-response on the results will be commented upon in the discussion section.

Table 1: Sample sizes by country and age-group, men and women aged 60+

Country	N men	N women	Household response %
Belgium	740	936	84
Denmark	644	817	62
France	1,536	1,952	79
Germany	980	1,174	48
Great-Britain	1,260	1,610	72
Greece	1,646	1,960	90
Ireland	1,001	1,018	56
Italy	1,745	2,070	91
Netherlands	927	1,126	88
Portugal	1,543	1,898	89
Spain	2,085	2,682	67
All countries	14,228	17,459	77
Age-group			
60-69	8,082	8,844	
70-79	4,568	5,913	
80+	1,638	2,702	

5.3.3 Socioeconomic indicators

Two measures of socioeconomic status were used in this study: level of education and net household income. The subjects were divided into three groups according to their level of educational attainment based on the International Standard Classification of Education (ISCED): 1) less than second stage of secondary education; 2) second stage of secondary education; and 3) recognized third level education, which is constituted by vocational and university education.[14]

Net household income includes all income sources of every person in the household and any income that is received by the household as a whole. Subjects were asked to count the income from all sources and then to provide the total net income per month in national currency. The net household income is corrected for the number of persons in the household by dividing it by the square root of the number of persons in the household.[15] Finally, the total elderly sample was divided in income quintiles according to the subject's position within the total elderly survey population's range of income. The income quintiles were determined for each country separately[1].

Fig. 1 and 2 show the distribution of the elderly population by level of education of men and women, respectively. They clearly show what we described in the introduction as a potential drawback of using education as a socioeconomic indicator in an elderly population; i.e. the distribution across the three levels of education is considerably skewed, especially among women. For all countries together, the proportion of elderly women with a third level of education is only 5%. The proportion of men is somewhat higher, although it is still small (10.9%). Some countries have notably more skewed distributions than others. The countries with the most skewed distributions appear to be mostly Southern European countries.

5.3.4 Health indicators

Three measures were used to obtain a comprehensive picture of a subject's self-reported health. First, subjects were asked to rate their health in general on a five-point scale, ranging from 'very good', 'good', 'fair' and 'bad' to 'very bad'. We used the percentage of people scoring less than 'good' health as an indicator for self-assessed poor health. Second, taken as indicator for cut down in daily activities was the percentage of people answering yes to the question: 'Have you had to cut down things you usually do about the house, at work or in free time because of illness or injury?' and/or 'because of an emotional or mental health problem?' Third, all subjects were asked if they experienced any limitation in daily activities due to any physical or mental health problem, illness or disability. This question was rated on the following three-point scale: 'yes, severely', 'yes, to some extent' and 'no'. As indicator for long-term disability we measured the percentage of people scoring 'yes' regardless of the severity of limitations they pointed out to experience.[13]

[1]Belgian data are still provisional. They are currently being revised due to inconsistencies found in the codification of some income components. The precise impact of these revisions on the results presented in this report cannot be assessed until the final data have become available.

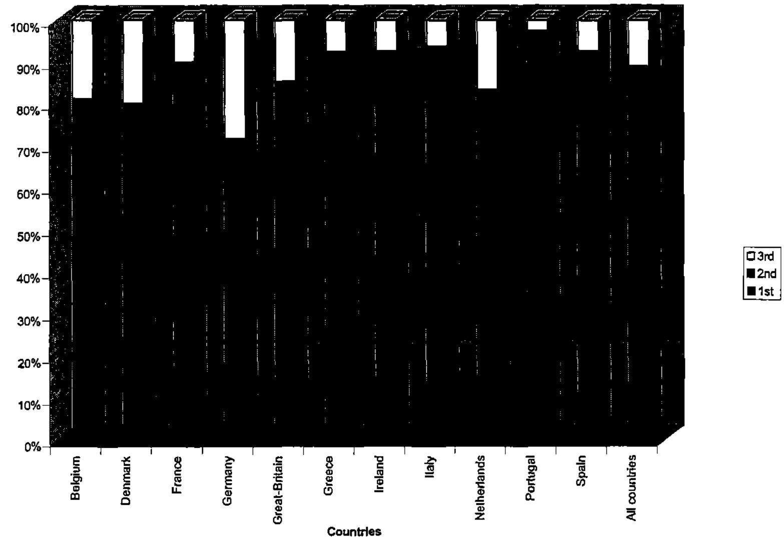

Figure 1: Distribution of level of education among elderly men (60+)

5.3.5 *Data analyses*

Prevalence rates by education or income were age-adjusted to 5-year age group, with 85+ as the highest age group, applying direct standardization with the age distribution of European standard population as the standard. To provide summary measures of the magnitude of socioeconomic inequalities in health, we calculated the rate differences, odds ratios and relative indices of inequality (RII) for both income and education. These measures were calculated for the three age groups and for the 12 countries separately. These indices were also estimated for the combined data set of the 12 countries to acquire an indication of the whole of Europe.

Rate differences express the absolute differences of the prevalence of health indicators between two groups of contrasting socioeconomic status. These rate differences were calculated by subtracting the prevalence rates of the highest socioeconomic group (i.e. the group with third level of education or an income in the highest quintile) from those of the lowest socioeconomic group (i.e. the group with first level of education or an income in the lowest quintile).

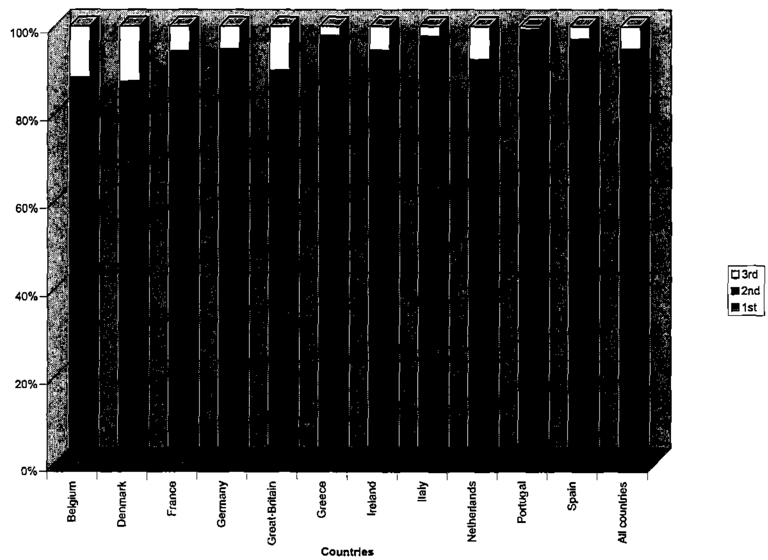

Figure 2: Distribution of level of education among elderly women (60+)

The odds ratios express prevalence odds of health indicators of the lowest socioeconomic group as a ratio of the prevalence odds of the highest socioeconomic group. The odds ratios and their 95% confidence intervals were derived from logistic regression analyses. Adjustments were made for age and country by the inclusion into the regression model of two nominal variables representing 5-year age groups and country.

The RII is a regression-based index that is used to measure socioeconomic inequalities in health in a comparable way in different countries. Typical of this index is that the socioeconomic position of each educational group or income group is quantified as the relative position of that group within the hierarchy of all educational or income groups before it is related to health indicators by means of logistic regression.[16] RII results in odds ratios that can be described as the ratio of the odds of having a health problem in the very bottom of the educational or income hierarchy compared to the very top of the hierarchy. This index has two advantages. First, all socioeconomic groups are taken separately into the analysis and second, the outcomes of this index are comparable between countries, age groups and socioeconomic indicators. When the

RIIs were estimated for all countries, the relative measure of socioeconomic position was determined for each country separately.

Interaction tests were performed to test whether the odds ratios differed between countries. The interaction test is based on the comparison of two regression models. One model had age, the income or education variable and country as independent variables, and the other model included the same independent variables and added an interaction term for the income or educational variable with country. With the chi-square test we determined whether the model improved significantly because of inclusion of the interaction term. These tests were performed for men and women separately, for both income and education.

5.4 Results

The results of the analyses on income for all countries combined are given in Table 2. Generally the prevalence rates for men and women increase with each lower income quintile. This increase is not predominantly linear however, as the second quintile often shows higher prevalence rates than the lowest quintile. Moreover, the prevalence rates increase more sharply in the lower income strata.

Health inequalities are found for every age group. Absolute health inequalities (rate differences) as well as relative health inequalities (odds ratios and RIIs) decrease with age among men and women, when the results of the 80+ groups are compared with those of the 60-69 year old. The odds ratios and RIIs of self-assessed poor health and long-term disabilities among 80+ men are significant, suggesting that income inequalities persist among the oldest elderly men. They do not persist among women.

Table 2: Income inequalities in three health indicators, men and women age 60+ years, all countries together

Health indicator	Age Group	Prevelance rates(%) Highest quintile	4th	3rd	2nd	Lowest quintile	Total	Summary indices RD[a]	Odds ratio	(95%-CI)	RII	(95%-CI)
Men												
Self-assesed Poor Health	60-69	41.7	49.7	56.4	62.5	62.5	53.2	20.8	2.24	(1.94-2.59)	3.02	(2.56-3.56)
	70-79	54.5	60.2	66.3	67.9	66.7	63.4	12.2	1.71	(1.40-2.10)	2.08	(1.65-2.61)
	80+	64.3	68.9	73.4	77.3	75.8	72.5	11.5	1.92	(1.33-2.77)	2.34	(1.54-3.55)
Cut down in Daily activities	60-69	11.7	12.9	18.0	19.8	20.0	16.0	8.3	1.98	(1.63-2.40)	2.61	(2.11-3.25)
	70-79	14.6	18.3	19.6	24.2	22.7	20.1	8.1	1.64	(1.27-2.12)	1.91	(1.45-2.51)
	80+	18.2	23.4	24.0	25.3	24.1	23.2	5.9	1.28	(0.85-1.92)	1.24	(0.80-1.92)
Long-term Disabilities	60-69	26.9	33.6	42.1	45.4	44.8	37.4	17.9	2.21	(1.91-2.56)	2.90	(2.46-3.42)
	70-79	40.1	43.7	44.9	52.0	50.1	46.3	10.0	1.46	(1.20-1.78)	1.74	(1.41-2.17)
	80+	49.6	54.7	60.2	60.3	62.4	57.8	12.8	1.75	(1.26-2.42)	1.91	(1.33-2.75)
Women												
Self-assesed Poor Health	60-69	50.3	58.1	62.4	68.0	67.7	61.1	17.4	2.09	(1.81-2.42)	2.62	(2.22-3.09)
	70-79	61.2	69.1	72.4	72.7	73.4	70.4	12.2	1.87	(1.55-2.26)	2.00	(1.62-2.47)
	80+	72.1	76.9	76.9	76.9	73.2	75.0	1.1	1.19	(0.90-1.56)	1.18	(0.86-1.62)
Cut down in Daily activities	60-69	15.9	18.1	19.9	21.8	22.3	19.7	6.4	1.57	(1.32-1.87)	1.77	(1.46-2.15)
	70-79	19.4	22.5	26.5	24.1	25.8	23.9	6.4	1.39	(1.12-1.71)	1.38	(1.10-1.73)
	80+	27.2	28.5	28.3	27.0	26.3	27.2	-0.9	1.03	(0.79-1.35)	0.99	(0.73-1.34)
Long-term Disabilities	60-69	31.7	38.8	42.6	46.1	45.8	40.8	14.1	1.80	(1.56-2.06)	2.05	(1.76-2.39)
	70-79	44.9	51.6	53.0	53.6	52.7	51.6	7.8	1.33	(1.12-1.58)	1.31	(1.09-1.58)
	80+	62.6	62.6	61.8	62.9	62.6	62.2	0.0	1.02	(0.79-1.30)	1.04	(0.79-1.37)

Note: RD=Rate Difference. {a} The difference between the prevalence rate of the group with the lowest socioeconomic status (lowest income quintile) and the prevalence rate of the group with the highest status (highest quintile).

The results for education are given in Table 3. The prevalence rates are clearly higher among the lower educated for every health indicator and among women as well as men. In terms of rate differences, absolute educational health inequalities decrease with age among women. Relative educational inequalities also decrease with age among women. The pattern among men is somewhat more ambiguous. Rate differences of cut down in daily activities and long-term disabilities increase with age. The odds ratios and RIIs of men show an unpredictable fluctuation over the age groups. It cannot be concluded from these figures that educational inequalities decrease with age among men. Significant inequalities remain among the oldest old in self-assessed poor health among men and women (RII) and in long-term disabilities among men.

Table 3: Educational inequalities in three health indicators, men and women age 60+ years, all countries together

Health indicator	Age Group	Prevelance rates(%) 3rd level	2nd level	1st level	Total	Summary indices RD[a]	Odds ratio	(95%-CI)	RII	(95%-CI)
Men										
Self-assesed Poor Health	60-69	34.6	43.7	58.7	53.2	24.1	2.39	(2.05-2.79)	3.57	(2.88-4.42)
	70-79	50.8	51.6	68.2	63.4	17.4	1.89	(1.53-2.33)	3.12	(2.33-4.18)
	80+	52.3	59.5	75.3	72.5	23.0	2.26	(1.47-3.46)	2.73	(1.54-4.84)
Cut down in Daily activities	60-69	12.0	16.0	16.8	16.0	4.8	1.95	(1.56-2.45)	2.39	(1.75-3.25)
	70-79	13.8	19.2	21.7	20.1	7.9	2.03	(1.50-2.73)	2.51	(1.70-3.69)
	80+	13.1	22.2	24.5	23.2	11.4	1.71	(0.94-3.10)	1.26	(0.63-2.53)
Long-term Disabilities	60-69	28.2	34.5	39.2	37.4	11.0	1.98	(1.68-2.34)	2.70	(2.15-3.38)
	70-79	37.7	44.8	47.8	46.3	10.1	1.75	(1.41-2.18)	2.13	(1.59-2.85)
	80+	40.2	53.7	58.8	57.8	18.6	2.03	(1.34-3.06)	1.91	(1.11-3.29)
Women										
Self-assesed Poor Health	60-69	36.2	42.8	65.7	61.1	29.5	2.50	(2.05-3.05)	4.55	(3.61-5.74)
	70-79	44.4	57.4	73.0	70.4	28.6	2.40	(1.83-3.14)	3.20	(2.36-4.33)
	80+	62.9	53.7	76.6	75.0	13.7	1.40	(0.90-2.17)	3.15	(1.86-5.33)
Cut down in Daily activities	60-69	14.5	16.8	20.8	19.7	6.3	1.56	(1.19-2.04)	2.03	(1.49-2.76)
	70-79	17.2	21.6	24.9	23.9	7.7	1.59	(1.11-2.26)	1.86	(1.28-2.70)
	80+	26.9	32.2	27.8	27.2	0.9	1.02	(0.63-1.65)	1.23	(0.68-2.23)
Long-term Disabilities	60-69	30.4	33.3	42.3	40.8	11.9	1.67	(1.36-2.05)	2.42	(1.91-3.07)
	70-79	41.3	49.2	51.6	51.6	10.3	1.52	(1.16-1.98)	1.62	(1.21-2.18)
	80+	58.3	58.5	61.7	62.2	3.4	1.22	(0.80-1.86)	1.35	(0.81-2.26)

Note: RD=Rate Difference. {a} The difference between the prevalence rate of the group with the lowest socioeconomic status (lowest education) and the prevalence rate of the group with the highest status (highest education).

Educational and income inequalities can be compared by means of the RII. In most aspects, the results of education and income are comparable; e.g. the inequalities are of similar magnitude. Educational inequalities in morbidity vary from income inequalities in the sense that among women educational inequalities in self-assessed poor health are somewhat larger than income inequalities. Tables 4-6 present the results per country for the three health indicators, respectively[1]. RIIs are not presented in the tables, because they show the same international patterns as the odds ratios. Some estimates are omitted because of very small samples in the highest educational levels. Table 4 gives the results of self-assessed poor health. From the interaction tests we can conclude that significant international variations are found in income inequalities in self-assessed health among both sexes and among women also in educational inequalities. Among men, the countries with the largest absolute inequalities are Great Britain, Greece, Ireland, Italy and Portugal, and those with the largest relative inequalities are Great

Britain, Greece, Ireland, Portugal and Spain. The countries with the largest inequalities among women, both absolute and relative are Great Britain, Greece, Ireland and Spain.

Table 4: Rate differences, odds ratios, RII's and 95% confidence intervals (95%-CI) of **Self-assessed health** by level of education and income, men and women 60+

Country	Overall rate	Income quintiles			Level of education		
		Rate difference[a]	Odds ratio	(95%-CI)	Rate difference[a]	Odds ratio	(95%-CI)
Men							
Belgium	43.5	2.0	1.21	(0.76-1.94)	15.8	1.96	(1.29-2.96)
Denmark	41.2	8.1	1.74	(1.02-2.96)	19.6	2.53	(1.59-4.03)
France	60.4	10.0	1.51	(1.09-2.11)	12.8	1.74	(1.23-2.47)
Germany	57.1	16.6	1.98	(1.32-2.95)	10.2	1.75	(1.23-2.50)
Great Britain	48.0	19.2	2.28	(1.57-3.31)	21.1	2.61	(1.84-3.71)
Greece	60.0	11.5	1.68	(1.21-2.33)	21.6	2.68	(1.80-3.79)
Ireland	42.7	25.0	3.39	(2.22-5.18)	20.8	3.16	(1.75-5.70)
Italy	70.6	15.0	2.14	(1.53-2.99)	23.6	2.28	(1.46-3.50)
Netherlands	46.0	15.4	1.81	(1.19-2.77)	16.9	2.00	(1.31-3.04)
Portugal	75.6	21.1	3.12	(2.14-4.56)	[b]		
Spain	65.5	15.0	2.17	(1.62-2.92)	3.3	2.89	(2.05-4.70)
SES*country			*p=0.003*			*p=0.113*	
All countries	58.7	18.8	2.03	(1.82-2.28)	23.2	2.18	(1.94-2.45)
Women							
Belgium	55.9	2.2	1.04	(0.69-1.57)	7.5	2.03	(1.32-3.11)
Denmark	50.4	12.5	1.47	(0.94-2.31)	10.5	1.47	(0.95-2.25)
France	66.6	17.0	2.19	(1.61-2.98)	17.2	2.41	(1.62-3.59)
Germany	64.2	9.3	1.53	(1.04-2.24)	14.1	1.78	(1.05-3.05)
Great Britain	50.3	12.5	1.81	(1.30-2.51)	21.4	2.64	(1.85-3.76)
Greece	67.8	21.3	2.74	(2.00-3.76)	[b]		
Ireland	45.8	17.7	2.41	(1.56-3.74)	28.2	3.40	(1.73-6.67)
Italy	80.2	-8.6	1.88	(1.34-2.65)	[b]		
Netherlands	50.7	15.5	1.67	(1.16-2.40)	7.0	1.24	(0.77-1.99)
Portugal	86.4	4.5	1.45	(0.98-2.13)	[b]		
Spain	74.1	15.1	2.66	(1.94-3.64)	20.1	2.54	(1.59-4.07)
SES*country			*p=0.001*			*p=0.006*	
All countries	66.4	14.4	1.85	(1.66-2.05)	28.2	2.29	(1.97-2.66)

Note: {a} The difference between the prevalence rate of the group with the lowest socioeconomic status and the prevalence rate of the group with the highest status.

{b} Less than 2.5% of the sample of men or women > 60 has a third level of education: values omitted.

The results for cut down in daily activities are listed in Table 5. The differences between countries are significant for education only. Largest absolute and relative inequalities are found in Greece, Ireland and the Netherlands among men, while among women Spain clearly shows the largest inequalities. It must be noted that some of the confidence intervals of level of education are very wide, suggesting that these results must be interpreted with caution. These wide intervals are the result of small sample sizes, especially among women.

Table 5: Rate differences, odds ratios, RII's and 95% confidence intervals (95%-CI) of **Cut down in daily activities** by level of education and income, men and women 60+

Country	Overall rate	Income quintiles			Level of education		
		Rate difference[a]	Odds ratio	(95%-CI)	Rate difference[a]	Odds ratio	(95%-CI)
Men							
Belgium	16.5	0.1	1.10	(0.57-2.11)	9.6	2.67	(1.33-5.35)
Denmark	18.4	-2.4	1.21	(0.61-2.38)	2.0	1.21	(0.68-2.15)
France	4.1	1.4	1.35	(0.60-3.07)	2.0	2.19	(0.67-7.15)
Germany	29.0	5.1	1.27	(0.83-1.95)	4.3	1.20	(0.82-1.75)
Great Britain	21.1	10.7	2.00	(1.27-3.15)	11.6	2.36	(1.44-3.87)
Greece	17.4	8.5	1.80	(1.17-2.79)	15.0	5.41	(2.19-13.39)
Ireland	17.8	11.4	2.36	(1.40-3.99)	14.2	7.99	(1.96-32.64)
Italy	8.6	2.6	1.92	(1.08-3.41)	7.6	4.60	(1.11-19.03)
Netherlands	21.3	12.3	2.26	(1.30-3.95)	9.8	1.98	(1.13-3.48)
Portugal	29.3	10.2	2.01	(1.38-2.92)	b		
Spain	20.7	8.3	1.76	(1.25-2.47)	4.2	1.88	(1.02-3.45)
SES*country			*p=0.515*			*p=0.006*	
All countries	18.1	8.5	1.76	(1.52-2.03)	6.8	1.92	(1.61-2.28)
Women							
Belgium	18.3	2.9	1.23	(0.69-2.20)	3.4	1.34	(0.74-2.43)
Denmark	27.3	9.0	1.44	(0.86-2.42)	1.3	1.88	(1.09-3.24)
France	6.6	3.1	2.06	(1.04-4.07)	4.7	2.55	(0.79-8.17)
Germany	29.3	-3.4	0.81	(0.54-1.20)	8.1	1.32	(0.70-2.46)
Great Britain	23.1	4.1	1.34	(0.90-1.99)	3.9	1.32	(0.86-2.01)
Greece	21.0	10.3	1.87	(1.30-2.68)	b		
Ireland	20.5	5.4	1.73	(1.03-2.91)	-1.6	0.89	(0.45-1.73)
Italy	11.6	1.3	1.20	(0.78-1.84)	b		
Netherlands	30.0	8.6	1.54	(0.97-2.45)	3.2	1.34	(0.79-2.28)
Portugal	33.0	1.0	1.05	(0.78-1.44)	b		
Spain	28.5	11.7	1.75	(1.33-2.29)	11.5	3.36	(1.18-9.75)
SES*country			*p=0.098*			*p=0.010*	
All countries	22.3	5.9	1.38	(1.23-1.56)	6.7	1.46	(1.21-1.78)

Note: {a} The difference between the prevalence rate of the group with the lowest socioeconomic status and the prevalence rate of the group with the highest status.

{b} Less than 2.5% of the sample of men or women > 60 has a third level of education: values omitted.

The results of the third morbidity indicator, long-term disabilities, are presented in Table 6. Differences between countries are significant for income and education among both sexes. The countries where the largest absolute inequalities are found also show the largest relative inequalities in long-term disabilities. Among men these countries are Ireland, Italy and The Netherlands and among women these are France, Greece, Ireland, Italy and Spain.

Table 6: Rate differences, odds ratios, RII's and 95% confidence intervals (95%-CI) of **Long-term disabilities** by level of education and income, men and women 60+

Country	Overall rate	Income quintiles			Level of education		
		Rate difference[a]	Odds ratio	(95%-CI)	Rate difference[a]	Odds ratio	(95%-CI)
Men							
Belgium	41.4	1.4	1.10	(0.68-1.78)	12.6	1.68	(1.11-2.54)
Denmark	34.3	1.2	1.35	(0.78-2.35)	5.0	1.43	(0.90-2.27)
France	40.0	18.1	2.15	(1.54-3.02)	7.9	1.68	(1.15-2.44)
Germany	52.9	3.6	1.16	(0.79-1.72)	0.3	1.01	(0.71-1.43)
Great Britain	45.5	14.2	1.71	(1.17-2.51)	19.0	2.32	(1.61-3.33)
Greece	39.4	15.9	2.11	(1.51-2.94)	9.5	1.56	(1.06-2.31)
Ireland	40.5	12.9	2.01	(1.33-3.05)	27.8	4.15	(2.14-8.05)
Italy	45.5	18.6	2.52	(1.85-3.45)	24.8	2.60	(1.56-4.36)
Netherlands	40.4	20.2	2.39	(1.54-3.69)	11.5	2.00	(1.31-3.04)
Portugal	46.6	10.8	1.67	(1.21-2.30)	b		
Spain	40.6	16.8	2.31	(1.73-3.10)	18.0	2.61	(1.74-3.90)
SES*country			*p=0.007*			*p<0.001*	
All countries	42.6	16.8	1.89	(1.69-2.10)	12.6	1.88	(1.37-2.13)
Women							
Belgium	47.0	-6.0	0.79	(0.52-1.19)	6.8	1.28	(0.83-1.97)
Denmark	46.3	10.0	1.41	(0.89-2.23)	9.1	1.37	(0.89-2.12)
France	43.2	9.6	1.80	(1.33-2.45)	13.4	2.26	(1.43-3.55)
Germany	49.5	-11.1	0.91	(0.63-1.31)	6.7	1.31	(0.77-2.25)
Great Britain	48.2	7.9	1.33	(0.95-1.86)	3.2	1.19	(0.84-1.68)
Greece	42.1	13.8	1.82	(1.35-2.44)	b		
Ireland	39.9	10.8	1.90	(1.22-2.95)	17.8	2.04	(1.06-3.92)
Italy	54.8	13.7	1.86	(1.41-2.47)	b		
Netherlands	49.8	10.2	1.38	(0.96-1.98)	1.8	1.24	(0.77-1.99)
Portugal	52.2	1.5	1.08	(0.81-1.43)	b		
Spain	49.0	16.3	1.97	(1.54-2.52)	15.9	1.88	(1.14-3.08)
SES*country			*p=0.001*			*p=0.035*	
All countries	47.8	12.0	1.49	(1.35-1.64)	11.8	1.55	(1.33-1.80)

Note: {a} The difference between the prevalence rate of the group with the lowest socioeconomic status and the prevalence rate of the group with the highest status.

{b} Less than 2.5% of the sample of men or women > 60 has a third level of education: values omitted.

Counting the number of times the countries rank among the two largest inequalities (counter over both relative and absolute measures, all three morbidity indicators and both income and education), Greece, Ireland, Italy and The Netherlands were found to rank most often among the countries with the largest inequalities among men. Among women the countries with the largest inequalities are most often Greece, Ireland and Spain. In contrast, the countries that most often show the smallest inequalities are Belgium and Germany among men and women, and Denmark among men. Income and educational inequalities show somewhat different patters. A country that ranks among the countries with the largest income inequalities does not necessarily rank among those with the largest educational inequalities as well. This is the case among both men and women.

5.5 Discussion

Absolute and relative socioeconomic morbidity inequalities persist into the oldest ages in Europe. This study indicates that absolute and relative morbidity inequalities related to income and education decline most often, but do not disappear with old age in Europe. Inequalities are found in all age groups, they are found for both indicators of socioeconomic status, in all countries and for both sexes. Variations are found between income and educational inequalities and also between countries. Among women, inequalities decline with age, which is not in all cases true among men.

Some caution has to be taken in interpreting these results however, because of a number of limitations of the ECHP data. One problem is that the ECHP excludes the institutionalized elderly, which leaves out a large group with a high burden of morbidity. Obviously, this negatively effects the generalisation of the elderly represented in the ECHP to all elderly. It might be that exclusion of the elderly in institutions leads to a substantial underestimation of the socioeconomic differences in health, because it can be expected that institutionalised have on average more health problems than the non-institutionalised. This in itself would lead to an underestimation of absolute differences. If in addition the proportion of institutionalized is greater among people with lower socioeconomic status, or if the rate of morbidity is higher among institutionalized people with lower status than institutionalized with higher status, the relative inequalities would also be underestimated. The effect of excluding institutionalized will depend on gender and age. We expect that the effect is larger for women and the oldest old.

We tested our expectations on the effect of excluding institutionalized on mortality data from three countries that include data on institutionalized elderly people. These countries were Belgium, England/Wales and Italy. We calculated risk ratios based on level of education both with institutionalized included and with institutionalized excluded, and compared these (results available at request). The analyses were applied to the three age groups that are distinguished in this study. With inclusion of institutionalized, the risk ratios of women increased in all countries in the two oldest age-groups. The effect of inclusion for men was inconsistent across the countries, for in some cases the risk ratios decreased, while they increased in others. As we expected, the largest increases were found among women of 80 years and older. So, the exclusion of institutionalized elderly probably resulted in an underestimation of socioeconomic morbidity inequalities among the eldest women and to some extent among younger women (60-79) and men.

Another problem is posed by the skewed distribution of the level of education. The distribution leaves us with no information on health inequalities within the large group of low educated elderly. Inequalities within this lowest group cannot be demonstrated because this part of the elderly population is homogeneous in terms of education (although not in other socioeconomic terms) or the educational classification is too crude to measure the educational differences that do exist. In contrast, for income the subdivision into quintiles allows for a comparison of the two lowest socioeconomic groups according to income. This comparison shows that morbidity differences exist between the lowest income quintiles.

What might be considered as a limitation is that no information on specific diseases or disabilities is available in the ECHP. Socioeconomic inequalities in morbidity might be related to a number of specific diseases, like e.g. cardiovascular diseases that occur more frequently in the lower socioeconomic groups as compared to the higher ones.[17,18] Identifying these particular diseases would provide relevant information on the background of inequalities in health among the elderly, be it e.g. life-style or other factors.

Some countries have a very low response rate, for instance Germany, with 48% of households, and Ireland with 56% of households. There is some evidence that non-response mostly occurs among the lower socioeconomic status groups.[19,20] This implies that the socioeconomic inequalities that are found in this study may be an underestimation of the real differences in a way similar to what is described for exclusion of institutionalized people. However, we may note that, if this underestimation really occurred, this can not explain the main finding of this study that socioeconomic inequalities are present even among the oldest old.

An advantage granted by the use of data of the ECHP is that of comparability of data. When national surveys are used for describing socioeconomic differences in morbidity, it appears to be difficult to compare data from different countries. National surveys differ strongly with respect to measurement of socioeconomic status and health status. The advantage of the ECHP is that it uses a common design and set of indicators. This enables pooling of the national data sets into one large European set containing a massive number of elderly subjects, even above 80 years. Although some degree of variation between countries is inevitable, the ECHP reduces this variation to a degree that cannot be reached by comparing national survey data.

This study provides evidence that socioeconomic inequalities in morbidity are present among the elderly, including the oldest old. To our knowledge, such inequalities among elderly as old as 80+ years have not been reported elsewhere. The results of this study can be compared to findings in mortality research. Mortality research suggests that, while they mostly decrease with age, relative mortality inequalities persist into old age.[4,11,21]

Comparing the results of this study with studies of middle-aged might provide further evidence for the finding that socioeconomic morbidity and mortality inequalities mostly decrease with age. The results for self-assessed health of this study can be easily compared to an international study by Cavelaars et al. (1998), because similar indicators of morbidity have been used.[22] Cavelaars et al. found large educational health differences for a number of countries for men and women aged 25-69 years. They estimated the RII for 11 European countries for 'perceived general health'. Compared to their results, the RIIs found in this study for the 60+ are on the average not lower than their RIIs and the confidence intervals, which are wide in both studies, overlap to great extent. This does not support the general impression from the literature that relative educational inequalities in health among the elderly are smaller than among the middle-aged.

Cavelaars (1998) also describes income inequalities in morbidity among the middle-aged.[12] The RIIs for perceived health that were found in their study are generally higher than those found for self-assessed health in this study, although the confidence intervals overlap. So, in contrast to educational inequalities, it seems that income inequalities in health among the elderly are somewhat smaller than among the middle-aged.

We can speculate about why income related morbidity inequalities are smaller among the elderly than among middle-aged people. Firstly, the income range among elderly people is smaller than among younger age-groups, which may be related to smaller health inequalities as well. Second, income might not accurately reflect the financial situation of the elderly. Most people have accumulated possessions during their life and financial benefits stemming from these are not taken into account by using income alone as indicator of economic status. Other indicators of wealth, e.g. house ownership, savings or stocks, could be more appropriate and maybe differences will appear not to decrease to the same extent when these new indicators are used to measure socioeconomic status of elderly instead of income.[23] Third, the time of measuring income or wealth needs to be considered. Since, in the study by Cavelaars and this study income is measured at the same time as morbidity, selection effects cannot be ruled out as a contributory factor.[12] These effects are very likely larger in the study among middle-aged, since among the elderly most do not rely anymore on income from work. This could explain why morbidity inequalities related to income among middle-aged are higher than among the elderly.

An important point that can be taken from these results is that socioeconomic inequalities exist; also among the elderly. These inequalities must not be neglected. The next step is to explain why health inequalities exist among the elderly. Explanation can be sought in the past of people's life, which means that present inequalities are the net effect of a life-time of differences in socioeconomic status and exposure to risk factors. Some studies have shown a relation between low socioeconomic status during childhood and cause specific adult (although not elderly).[24] In these times, while life expectancy increases further and further, we can possibly expect to observe the outcomes of adverse socioeconomic conditions in earlier life in socioeconomic health inequalities in old age. So, evidence can be found for causation operating over the life-course, the effects of exposure to risk factors accumulating over the years.

Explanation for socioeconomic morbidity inequalities among elderly people also has to be sought partly in more recent socioeconomic circumstances than in childhood. Present socioeconomic status and recent exposure to risk factors may explain present health inequalities. It has been demonstrated that deterioration in socioeconomic status after age 55 is associated with long-term illness among people who have survived until at least some 20 years later.[6] This finding suggests that the socioeconomic health inequalities found in this study among the elderly are in part due to socioeconomic differences in older age.

House et al. (1994) argued that elderly with lower socioeconomic status are more exposed to a range of psychosocial risk factors.[25] Furthermore, they conclude that the impact of psychosocial risk factors on health increases with age. Exposure to risk factors at old age will then still have notable effects on the health of elderly people. Income and education related differential exposure to (psychosocial) risk factors might thus explain part of the persistence of health inequalities among the elderly.

While inequalities in prevalence of morbidity may be due to an unequal incidence of health problems, they may also be explained by inequalities in recovery from these problems. There is some evidence that people in higher socioeconomic strata often fall less ill.[26] Longitudinal morbidity studies may shed light on this point by also studying the determinants of recovery, including the utilization of health care.

Despite the limitations of the ECHP data, the conclusion that socioeconomic inequalities in morbidity persist into the later stages of old age can safely be drawn. This is an important finding in itself for all countries that are included in this study. Social causation plays an important role, even ongoing at old age, in determining whose time for health problems comes first. Together with the presence of large socioeconomic differences in morbidity, this stresses that improving the material, social and cultural resources of elderly people may play a key role.

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6

Educational inequalities in prevalence, incidence and recovery of disability at old age: a comparison of self-reports and performance-based measures of disability

Huisman M, Kunst AE, Deeg D, Grigoletto F, Nusselder W, Mackenbach J. Educational inequalities in prevalence, incidence and recovery of disability at old age: a comparison of self-reports and performance-based measures of disability. (Submitted)

6.1 Summary

Introduction: Studies on socioeconomic inequalities in disability describe inequalities in terms of self-reported disability and most studies use prevalence of disability as outcome of interest. Information on socioeconomic inequalities in incidence of and recovery from disability is still scarce, and information on socioeconomic inequalities in performance-based disability as compared to self-reported disability as well. The aim of the study was to estimate socioeconomic inequalities in prevalence, incidence and recovery of disability in two older European populations, and to compare inequalities in self-reported disability to inequalities in performance based disability.

Data and Methods: We analysed data from two European longitudinal studies on aging. Education was the indicator of socioeconomic status. Self-reported disability was determined by asking participants to what degree they experienced difficulty with several functional tasks. Timed performance on several tasks was rated by interviewers. Both measures of disability were dichotomised. Socioeconomic inequalities were expressed in prevalence, incidence and recovery ratios.

Results: Educational inequalities in prevalence and incidence of disability were observed. No large educational inequalities in recovery from disability could be demonstrated. The prevalence inequalities according to self-reported disability were larger as compared to the prevalence inequalities according to the performance-based measure of disability in one of the studies.

Conclusions: The findings of performance-based measures of disability in this study stressed the importance of socioeconomic inequalities in disability among older populations. Our results suggest that a high education serves to postpone or avoid disability, but provides less benefit when disability is already present.

6.2 Introduction

Socioeconomic status is a well-documented determinant of disability and physical functioning in later life.[1-8] Studies on socioeconomic inequalities in disability mostly describe these inequalities in terms of prevalence of self-reported measures of disability, such as the prevalence of one or more restrictions in Activities of Daily Living (ADL). However, prevalence of self-reported disability is only one measure of disability. An alternative type of measure is the test of performance on specific tasks in which interviewers record the time it takes a person to perform a specific task, or count how often a specific task can be completed by the person within a certain time. Furthermore, prevalence of disability in a population is a function of several factors, including incidence of disability, recovery from disability and mortality. These factors influence socioeconomic inequalities in disability prevalence, and differences have been found in the degree to which these factors do so.[9,10] Therefore any conclusion on socioeconomic inequalities in disability based upon measures of prevalence of self-reported disability may need to be checked and perhaps adjusted by also examining measures of incidence or recovery of disability rather than just prevalence. Similarly, studies based on performance-based measures of disability may or may not confirm studies using self-reported disability measures.

This study estimated the magnitude of socioeconomic inequalities in prevalence, incidence and recovery of disability in two European populations of older age. It also estimated whether the magnitude of socioeconomic inequalities in performance-based measures of disability is similar to the magnitude of socioeconomic inequalities in self-reported disability. For this purpose we used data from two European studies with a longitudinal design, which included both performance and self-reported measures of disability.

6.3 Data and Methods

6.3.1 Data

We analysed data from two longitudinal studies on aging from different parts of Europe: the Longitudinal Aging Study Amsterdam (LASA), and the Italian Longitudinal Study on Aging (ILSA). Studies from different parts of Europe were included because self-reported disability may be partly dependent on culture and language. These studies include several indicators of physical functioning and disability, and provide repeated measures of physical functioning and disability at follow-up. The LASA study comprised three waves, and the ILSA study two waves of data, including baseline. The LASA baseline was from September 1992 to September 1993 and the follow-up study covered the period of 1992 to 1999. The ILSA baseline started March 1992 and the period covered by the study was 1992 to 1995. Time intervals between the waves were about three years in both studies. The age ranges of the samples were 55 to 85 years at baseline and 65 to 84 years, respectively. The study samples were randomly selected from the registries of several municipalities and were representative samples of the total national (Dutch and Italian) populations of these age groups. The sampling of the studies is described shortly below, but both studies have been described in more detail elsewhere.[11,12]

A random sample was drawn from eleven urban and rural municipalities in The Netherlands, which was stratified by age, gender and expected attrition due to mortality after 5 years of follow-up in each age group, including community-dwelling and institutionalised people. This sample was recruited in 1991, initially for the NESTOR-LSN study on "Living arrangements and social networks of older adults". The response rate was 62.3% (N=3,805). After eleven months these participants of the NESTOR-LSN study were approached for the first LASA wave. A total of 3,107 subjects (=81.7% of 3,805 of the NESTOR-LSN sample) were interviewed for LASA at baseline. Of these, we excluded 56 subjects from the analyses due to missing information on education and disability at baseline, leaving a total of 3,051 subjects (See Table 1).

The ILSA sample was drawn from the demographic lists of eight municipalities that were spread across Italy to derive a nationally representative sample of the Italian population aged 65-84 years. The sample included both community-dwelling and institutionalised persons. From each of the eight municipalities 88 persons of each sex and each of four age groups (65-69, 70-74, 75-79, 80-84) were selected. From these subjects 170 were excluded because they had died, or did not live at the registered address. The response rate of the home interview was 84%, after which 2,306 men and 2,316 women remained in the sample. The non-respondents were generally somewhat older than respondents, but there were no differences according to educational level between respondents and non-respondents.[13] We removed subjects with missing information on education or disability at baseline from the sample (n=1,502; 32%), leaving a total of 3,120 to be included in the analyses.

Table 1: Characteristics of the study populations

Population	Number of participants at baseline	Person years without *self-reported* disability	Person years with *self-reported* disability	Person years without *performance* disability	Person years with *performance* disability
LASA					
Sex					
Men	1,477	5,100	1,166	4,631	1,015
Women	1,574	4,988	2,424	4,900	1,718
Age					
55-69	1,449	6,616	924	6,268	657
70-85	1,602	3,472	2,666	3,263	2,076
Total Population	3,051	10,088	3,590	9,531	2,733
ILSA					
Sex					
Men	1,632	3,175	1,630	2,986	1,082
Women	1,488	2,585	1,778	1,765	1,640
Age					
65-74	1,617	3,568	1,263	3,169	838
75-84	1,503	2,193	2,144	1,583	1,884
Total Population	3,120	5,761	3,408	4,752	2,722

Note: These are the numbers after removal of those with missing information on education and disability status at baseline.

6.3.2 Measure of socioeconomic status

The participant's level of educational attainment was used as the indicator of socioeconomic status. We distinguished two levels of education. Participants were defined as having a lower level of education if their educational attainment was lower than secondary education. Participants with at least a secondary level education were defined as having a higher level of education.

6.3.3 Measures of disability

We use disability as an umbrella term to refer to self-reported activity limitations (referred to as 'self-reported disability'), and to the performance-based measures of physical functioning (referred to as 'performance-based disability').

In the LASA, self-reported disability was determined by asking participants whether they experienced difficulties with climbing stairs, cutting their own toenails, and using own or public transport. Performance was tested by recording the time needed to perform the following tasks: putting on and taking off a cardigan, walking a short distance, and rising from, and sitting down in a chair.

In the ILSA self-reported disability was measured by asking participants whether or not they experienced difficulties with washing themselves, getting dressed, going to the toilet, getting in and out of bed or rising from a chair, having a meal, or experienced incontinency problems. The performance of the following tasks was measured: rising from a chair, climbing a step, walking on a straight line, standing up on one leg, walking 5 metres at usual speed, and making a turn of 180 degrees. The time that was needed to rise up from the chair was recorded, as was the number of times the participant could step up onto a 23 centimetres step within 10 seconds, and the number of errors that a participant made while walking over a line of two metres in length and 5 centimetres wide. The mean time of four times standing up on one foot was recorded, the number of steps and how much time it took to walk 5 metres at ones own pace, and the number of steps it took to complete a 180 degrees turn.

For both studies we constructed one single indicator of self-reported disability, and one of disability measured by performance tests, based on the measures described above. The LASA participants who indicated not to be able to climb stairs, cut their toenails, and/or use own or public transport, or indicated that they could only perform these activities with help from others were defined as having self-reported disability. The scores of the performance tests were divided into quartiles. Participants who scored into the fourth quartile (25% with worst performance) on at least two of these tests were defined as having disability according to the performance test measures.

A similar approach was used with the ILSA measures. Firstly, participants were defined as having self-reported disability when they indicated to require help with or could not perform one of the activities that were asked (washing, getting dressed, etc). The outcomes of the performance tests were already categorised into 3 groups, including a group that was not able to perform the test at all. Subjects in the group with the worst two scores on at least two of the tests were defined as having disability according to performance tests.

We also performed the analyses with alternative cut off points as a check of the robustness of our findings. As an alternative to the cut off of the self-reported measures we defined only those participants who indicated that they could not perform the specific actions, even with help, as disabled. As alternative cut off for performance-based measures of disability we defined those participants who scored in the worst performance category on just one of the performance tasks, instead of two, as disabled. In those cases where the use of alternative cut off points resulted in different findings, this is mentioned in the text.

6.3.4 Data analyses

Analyses were performed separately for men and for women of all ages, and separately for men and women aged 55-69 years and 70-87 years in the LASA and 65-74 and 75-84 years in the ILSA study.

The prevalence of disability was estimated at the latest period of follow-up, which was the 3rd wave of the LASA and the 2nd wave of the ILSA, because this was the prevalence that chronologically followed from the incidence and recovery rates during the follow-up periods. Prevalence rates were age standardised according to the direct method with the population of the European Union in 1995 as the standard.[14] Incidence of disability was defined as the number of new disability cases occurring during follow-up per number of person years of participants at risk of getting disabled (i.e. the non-disabled participants). Recovery was defined as the number of recoveries from disability at follow-up, per number of person years at risk (i.e. disabled participants). We also estimated mortality for both measures of disability. Mortality was defined as the number of deaths occurring per number of person years at risk of the non-disabled, and of the disabled separately.

We estimated prevalence ratios with log linear regression with binomial error. Poisson regression analysis (log linear regression with Poisson error) was used to estimate educational inequalities in incidence, recovery and mortality, with the logarithm of the person years at risk as the offset variable. Mortality rate ratios were estimated for the non-disabled and for the disabled according to both measures. To control for age, a variable was included in the regression models indicating three-year age groups. Analyses including both men and women were also controlled for sex. The regression analyses were performed with the SAS statistical package, version 6.12.[15]

6.4 Results

6.4.1 Educational inequalities in prevalence of disability

Educational inequalities in prevalence of disability were consistently observed in the data of both studies, for men and women and both age groups according to self-report and according to performance-based measures (Table 2), with the exception of self-reported disability among men of the LASA study (PR: 1.19; 95%-CI: 0.95-1.50). Educational inequalities in the LASA study were large among the ages 55-69 years (self-reported PR: 1.76, 95%-CI: 1.31-2.36; performance-based PR: 1.65, 95%-CI: 1.26-2.16), with a higher prevalence of disability in the lower educated groups. Inequalities in self-reported disability in the ILSA population were substantial in the total population (PR: 1.65; 95%-CI: 1.38-1.96), as well as among men and women and both age groups.

Table 2: Age-standardised prevalence of disability (% of population) at latest follow-up, and prevalence ratios adjusted for age and/or sex

	Self-reported			Performance tests		
	Low Education	High Education	PR (95%-CI)	Low Education	High Education	PR (95%-CI)
LASA						
Sex						
Men	27	20	1.19 (0.95-1.50)	32	22	1.28 (1.04-1.57)
Women	40	27	1.30 (1.13-1.50)	36	27	1.23 (1.08-1.40)
Age						
55-69	21	11	1.76 (1.31-2.36)	21	13	1.65 (1.26-2.16)
70-85	63	44	1.09 (1.01-1.18)	59	45	1.11 (1.02-1.21)
Total Population	36	23	1.28 (1.13-1.44)	35	24	1.22 (1.10-1.36)
ILSA						
Sex						
Men	36	24	1.65 (1.30-2.09)	30	18	1.64 (1.26-2.14)
Women	42	26	1.65 (1.27-2.15)	46	38	1.21 (1.01-1.46)
Age						
65-74	31	20	1.61 (1.25-2.06)	26	16	1.50 (1.14-1.96)
75-84	56	34	1.69 (1.32-2.16)	62	43	1.32 (1.09-1.59)
Total Population	39	24	1.65 (1.38-1.96)	38	25	1.39 (1.18-1.63)

Differences in the magnitude of educational inequalities between the self-reported and the performance-based measure were observed for the ILSA study. Inequalities were slightly larger according to self-reported disability in the total ILSA population, among women, and among those aged 70-85 years. However the confidence intervals of the prevalence ratios of both measures overlap, which means that these small differences cannot be demonstrated with statistical significance. With the use of the alternative cut off points in the ILSA study larger inequalities according to self-reported disability were also observed among men (see appendix). Differences in the magnitude of inequalities between both measures were not observed for the LASA study.

6.4.2 *Educational inequalities in incidence of disability*

We observed higher incidence of disability among the lower educated in the populations of both studies (Table 3). The lower educated were between 1.30 and 1.40 times as likely to become disabled than the higher educated in the LASA study (self-reported RR: 1.38; 95%-CI: 1.16-1.65; performance-based RR: 1.34; 95%-CI: 1.12-1.60), and between 1.40 and 1.80 in the ILSA study (self-reported RR: 1.45; 95%-CI: 1.14-1.83; performance-based RR: 1.73; 95%-CI: 1.25-2.41).

Only small differences were found in inequalities in incidence between both measures of disability. In the LASA study, among participants aged 55-69 years, the inequalities in incidence of the performance-based measure of disability were slightly larger than inequalities in incidence of self-reported disability, while among participants aged 70-85 years the inequalities were slightly larger according to self-reported disability. In the ILSA study, the inequalities were somewhat larger in incidence of the performance-based measure of disability than of self-reported disability among men, and among those aged 65-74 years. These findings were also expressed in the slightly larger incidence inequality in the performance-based measure in the total population in this study as compared to inequality in incidence of self-reported disability.

However, we must note that these differences were not replicated when we performed the analyses with alternative cut off points (see appendix). Alternative cut off points showed somewhat larger inequalities according to self-reported disability as compared to the performance-based measure in both sexes and both age groups in the ILSA study. With alternative cut off points in the LASA study inequalities among men were somewhat larger according to performance tests.

Table 3: Age-standardised incidence rates of disability during follow-up (per 1000 pyr), and incidence rate ratios adjusted for age and/or sex

	Self-reported			Performance tests		
	Low Education	High Education	RR (95%-CI)	Low Education	High Education	RR (95%-CI)
LASA						
Sex						
Men	41	32	1.37 (1.03-1.83)	43	33	1.35 (1.02-1.78)
Women	68	57	1.35 (1.08-1.70)	59	50	1.33 (1.06-1.67)
Age						
55-69	31	22	1.20 (0.88-1.63)	31	22	1.59 (1.16-2.16)
70-85	108	77	1.47 (1.18-1.83)	95	72	1.24 (1.00-1.53)
Total Population	59	42	1.38 (1.16-1.65)	54	40	1.34 (1.12-1.60)
ILSA						
Sex						
Men	120	79	1.63 (1.18-2.26)	52	24	2.15 (1.36-3.42)
Women	136	126	1.27 (0.90-1.79)	79	58	1.26 (0.79-2.00)
Age						
65-74	99	79	1.22 (0.89-1.67)	46	25	1.65 (1.06-2.57)
75-84	106	59	1.77 (1.23-2.54)	95	49	1.78 (1.09-2.89)
Total Population	127	93	1.45 (1.14-1.83)	62	33	1.73 (1.25-2.41)

6.4.3 Educational inequalities in recovery from disability

We observed generally higher rates of recovery among the higher educated in the LASA study (self-reported RR in the total population: 0.79; 95%-CI: 0.58-1.08; performance-based RR: 0.93; 95%-CI: 0.69-1.25), with the exception of men for recovery from the performance-based measure of disability (Table 4), but inequalities were not statistically significant in most cases. In the ILSA study we found higher recovery among the lower educated according to self-reported disability (RR: 1.24; 95%-CI: 0.87-1.77). Differences between self-reported and performance-based measures in educational inequalities in recovery were mostly not large, with some exceptions (e.g. ILSA age-group 65-74: self-reported RR=1.19 (95%-CI: 0.75-1.88) and performance based RR=0.86 (95%-CI: 0.47-1.56)).

Table 4: Age-standardised recovery rates of disability during follow-up (per 1000 pyr), and recovery rate ratios adjusted for age and/or sex

	Self-reported			Performance tests		
	Low Education	High Education	RR (95%-CI)	Low Education	High Education	RR (95%-CI)
LASA						
Sex						
Men	52	73	1.02 (0.60-1.76)	110	88	1.17 (0.72-1.91)
Women	78	107	0.70 (0.48-1.03)	97	123	0.79 (0.55-1.15)
Age						
55-69	85	114	0.62 (0.39-0.97)	133	137	0.85 (0.54-1.34)
70-85	35	53	1.05 (0.67-1.65)	45	52	0.99 (0.67-1.47)
Total Population	67	92	0.79 (0.58-1.08)	101	106	0.93 (0.69-1.25)
ILSA						
Sex						
Men	208	168	1.43 (0.91-2.25)	50	47	1.20 (0.52-2.76)
Women	167	149	0.98 (0.56-1.71)	61	76	0.89 (0.49-1.70)
Age						
65-74	183	161	1.19 (0.75-1.88)	76	92	0.86 (0.47-1.56)
75-84	68	53	1.32 (0.76-2.31)	24	15	1.59 (0.56-4.48)
Total Population	185	161	1.24 (0.87-1.77)	58	66	1.01 (0.61-1.69)

Table 5: Age-standardised mortality*, and Mortality Rate Ratios (RR) adjusted for age and sex

	Self-reported			Performance tests		
	Low education	High Education	RR	Low education	High Education	RR
LASA						
Non-disabled	38	33	1.37 (1.10-1.70)	43	33	1.55 (1.25-1.93)
Disabled	64	63	1.46 (1.19-1.80)	76	65	1.40 (1.13-1.73)
ILSA						
Non-disabled	15	15	1.03 (0.66-1.63)	19	17	1.02 (0.63-1.66)
Disabled	15	23	0.84 (0.45-1.57)	22	29	0.82 (0.48-1.43)

Note: * Mortality = number of deaths per 1000 pyr for all ages and both sexes

Mortality inequalities are shown in Table 5. Because the numbers of deaths were rather small we performed analyses for mortality for the total samples only. Inequalities in mortality did not differ much between self-reported and performance-based measures, both for mortality from a non-disabled state as for mortality from a state of disability. A somewhat larger rate ratio was only observed for mortality from non-disabled state for the performance-based measure in the LASA study (self-reported RR: 1.37; 95%-CI: 1.10-1.70; performance-based RR: 1.55; 95%-CI: 1.25-1.93). Surprisingly, we found higher mortality of disabled higher educated as compared to the lower educated in the ILSA study.

6.5 Discussion

We reported that educational inequalities in the prevalence of disability were substantial in the ILSA sample and among men of the LASA; that there were educational inequalities in incidence of disability, with higher incidence among the lower educated, but that educational inequalities in recovery from disability did not indicate a consistent disadvantage for the lower educated. We observed some variations between the results for self-reported measures of disability and performance based measures. In the ILSA study the prevalence inequalities according to self-reported disability were larger as compared to the prevalence inequalities according to the performance-based measure of disability. Moreover, we found that for both disability types educational inequalities were stronger for incidence of disability than for recovery, for both self-reported and performance based disability.

In the interpretation of these results we must keep in mind that selective non-response and attrition may have influenced our findings. A study that provided a detailed evaluation of attrition in the LASA study showed that attrition in this study was minimally related to socio-demographic characteristics, including education.[16] Also, non-responders of the ILSA study were not different from responders in terms of education.[13]

Differences existed between educational groups in the number of excluded subjects because of missing information on disability, but these differences were small. We estimated the numbers of observed transitions that were lost due to missing information on disability at baseline and/or at follow-up (results not shown). In the LASA study about 11% of the transitions were lost for both self-reported and performance-based disability, and this percentage was higher among the lower educated than among the higher educated (about 5%). The majority of the missing transitions were transitions from a state of non-disabled at baseline or first follow-up to missing in the subsequent follow-up (but alive), suggesting that incidence rates may have been underestimated in LASA, especially in lower educated groups. In the ILSA sample 17% of the transitions for self-reported disability, and 24% for performance-based disability were lost. For self-reported disability, the percentage of missing transitions was 3% points higher among the lower educated than among the higher educated, but for performance-based disability the reverse was true. In the ILSA sample the majority of the excluded subjects had missing information at both baseline and follow-up. Because the differences between the educational groups were small, we expect that exclusion of subjects with missing information will not have influenced our results greatly.

Several studies have compared self-reported measures of disability with performance-based measures in terms of reproducibility and agreement in scores.[17-21] Conclusions about comparability of both types of measures varied between studies. The two types of measures in this study essentially measured different aspects of functioning and are therefore not strictly comparable in concept. It must be kept in mind therefore that it was not a purpose of this study to compare the two types of measures directly, but only in terms of observed socioeconomic inequalities in disability.

As far as we know, this study is the first to compare self-reported and performance-based measures with respect to socioeconomic inequalities in disability. In LASA about equally large educational inequalities were demonstrated in both types of measures of disability. This may suggest that the higher self-reported disability among the lower educated does reflect a higher prevalence of physical functioning in the lower educational groups and is not due to differences in reporting behaviour. Nonetheless, the educational inequalities in self-reported disability in the ILSA study were found to be larger than the inequalities in performance-based disability, suggesting that other factors in addition to physical functioning played a role in generating inequalities in disability.

A strong point of our study is that we estimated the effect of education using different cut off points. We observed that with using different cut off points some of the results changed. This illustrates that the pattern of educational inequalities within populations is dependent on the type of disability measure used. If the goal is to estimate the magnitude of educational inequalities in disability the definition of disability is not irrelevant. Sensitivity analyses may be needed also to improve the comparison of results between studies.

It is important to note however, that also after applying the alternative cut off points, education appeared to be more strongly related to incidence than to recovery. Furthermore, although there were some differences in the magnitude of inequalities in disability between self-reported and performance-based measures, the association of education with incidence and recovery were generally similar for both measures. These findings lend extra credibility to the conclusion that education serves to postpone or avoid disability, but that it loses a part of its protective effect after the onset of disability.

We found that education was more strongly related to incidence of disability than to recovery, which has also been found in previous studies, using different methods and measures of disability on data from different countries. Zimmer and colleagues (1998) and Grundy and Glaser (2000) found for Taiwan and the United Kingdom, respectively, that education was related to incidence or onset of physical functioning problems, but not to changes in functioning among those who already had physical functioning problems at baseline.[22-23] Melzer and colleagues (2001) reported educational inequalities in incidence of mobility disability, but no significant educational inequalities in recovery and death among the disabled for the United Kingdom.[9] Zimmer and House (2003) reported for the USA that education was strongly associated with the onset of activity limitations but not with the progression after limitations were present.[24] These findings suggest that a higher educational level helps one to avoid disability, but may lose part of its protective effects once disability is present. However, in a study among older people in Wuhan, China, Liang, Liu and Gu (2001) reported both a beneficial effect of education on incidence of and recovery from ADL disability.[25] We found for the LASA study that the chances of recovery from performance-based disability based on the alternative cut-off points were lower among the lower educated than among the higher educated (RR: 0.76; 95%-CI: 0.62-0.93). More research is needed to assess the effect of education on chances to recover from disability, in difference settings, using different disability measures and including sufficient disabled persons in the sample.

The association of education with the two types of disability was replicated in two datasets from culturally different parts of Europe. These studies differed in several aspects of design and measurement of disability, and therefore we have refrained from comparing results between both studies. But while these differences prevented us to make a direct comparison of the results, the findings from both studies are largely in agreement with regard to socioeconomic inequalities in self-reported and performance-based measures of disability. These findings strengthen the evidence base of the relationship of socioeconomic status and different measures of disability at older age.

As the aim of our study was to estimate the magnitude of socioeconomic inequalities in prevalence, incidence and recovery of disability, we adjusted only for age and sex in our models. Our reason not to adjust for health behaviours, or for other factors such as income and occupational class is that these factors are not just likely to be confounders, but are also likely to be on the pathway linking education to disability. Therefore, adjusting for these variables may lead to an underestimation of the gross effect of education on disability.

Several causal factors may contribute to the relationship of education to disability. These include longterm influences on adult health of childhood circumstances, the association of education to income and occupation, and the direct influence of education on the health behaviours of individuals.[26] There is evidence that childhood circumstances are related to stroke and to COPD in later life,[27-29] which chronic diseases are both associated with disability. Also, unhealthy behaviour is less prevalent among the higher educated,[30] which is likely to play a role in avoiding or postponing the onset of disability. Another factor that is likely to contribute to the effect of education is that the lower educated are more likely to work in manual labour, and physical exposures related to manual labour in earlier life may predispose workers to increased levels of disability in later life.[31-34] Future research should try to estimate the relative contributions of these, and possible other factors, to the observed association of education with incident disability.

6.6 Acknowledgements

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6.8 Appendix: Tables with the results of the alternative cut off points

Table 6: Age-standardised prevalence of disability (% of population) at latest follow-up, and prevalence ratios with alternative cut off points adjusted for age and/or sex

	Self-reported			Performance tests		
	Low Education	High Education	PR (95%-CI)	Low Education	High Education	PR (95%-CI)
LASA						
Sex						
Men	26	19	1.20 (0.95-1.52)	53	39	1.13 (0.98-1.32)
Women	36	26	1.27 (1.10-1.46)	51	41	1.19 (1.08-1.32)
Age						
55-69	19	10	1.81 (1.33-2.47)	38	26	1.49 (1.25-1.77)
70-85	59	43	1.08 (1.00-1.18)	77	63	1.09 (1.01-1.17)
Total Population	33	22	1.26 (1.11-1.42)	52	40	1.19 (1.09-1.29)
ILSA						
Sex						
Men	14	9	1.97 (1.22-3.18)	43	33	1.34 (1.13-1.59)
Women	16	7	2.05 (1.15-3.68)	67	61	1.07 (0.96-1.19)
Age						
65-74	9	4	2.19 (1.19-4.04)	45	33	1.19 (1.02-1.40)
75-84	28	15	1.93 (1.22-3.06)	76	61	1.15 (1.01-1.31)
Total Population	15	8	2.02 (1.40-2.93)	55	43	1.17 (1.05-1.30)

Table 7: Age-standardised incidence rates of disability during follow-up (per 1000 pyr), and incidence rate ratios with alternative cut off points adjusted for age and/or sex

	Self-reported			Performance tests		
	Low Education	High Education	RR (95%-CI)	Low Education	High Education	RR (95%-CI)
LASA						
Sex						
Men	49	35	1.32 (0.99-1.75)	99	71	1.60 (1.27-2.02)
Women	72	55	1.33 (1.06-1.68)	111	80	1.33 (1.08-1.64)
Age						
55-69	32	21	1.32 (0.96-1.81)	42	26	1.42 (1.14-1.78)
70-85	115	83	1.34 (1.08-1.66)	234	160	1.50 (1.21-1.86)
Total Population	62	43	1.34 (1.12-1.60)	111	75	1.46 (1.25-1.71)
ILSA						
Sex						
Men	40	23	1.77 (1.09-2.87)	84	64	1.31 (0.94-1.82)
Women	44	35	1.94 (1.06-3.55)	113	140	0.89 (0.60-1.32)
Age						
65-74	26	19	1.51 (0.81-2.81)	86	70	1.13 (0.83-1.54)
75-84	52	25	2.05 (1.27-3.31)	116	109	1.13 (0.73-1.77)
Total Population	42	26	1.84 (1.26-2.69)	96	83	1.14 (0.89-1.47)

Table 8: Age-standardised recovery rates of disability during follow-up (per 1000 pyr), and recovery rate ratios with alternative cut off points adjusted for age and/or sex

	Self-reported			Performance tests		
	Low Education	High Education	RR (95%-CI)	Low Education	High Education	RR (95%-CI)
LASA						
Sex						
Men	59	69	1.17 (0.67-2.05)	33	26	0.75 (0.55-1.03)
Women	78	88	0.95 (0.64-1.42)	48	46	0.76 (0.57-1.00)
Age						
55-69	83	102	0.72 (0.45-1.15)	48	43	0.74 (0.56-0.97)
70-85	44	41	1.38 (0.87-2.20)	34	21	0.80 (0.58-1.11)
Total Population	69	80	0.79 (0.58-1.08)	43	35	0.76 (0.62-0.93)
ILSA						
Sex						
Men	57	110	0.76 (0.24-2.40)	67	81	0.84 (0.52-1.37)
Women	132	0	-	57	54	1.05 (0.62-1.79)
Age						
65-74	100	92	0.90 (0.20-4.11)	79	89	0.90 (0.59-1.36)
75-84	35	18	1.77 (0.41-7.66)	25	24	1.04 (0.51-2.12)
Total Population	96	82	0.99 (0.72-1.37)	61	67	0.94 (0.66-1.34)

7

The effect of mortality selection on educational inequalities in disability prevalence at age 75 years and older: a multi-state life table analysis

Kunst A, Huisman M, Nusselder W, Deeg D, Mackenbach J. The effect of mortality selection on educational inequalities in disability prevalence at age 75 years and older: a multi-state life table analysis. (To be submitted).

7.1 Summary

Introduction: Socio-economic inequalities in health among elderly populations may be influenced by differential selection on mortality at younger ages. Due to lack of empirical studies, it is uncertain whether this selection effect is marginal or substantial. The objective of this paper is to estimate the extent to which mortality selection influences educational inequalities in disability prevalence among elderly people.

Data and Methods: Data from a longitudinal study in the Netherlands (1991-1999, N=3051) were used to estimate educational differences in incidence of disability, recovery from disability, and mortality of disabled and non-disabled persons. These data were used to construct multi-state life tables (MSLT) by sex and educational level. Using these MSLT, the effect of mortality selection was evaluated by applying alternative scenarios with regards to the risk of dying at younger ages (57-74 years), and comparing these scenarios with respect to survival and disability prevalence at ages 75 years and over.

Results: We observed substantial educational inequalities in disability incidence and in mortality among non-disabled persons and disabled persons, but we found only small inequalities in recovery from disability. Compared to men or women with high education, those with low education have lower life expectancies at 75th birthday (about 1 year less), a similar expectancy of life with disability, and therefore a larger proportion of life spend with disability. A hypothetical elimination of mortality at younger ages would increase the relative prevalence of disability after the 75th birthday, as well as educational differences in this prevalence. However, the effects are marginal, in the order of 1 percent point or less.

Conclusions: In this study population, mortality selection at younger ages hardly influenced educational differences in the prevalence of disability at ages 75 years and older. Further research should determine whether this finding can be generalised to other populations and health problems.

7.2 Introduction

Increasingly more attention is given to socio-economic inequalities in mortality among elderly populations. In recent years, these inequalities have been documented in much detail, and for increasingly more countries.[See e.g. 1-5] A main challenge is now to explain these inequalities and to identify underlying mechanisms that are amenable to change.

A mechanism that might be particularly relevant for understanding the occurrence of disability and mortality among elderly populations is mortality selection. This mechanism is proposed to operate as follows: strong mortality selection at younger ages decreases the pool of frail people, thus reducing the prevalence of disability and disease at more advanced ages. As mortality selection at younger ages is stronger among lower social groups, its effect would be to reduce inequalities in disability and ill health among elderly people.

Some authors have suggested that this mechanism might partly explain the finding that inequalities in health diminish, at least in relative terms, with increasing age.[6,7] For example, in a discussion on observed convergence of socio-economic health inequalities in old age, House and colleagues (1994) state that processes of selective mortality undoubtedly accounted for some of it.[6] If this explanation holds, it implies that inequalities in mortality and disability at old age would be larger if the force of mortality selection were to diminish, a situation that is likely to happen in the future given the secular decline in mortality.

Even though mortality selection is likely to play some role, it is highly uncertain whether this role is either marginal or substantial. Studies that have aimed to quantify its exact impact focused on racial disparities in mortality in the United States, where Black-White mortality differences diminish and even reverse with increasing age.[8] Only one study has investigated the effect of mortality selection on inequalities in health according to socio-economic factors in the US,[9] while no one addressed this issue in a European context.

Our study aims to make a first step in assessing the influence of mortality selection on socio-economic health inequalities in a European context. The objective of this paper is to estimate the extent to which mortality selection influences educational inequalities in disability prevalence among elderly people.

As such estimates cannot be derived from empirical observations only, simulation models will have to be applied. In this study, we apply the multi-state life table (MSLT), which is a modelling technique that has shown to be highly useful for addressing public health issues involving population dynamics. Thanks to the explicit life course perspective that is applied in the MSLT, this technique facilitates the study of processes occurring in earlier in the life course (including mortality selection) on the occurrence of health outcomes in later life (including disability prevalence).

Application of the MLST requires the availability of longitudinal data on both mortality and health indicators among an elderly population. In this study, we will apply data from the Longitudinal Aging Study Amsterdam (LASA)[10] one of the first large-scale longitudinal studies that have been carried out in Europe focussing specifically on the health of elderly men and women. LASA is a Dutch nation-wide longitudinal study in which men and women aged 55 to 85 in 1992-93 were followed up for mortality and disability by two subsequent waves each 3 years apart, in 1995-96 and 1998-99. LASA data allow the estimation of educational differences in disability incidence and in recovery from disability occurring between each of the waves, and of educational differences in mortality rates among disabled people and among non-disabled people. Using the MSLT, it is possible to estimate from these rates educational differences in life expectancy and in disability prevalence, and to simulate what would happen to these educational differences if no mortality selection were to occur at younger ages.

7.3 Data and methods

7.3.1 The LASA study

Micro-level data were obtained from the LASA study. The baseline measurement, which was carried out between September 1992 and September 1993, covered a sample of 3107 men and women aged 55 to 85 years. This study sample was randomly selected from the population registries of municipalities from three representative regions located in the west, east and south of the Netherlands. This study has been described in detail elsewhere.[10]

The participant's level of educational attainment at baseline was used as the indicator of socio-economic status. Other socio-economic indicators were not used in our analyses because they could not be applied to most study participants (e.g. current occupation) or the proportion of missing values was larger than for education (e.g. income). In our analyses, we distinguished two educational levels. A "low" educational level was assigned to those with no education and those who completed only elementary or lower secondary education. A "high" education level was assigned to those who had completed upper secondary or higher educational levels. Those with educational level unknown (N=8) were excluded from further analysis.

For our study, we confined the age range to age 57-85 years at baseline. The lowest ages were excluded because of too few participants. Table 1 presents the number of person-years at risk lived between the baseline and second follow-up (6 years later), classified according to age during follow-up (instead of at baseline). The table also shows the distribution of person-years according to educational level. The proportion of participants with low education is much higher among women than among men (about 50 versus 25 percent) and increases with age.

Table 1: Number of person-years at risk and % with low education by age and sex. LASA study from baseline to wave 2, 1992-1999.

Age at baseline or at start of first follow-up	Number of person-years at risk		% with low education	
	Men	Women	Men	Women
Total	6279	7368	25·2	50·8
By age				
- 57-59	584	649	23·0	38·0
- 60-62	750	840	23·8	39·0
- 63-65	731	852	16·3	42·4
- 66-68	683	859	19·9	36·5
- 69-71	640	824	24·5	55·5
- 72-74	631	695	23·1	52·1
- 75-77	652	724	24·0	49·3
- 78-80	693	725	24·7	50·2
- 81-83	565	702	29·1	62·2
- 84-86	296	409	37·3	53·9
- 87-89	52	89	41·8	67·7

7.3.2 Measurement of disability

At both baseline and during each follow-up wave, the disability status of participants was measured by means of performance-based tests, and by means of the participant's own reports of difficulties with performing some daily activities.

Performance was tested on three tasks: putting on and taking off a cardigan, walking a short distance, and rising from and sitting down in a chair. For each task, the time needed to perform that task was measured. In our analysis of these data, we divided these scores on performance tests into quartiles. Participants were defined as being "disabled" when they fell into the lower quartile (i.e. the 25% of all participants with the worst score) on at least 2 of these 3 tasks. At the time of the second follow-up wave, the age-standardised prevalence of disability was 35% among low educated compared to 24% among the high educated.

Self reports of functional disability were determined by asking participants whether they experienced difficulties with climbing stairs, cutting their own toenails, and using own or public transport. Participants were defined as being "disabled" if they could not, or only with help from others, perform one or more of these 3 tasks. At the time of the second follow-up wave, the age-standardised prevalence of disability was 36% among low educated compared to 23% among the high educated.

We also applied alternative measures for both performance-based and self-reported disability. These alternative measures showed the same basic patterns of educational differences in disability as those presented below (table 2), although with some discrepancies. Details are given elsewhere.

Participants were excluded from further analyses when information on performance-based or self-reported disability was missing from the baseline survey. This applied to 56 participants, i.e. 1,8% of the study population. Participants with missing information on disability in one or both of the follow-up waves were excluded from the longitudinal measurement of disability incidence and recovery rates, but their mortality levels were taken into account in the measurement of mortality. In almost 50% the type of transition could not be determined because in either the beginning or the end, or both, information on disability was missing. This percentage did not differ between higher and lower educated groups.

7.3.3 Measurement of transition rates

The data described above were used to estimate four types of transition rates: disability incidence, recovery from disability, mortality of disabled people, and mortality of non-disabled people. The incidence rate was defined as the number of new cases of disability occurring during a follow-up period, divided by the number of person-years lived by participants who were at risk of getting disabled (i.e. the non-disabled population). The recovery rate was defined as the number of recoveries from disability divided by number of person-years at risk among the disabled population. The rate of mortality among non-disabled people was defined as the number of deaths occurring per person-years at risk among the non-disabled population. Mortality among disabled was measured in a similar way.

The number of person-years at risk was determined by calculating for each subject the number of days lived during the follow-up and dividing these by 365. The assumption was made that during the time interval of 3 years, each person could make only one transition, and that this transition occurred in the middle of the time interval. In such a case half of the person years lived were allocated to the state that was measured at the beginning of the period and the other half to the state that was present at the time of follow-up. This method is similar to the standard procedure that is used in cause-elimination life tables to estimate 'independent' or 'net' rates to die from specific causes of death.

Educational differences in incidence, recovery and status-specific mortality were measured by means of rate ratios comparing the lower to the higher educational level. These rate ratios and their 95% confidence intervals were estimated by means of Poisson regression analysis, using the SAS statistical package, version 6.12. In order to control for age, categorical variables representing 3-year age groups were included in the regression models. Analyses including both men and women also were controlled for sex.

Due to the relatively small numbers of deaths in the study cohort, it was not possible to determine age-sex variations in the magnitude of educational differences in mortality. In contrast, there were sufficient cases of incidence and recovery to study interactions between education and age/sex. Detailed results are presented elsewhere.[11] We did not observe substantial and consistent variations according to sex. Larger variations were however observed according to age, with larger educational inequalities among younger age groups (table 2).

7.3.4 *Multi-state life tables analyses*

We constructed one MSLT for each sex and educational level separately, applying an Excel spreadsheet program developed by Nusselder et al.[12] As empirical input to this table, we used estimates of the four types of transition rates according to 3-year age group and sex, combined with estimates of the magnitude of educational differences in these transition rates (as given in table 2). We also took into account the observed age variations in educational inequalities in incidence and recovery.

We used three-year age intervals in the MSLT, which equals the length of the follow-up intervals in the LASA study. We started the life table calculations at age 57 years. The initial cohort population (the radix) was distributed over the non-disabled and the disabled state according to the prevalence of disability that was observed in the LASA study for men and women of 55-59 years at baseline.

In the LASA study, the maximum age group was 87-89 years, corresponding to those living between the first and second follow-up wave (Table 1). As a result, the empirical estimates were restricted to men and women living before their 90th birthday. Therefore, the MSLT was closed at age 90 years. For the upper age group of 90+ years, we assumed that the life expectancy at this age interval was 1.2 years, of which 0.2 years free of disability and 1 year with disability. The 1.2 years assumption is close to estimates for the total Dutch population of 1995. Alternative assumptions did not substantially lead to changes in the results presented in this paper.

Life table measures were used to summarise mortality levels and disability prevalence according to sex and educational level. Mortality levels were expressed in terms of total life expectancy (LE) at 57th and the 75th birthday. The prevalence of disability was expressed by means of life expectancy with disability at 57th or 75th birthday. This measure is expressed in absolute terms (i.e. in absolute number of years, denoted LED) and in relative terms (i.e. as a percentage of total life expectancy, denoted as %LED).

7.3.5 Scenarios

Using the MSLT, it is not only possible to calculate educational differences in LE and LED at the 75th birthday, but also to simulate what would happen to these educational differences if no mortality selection were to occur at younger ages. The effect of mortality selection was evaluated by applying a series of scenarios with regards to the risk of dying at younger ages. In this paper, we present the results for four scenarios.

1. *Null scenario.* In this scenario, the mortality probabilities between the 57th and 75th birthday (by age, 3-year age interval, disability status and education) are as estimated on the basis of the LASA study.

2. *Historical scenario.* In this scenario, the mortality probabilities referred to above are all increased by 50%. This scenario refers to situations that may have prevailed in the recent past, when levels of premature mortality were substantially higher.

3. *Equality scenario.* In this scenario, the mortality probabilities for the low and high educated are set at the same, average values that are observed in the LASA study for all educational groups together. This scenario refers to a situation of equality in terms of state-specific mortality risks.

4. *Elimination scenario.* In this scenario, all mortality probabilities are assumed to be zero. It automatically removes all mortality differentials, not only between educational levels, but also between disabled and non-disabled persons. Even though this scenario is highly unrealistic, it can be used to quantify the maximal effect of mortality selection.

In the 'equality scenario', due to difference in mortality by disability status, and the higher prevalence of disability among lower educational levels, the resulting life expectancies are slightly smaller among lower educated than among higher educated. In further analyses we observed that taking into account these residual inequalities would not change our results.

7.3.6 Sensitivity analyses

Sensitivity analyses were carried out to evaluate whether our results were robust assumptions that had to be made in order to cope with uncertainties in the empirical data. In this paper, we will present here the evaluations with regards to three assumptions that potentially most problematic.

1. *Assumptions on age-sex variations in educational inequalities in mortality rates.* Due to small number problems, the LASA data could not be used to determine age-sex variations in the magnitude of educational differences in mortality. In our models, we therefore assumed that these inequalities did not vary by sex, and that they gradually diminished from its observed relative risks (which were applied to ages 57-64) towards one third of this value (which was applied to ages 84-89). However, more detailed and accurate estimates are available from a series of other studies. Therefore, in one sensitivity analysis, we applied estimates of educational differences in mortality according to age and gender, as estimated in a recent international overview.[13]

2. *Assumptions on age variations in educational inequalities in incidence and recovery rates*. We judged that there was sufficient evidence in the LASA data to assume that the magnitude of inequalities in incidence or recovery varied according to age. However, this evidence lacked statistical significance, and was not consistent according to the disability measure used (Table 2). Therefore, in one sensitivity analysis, we assumed no interaction between age and education.

3. *Other measure of disability*. The findings presented below are based on performance-based disability. We judge that such measures are most appropriate in longitudinal studies, especially because of their objective measurement and their relatively high test-retest reliability.[14,15] Nonetheless, participants' own reports of functional disability may have a complementary value, if only because they capture different aspects of disability, thanks to their emphasis on complex, daily tasks instead of physical impairments. Therefore, we evaluated whether similar results were obtained by using a self-reported measure of functional disability.

The scenarios refer to alternative patterns of mortality (selection) between the 57th and 75th birthday. The choice of slightly different age ranges was found to produce similar results as those presented below.

7.4 Results

In the LASA population as a whole, the incidence of disability increases with age, while recovery rates decrease with age (figure 1). High incidence rates are observed especially in the age groups 84-86 and 87-89 years. Mortality rates of non-disabled persons increase regularly with age. The age pattern of mortality of the disabled population is less regular due to the small number of deaths at young ages, but shows a much higher overall level of mortality compared to non-disabled persons.

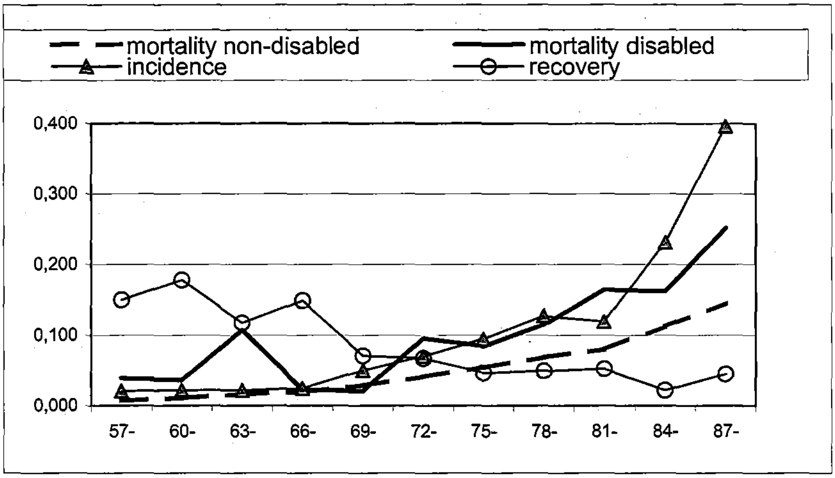


Figure 1: Transition rates (per 1,000 person years) in the total LASA population. Men and women together, per 3-year age group

Educational inequalities in disability incidence are substantial and statistically significant (table 2). The RR comparing low to high education equals 1.34 for performance-based measures, and 1.38 for self reports. Large age differences are observed, with larger inequalities among younger ages with respect in the incidence of performance based measures, but an opposite pattern when disability is measured by means of self reports. Recovery rates are lower among less educated persons, but the difference with high educated persons is relatively small and not statistically significant. A significant association is however observed in the younger age group for recovery from self reported disability. Substantial mortality differences (RR of about 1.40) are observed within both disabled and non-disabled populations.

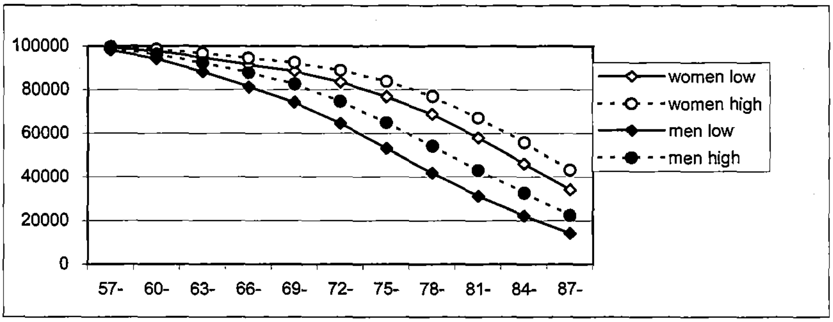
Table 2: Educational differences in transition rates. Estimates used as input into the multi-state life table analysis.

Transition type - age at start follow-up	Relative risk of low versus high (95 % CI)			
	Performance tests of disability		Self reports of disability	
Incidence of disability				
- all ages	1.34	(1.12-1.60)	1.38	(1.16-1.65)
- 57-71 years	1.59	(1.16-2.16)	1.20	(0.88-1.63)
- 72-87 years	1.24	(1.00-1.53)	1.47	(1.18-1.83)
Recovery from disability				
- all ages	0.93	(0.69-1.25)	0.79	(0.58-1.08)
- 57-71 years	0.85	(0.54-1.34)	0.62	(0.39-0.97)
- 72-87 years	0.99	(0.67-1.47)	1.05	(0.67-1.65)
Mortality of non-disabled				
- all ages	1.55	(1.25-1.93)	1.37	(1.10-1.70)
Mortality of disabled				
- all ages	1.40	(1.13-1.73)	1.46	(1.19-1.80)

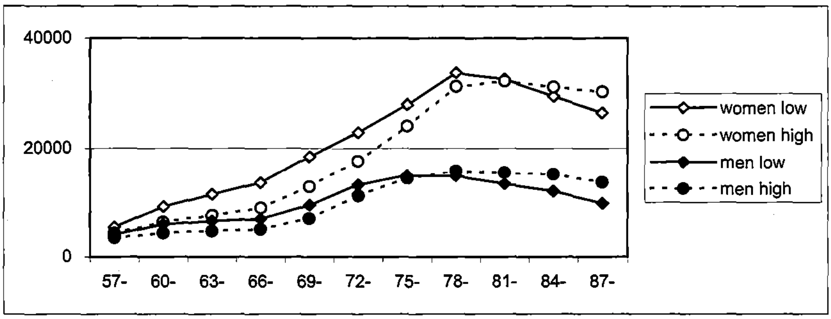
Application of MSLT showed large differences by sex and education in the number of years lived in life table populations (figure 2-A). At each age, men and women with a lower level of education can expect to live fewer years than those with higher education. A more complex pattern is observed for years lived with disability (figure 2-B). Among both men and women, this number is initially higher among those with low education. After the age of about 80 years, this number decreases more rapidly, due to a stronger drop in the number of survivors (figure 2-B). At each age, the age-specific prevalence of disability is higher among low educated persons (figure 2-C).

Compared to men with high education, those with low education have smaller life expectancies (table 3). On the average, they can expect to live 2.6 years less after the 57th birthday, and 1.2 years less after the 75th birthday. Despite these differences, lower and higher educated men can expect to live the same number of years with disability (3.4 years). As a result, low educated men can expect to spend a larger proportion of their live with disability. After the 75th birthday, this difference amounts to 5.5 percent points.

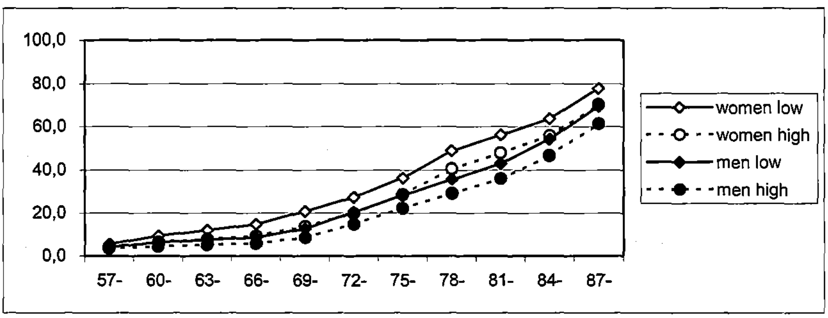
Figure 2: Life table population according to disability status, by sex and educational level. Estimates from multi-state life table



A) Total number of person-years lived per single year of age. Average per 3-year age interval. Assuming 100.000 persons at baseline (57th birthday)



B) Number of person-years lived with disability. Average per 3-year age interval



C) Life table prevalence of disability. Average per 3-year age interval

Table 3: Expectancy of life with disability by age, per sex and educational level. Estimates from multi-state life table. Men

	Life table measure		
	Total population	Low education	High education
Life expectancy (LE)			
- at 57th birthday	22·0	20·0	22·6
- at 75th birthday	9·2	8·4	9·5
Expectancy of life with disability (LED)			
- at 57th birthday	3·4	3·4	3·4
- at 75th birthday	3·4	3·4	3·4
LED as % of LE			
- at 57th birthday	15·7	17·2	15·2
- at 75th birthday	36·9	41·0	35·5

Educational differences in life expectancy are slightly smaller among women compared to men (table 4). However, the differences in LED and %LED are larger. For example, after the 75th birthday, the difference in %LED amounts to 7.1 percent points.

Table 4: Expectancy of life with disability by age, per sex and educational level. Estimates from multi-state life table. Women

	Life table measure		
	Total population	Low education	High education
Life expectancy (LE)			
- at 57th birthday	26·4	25·4	27·2
- at 75th birthday	11·3	11·0	11·7
Expectancy of life with disability (LED)			
- at 57th birthday	6·8	7·2	6·5
- at 75th birthday	5·7	5·9	5·5
LED as % of LE			
- at 57th birthday	25·9	28·2	23·8
- at 75th birthday	50·7	54·1	47·0

The four scenarios differ with respect to the estimated proportion of men that die between their 57th and 75th birthday (table 5). This proportion is higher in the 'historical scenario' and – by definition – zero in the 'elimination scenario'. The 'equality scenario' produces almost equal mortality rates for lower and higher educated men, with the residual differences being due to differences in the prevalence of disability (see Methods section). When compared to the 'null' scenario, the 'elimination scenario' shows an increase in the expectancy of life with disability, both in absolute terms (LED) and in relative terms (%LED). This increase is however very modest, e.g. from 41.0 to 42.7 % for LED in relative terms. Similarly, after hypothetical elimination of mortality at younger ages, the difference between lower and higher educated men in the relative LED increases, but by 0.6 percent points only (from 5.5 to 6.1%). The changes are somewhat larger but still modest when the 'elimination scenario' is compared to the 'historical scenario'.

Table 5: Expectancy of life with disability. Estimates from alternative scenarios of mortality selection. Men

Measure - scenario [a]	Life table measure		
	Low education	High education	Difference (low minus high)
Chance (%) to die from 57th to 75th birthday			
- historical scenario	54·5	40·9	13·6
- null scenario	40·9	29·7	11·2
- equality scenario	33·2	32·0	1·2
- elimination scenario	0·0	0·0	0·0
Life expectancy with disability (LED) at 75			
- historical scenario	3·4	3·3	0·1
- null scenario	3·4	3·4	0·0
- equality scenario	3·5	3·4	0·1
- elimination scenario	3·6	3·5	0·1
LED as % of total life expectancy at age 75			
- historical scenario	40·2	35·0	5·2
- null scenario	41·0	35·5	5·5
- equality scenario	41·2	35·4	5·8
- elimination scenario	42·7	36·6	6·1

Note: [a] The four scenarios differ with regards to risk of dying between the 57th and 75th birthday, by 3-years age interval, sex, disability status, and educational level. In the:

- null scenario, these mortality risks are as observed in the LASA study;
- historical scenario, these mortality risks are all increased by 50%;
- equality scenario, both educational levels have similar mortality risks;
- elimination scenario, these mortality risks are set at cero.

Almost identical results are obtained for women (table 6). Comparison of the 'elimination scenario' to the 'null scenario' shows an increase of LED in relative terms from 54.1 to 55.0%, i.e. by less than one percent point. The educational difference in relative LED increases by 0.4 percent points only (from 7.0 to 7.4%) even when the two extreme scenarios are compared.

Table 6: Expectancy of life with disability. Estimates from alternative scenarios of mortality selection. Women

Measure - scenario [a]	Life table measure Low education	 High education	 Difference (low minus high)
Chance (%) to die from 57th to 75th birthday			
- historical scenario	28·3	19·7	8·6
- null scenario	20·0	13·6	6·4
- equality scenario	17·1	16·1	1·0
- elimination scenario	0·0	0·0	0·0
Life expectancy with disability (LED) at 75			
- historical scenario	5·9	5·5	0·4
- null scenario	5·9	5·5	0·4
- equality scenario	5·9	5·5	0·4
- elimination scenario	6·0	5·6	0·4
LED as % of total life expectancy at age 75			
- historical scenario	53·7	46·7	7·0
- null scenario	54·1	47·0	7·1
- equality scenario	54·2	46·9	7·3
- elimination scenario	55·0	47·6	7·4

Note: [a] See note to Table 5

Basically the same results are obtained in sensitivity analyses that are based on different assumptions or measures. Table 7 presents key results of these analyses, by focussing on the relative measure of LED. This measure is higher among the low educated as compared to higher educated in all analyses, although the magnitude of this educational differences varies according to the method used. For example, larger educational differences in %LED are found when disability is measured by means of self reports instead of performance tests (lower part). However, a common finding to each analysis is that the application of the 'elimination scenario' increases the educational differences in relative LED, but that this increase is small (less than 1 percent point) in each case.

Table 7: Comparison of null to elimination scenario, using alternative assumptions

Alternative assumption of measures	LED as % of LE· at 75th birthday		
	Low education	High education	Difference (low minus high)
Basic analyses (tables 5 and 6)			
Men			
- null scenario	41·0	35·5	5·5
- elimination scenario	42·7	36·6	6·1
Women			
- null scenario	54·1	47·0	7·1
- elimination scenario	55·0	47·6	7·4
Inequalities in incidence or recovery do not vary by age			
Men			
- null scenario	41·9	35·0	6·9
- elimination scenario	43·5	36·2	7·3
Women			
- null scenario	54·6	46·1	8·5
- elimination scenario	55·4	46·7	8·7
Inequalities in mortality according to European study			
Men			
- null scenario	40·0	35·8	4·2
- elimination scenario	41·9	37·0	4·9
Women			
- null scenario	53·5	47·8	5·7
- elimination scenario	54·4	48·3	6·1
Disability measured by self reports			
Men			
- null scenario	39·0	31·4	7·6
- elimination scenario	40·7	32·6	8·1
Women			
- null scenario	57·9	47·3	10·6
- elimination scenario	59·4	48·4	11·0

7.5 Discussion

7.5.1 Summary

Socio-economic inequalities in health among elderly populations may be influenced by differential selection by mortality at younger ages. Due to lack of empirical studies, it is uncertain whether this selection effect is marginal or substantial. In this paper, we estimated its role using data from a national longitudinal study, which were analysed by means of the multi-state life table methodology. Life table simulations showed mortality selection effects. Without mortality at younger ages, the prevalence of disability at old age would increase, and more so among elderly people with low education. However, educational differences would be only marginally larger, suggesting that mortality selection effects are modest.

7.5.2 Evaluation of data

For this study, we used data from a longitudinal study with generally high quality. This study was selected because of its broad age range (up to 90 years), long and repeated follow-up, and comparable measurements of disability in subsequent waves. The quality of the LASA study is evaluated in detail by internationally accessible reports.[16,17] Nonetheless, some problems with the available data remained, and these need to be evaluated for their possible effects.

1. A main concern in longitudinal studies on disability related to the test-retest validity of disability measures. Problems in this regard may lead to misclassification of people in terms of incidence and recovery. Even though these measurements problems may have affected results of our analyses, the fact that application two different ways of measuring of disability (performance based and self-reported) yielded similar results (table 7), suggests that our results are fairly robust to problems with test-retest reliability.
2. Due to a fairly small number of transitions between the states of non-disabled, disabled and dead, it was not possible to make precise estimates of the magnitude of educational differences in transition rates, especially in the younger age groups. As a way to evaluate the potential impact of imprecision in inequality estimates, we applied alternative estimates, both for disability and for mortality (table 7). These sensitivity analyses yielded essentially the same results.
3. Because the LASA study focussed on elderly populations, men and women younger than 55 years of age were not included. As a result, selection of mortality at ages below 55 years could not be taken into account in our life table models. However, we expect that inclusion of younger ages groups would have no substantial effect on our results, because the incidence and prevalence of disability at these younger ages is very small, and therefore there is little opportunity for early mortality to be selective according to disability status at old age.
4. A number of potential participants were excluded from analysis due to non-response at the baseline survey, attrition between baseline and follow-up waves, and missing values on disability. If non-response or sample attrition would be higher among lower educational

groups and among people with disability, the effect would be to underestimate educational differences in mortality and disability. Even though this effect cannot be excluded, evaluations of the LASA study showed that non-response and attrition rates do not strongly vary according to socio-demographic characteristics such as educational level.[17] Furthermore, although the number of observations that were missed due to missing information on disability in this study should not be neglected, we observed that this number hardly differed between the educational groups.

As an additional way to check our data against some of these problems, and especially problems with attrition and non-response, we compared our life expectancy estimates with those based on national death registries with (near) complete coverage of national populations. Results are given in appendix table 8. Our life expectancy estimates for the total LASA population approximate the estimates for the national Dutch population closely, with differences of less than 0.5 years for both men and women, and for different ages. Because our estimates of educational differences in life expectancy could not be compared with estimates from Dutch sources, we compared them with those from six European countries with national longitudinal mortality studies.[18] Our estimates are 0.8 years below the average of other countries, suggesting that educational differences in mortality are underestimated in our study. Nonetheless, the discrepancy is small and it does not imply that the role of mortality selection is seriously underestimated in our study.

7.5.3 Comparison to other studies

Some previous attempts were made to determine the effect of mortality selection (on gender differentials), using a method different from the one that we applied in our study. These earlier studies used a 'pseudovariables' method.[19,20] This method involves including pseudo data about those respondents who died between baseline and follow up, by assuming that the health value of these subjects is lower than the worst possible health score reported by surviving respondents. The bias of mortality selection is then estimated by assessing inequalities in disability first without including those who died during the follow-up period, and subsequently assessing inequalities after including those who died. Beckett applied a modified version of this approach to data from the NHANES I Epidemiologic Followup Study (2000) to assess the contribution of mortality selection to converging socio-economic inequalities in health in old age.[10] She reported that there was no evidence that sample selection (both mortality selection and non-response) contributed to a convergence in educational inequalities in odds of reporting more health conditions, or functional impairment in later life.

The method applied by Beckett might be criticised for the assumptions that were made. For example, Strauss et al. point out that it may be defensible to assume the health of decedents as being poor or worse, but that it is much less straightforward to assume that a deceased would have reported specific problems with physical functioning (1993).[20] Our method circumvents this problem by using the multi-state life table approach in which underlying transition rates underlying both mortality and disability are modelled. It thereby also takes into account the possibility of recovery from disability. Despite the large variations in methods, we arrived at essentially the same conclusion as Beckett did.

7.5.4 Interpretation

These results raise the question why, at least in our study, mortality selection effects do not greatly influence socio-economic inequalities in disability prevalence at old age. Two mechanisms may play a role. The first mechanisms relates to dilution in a chain of associations. Mortality selection can only exert a large influence if both (a) mortality rates strongly differ according to disability status and (b) disability prevalence strongly differs according to socio-economic status. Even though both associations are observed in our data (Figures 1 and 2), the differences are not dramatic. For example, death at old age does not almost exclusively occur among disabled people. Because the product of two moderate associations is a weaker association, the effect of mortality selection may have been strongly diluted in our case.

The second mechanism relates to the timing of the relevant events. Because the incidence of disability is strongly increasing after the age of 75 years (Figure 1), mortality at ages below 75 years can only have a moderate effect on the accumulation of the pool of disabled people at older ages. The results of our 'elimination scenario' suggest that even if no mortality would occur before the age of 75 years, a large and unequally distributed pool of disability would soon be formed at higher ages.

This interpretation implies that our results may not be generalised to other populations or to other health indicators. Mortality selection may exert a larger effect in populations where disability status is more strongly related to socio-economic factors. A recent European overview observed that the relationship between socio-economic factors and health at ages 60 years and older varied between European countries, with larger differences in for example Greece and Portugal.[5] Similarly, mortality selection may play a larger role in health outcomes that are more strongly related both to mortality and socio-economic status. According to a European overview, stroke prevalence at younger ages is more strongly related to educational level, but this educational difference disappears at older ages.[21] This decline, which is more marked for stroke than for any other disease except cancer, may perhaps be attributed to selective mortality of stroke patients, especially among lower educational groups.

Larger effects of mortality selection may perhaps be identified if mortality is studied not only in relationship to the occurrence of disability or specific diseases, but also in relationship to their precursors or risk factors. This is especially important for causes of death that become manifest at later ages only, because mortality selection at younger ages may have already taken place on the basis of their precursors or risk factors. For example, the effect of mortality selection on smoking-related causes may be assessed more fully by using smoking status. An Italian study observed that the educational gradient in smoking rapidly changes after the age of 60 years, because of differential mortality that occurred before the age of 60 among smokers, with the highest rates among smokers from lower socio-economic groups.[22] Similar selection processes are likely to occur, after some delay, with socio-economic differences in the smoking-related diseases.

7.5.6 Implications

In our study population, mortality selection at younger ages hardly influenced educational differences in the prevalence of disability at ages 75 years and older. Thus, no empirical support was found for the idea that socio-economic inequalities in health among elderly populations could have been diminished due to differential selection by mortality at younger ages. Further research should aim to determine whether this finding can be generalised to other populations and health problems.

Our results cast doubt on the traditional view that inequalities in health among the elderly population are small as compared to middle ages, and that a main challenge for research is to explain the small magnitude of these inequalities relative to those among middle-aged, e.g. with reference to mortality selection. Our paper showed that, also after 75th birthday, men and women with lower education have shorter life expectancies and spend a larger part of their remaining life with disability. The 'true' size of health inequalities might even be larger, if mortality selection effects would not have concealed some of it. But irrespective of how large this 'true' size, the evidence from this and other recent studies underline that inequalities in health at old age remain large. These results provide enough warranty to search for ways to reduce these inequalities, not by a mechanism such as mortality selection, but by dedicated policies.

7.6 References

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7.7 Appendix table

Table 8: Comparison of life expectancy estimates from the multi-state life table with life expectancy measure published in other sources

Measure	Number of years		
	From MSLT	Other source [a]	Difference
Life expectancy at 57th birthday in total population			
- men	22·0	21·5	0·5
- women	26·4	26·2	0·2
Life expectancy at 75th birthday in total population			
- men	9·2	9·1	0·1
- women	11·3	11·8	-0·5
Life expectancy at age 57: difference high-low education			
- men	2·6	3.4	-0.8
- women	1·8	2.6	-0.8

Note: [a] Life expectancy in total population: mortality data from Statistics Netherlands 1995. Processed by A. Kunst.

Educational differences in life expectancy at 50th birthday: estimates for 6 European countries, made by Kunst et al. Average of 6 values.

Part IV

The contribution of smoking to socioeconomic inequalities in health

8

Educational inequalities in smoking among men and women aged 16 years and older in eleven European countries

Huisman M, Kunst AE, Mackenbach J. Educational inequalities in smoking among men and women aged 16 years and older in eleven European countries. *Tobacco Control* (in press).

8.1 Summary

Introduction: To determine those groups who are at increased risk of smoking related diseases, we assessed in which male and female generations smoking was more prevalent among lower educated groups than among the higher educated, in eleven European countries.

Methods: We performed cross-sectional analysis of data on smoking, covering the year 1998, from a social survey designed for member states of the European Community. Data of four generations of higher versus lower educated men and women from eleven member states of the European Community were included. We estimated age-standardised prevalence rates and prevalence odds ratios of current and ever daily smoking.

Results: A north-south gradient in educational inequalities in current and ever daily smoking was observed for women older than age 24 years, showing larger inequalities in the northern countries. For men such a gradient was not observed. A disadvantage for the lower educated in terms of smoking generally occurred later among women than among men. Indications of inequalities in smoking in the age group 16-24 were observed for all countries, with the exception of women from Greece and Portugal.

Conclusions: Preventing and reducing smoking among lower educated subgroups should be priority of policies aiming to reduce inequalities in health in Europe. If no steps are taken to adequately control the tobacco use among the lower educated groups specifically, inequalities in lung cancer and other smoking related diseases should be anticipated in all populations of the European Union, and both sexes.

8.2 Introduction

Smoking and smoking related diseases are important causes of socioeconomic inequalities in health. Among men in Western Europe, lung cancer is found to be the second largest contributor to educational inequalities in mortality (ischemic heart disease is the largest).[1] Socioeconomic inequalities in smoking need to be closely monitored in order to predict future burdens of lung cancer and other smoking related diseases in relation to socioeconomic status.

Many authors refer to the description of the diffusion of innovations of Rogers,[2] to understand the diffusion of smoking in populations.[See e.g. 3-5] The lag in the adoption of smoking between higher and lower socioeconomic groups, and the lag in adoption between men and women, two well-established aspects of the diffusion of smoking in western countries,[3,6,7] are both in accordance with the description of Rogers.[3,7] These two aspects are both described in the trajectory of the diffusion of smoking that is referred to as 'the smoking epidemic'.[8]

The smoking epidemic is divided into four stages. In the first stage of the smoking epidemic, prevalence of smoking is low among men and women. In the second stage, the prevalence rises rapidly among men as smoking becomes more and more fashionable, reaching levels of 50-80%. The prevalence among women also rises, typically with a lag of about two decades later than among men. In the third stage the prevalence of smoking has peaked and starts declining among men. After a delay of a few decades it starts declining among women as well. In the fourth stage the prevalence of smoking continues to decline, slowly reaching a stable minimum prevalence level. Because the higher educated are the first to adopt innovations, this trajectory starts earlier among the higher educated than among the lower educated. This means that as the smoking epidemic evolves the lower educated men and women become disadvantaged in terms of smoking prevalence only in the later stages of the epidemic, after the decline of smoking among higher educated men and women has set in.

At present, many northern European countries have reached the fourth stage of the smoking epidemic, which is characterized by persisting or widening socioeconomic differences in smoking, even though overall prevalence of smoking is decreasing.[8] Socioeconomic inequalities in smoking in southern European countries are found to lag behind those of northern European countries, and southern European countries have mostly reached the third stage of the smoking epidemic.[3,5,6] It is of interest to monitor socioeconomic inequalities in smoking in the south of Europe as well because these inequalities may well be different in magnitude from those experienced before by the northern countries that reached this stage earlier. For instance, due to increased awareness of the health effects of smoking and increased policy attention to smoking in Europe, the prevalence of smoking may peak at lower rates among the lower socioeconomic groups in those countries that lag behind in the smoking epidemic. This argument similarly counts for comparing socioeconomic inequalities among women to those among men, because women mostly lag behind men in the smoking epidemic.

Several questions about current (and future) socioeconomic inequalities in smoking in European countries are therefore still open. How will inequalities in smoking evolve among men in countries that have reached the fourth stage of the smoking epidemic? Will inequalities in smoking in southern countries evolve in the same way as in northern countries? Will inequalities in smoking among women evolve in the same way as among men?

By determining socioeconomic inequalities in smoking among several generations of men and women at a given point in time, we can obtain a picture of how inequalities in smoking have evolved in recent years. The purpose of this study is to determine the association of socioeconomic status with smoking in several generations of men and women using cross-sectional data from eleven European countries at the end of the 1990's.

8.3 Data and Methods

We analysed data from the European Community Household Panel survey (ECHP), which is a social survey designed for the member states of the European Union. The survey used a uniform random sampling design, targeting the national household population of the countries included, and using common blueprint questionnaires. The data were collected by national statistical institutes or research centres. Data checks, weightings and imputations were done centrally by the Statistical Office of the European Communities (Eurostat). Eurostat prepared a user's database from the data of all countries, which included cleaned and encoded data and was ready to use for analyses. For more information about the design of the ECHP we refer to an extensive review of the design and procedures of the ECHP elsewhere.[9]

The data for the current study are from the fifth wave of the survey, of 1998, the first year that smoking data were collected. Countries that were a member state of the European Union in 1998, but did not yet include data on smoking during the fifth wave of the ECHP study were not included in this study. These countries were France, Luxembourg and The Netherlands.

Information on response rates is given in the first table. This table gives the household non-response percentages of the first wave of the survey and of the percentage of persons lost to follow-up until the fifth wave. There are large differences between countries in the response rates. The relatively high response rates in Greece and Italy are probably related to the fact that survey participation in these countries is compulsory. The low response rates in Germany reflect mostly a refusal of subjects to participate.[9] Non-response and attrition would present a problem in our study if they were related to educational level. Some analyses have been performed on attrition in the ECHP, which showed that attrition was only weakly related to educational level.[10] Surveys from Ireland, Italy, Greece, Spain, Austria and Portugal tended to lose disproportionately participants with a higher level of education, while the reverse occurred in surveys from Germany, Denmark, Belgium and the United Kingdom.

Table 1: Percentages of household non-response at first wave and attrition of interviewed persons until wave 5 (1998) of the ECHP

Country	Household Non-Response (first wave)*	Acquired number of interviewed persons	Attrition between 1994-1998**	Number of persons retained from the original sample
Finland	27%	8,173	10%	7,381
Denmark	38%	5,903	29%	4,187
Ireland	44%	9,904	36%	6,324
UK	28%	8,915	2%	8,764
Belgium	16%	6,710	20%	5,339
Germany	52%	12,233	5%	11,562
Austria	30%	7,437	26%	5,511
Italy	9%	17,729	10%	15,934
Spain	33%	17,893	23%	13,779
Portugal	11%	11,621	2%	11,412
Greece	10%	12,492	20%	9,985

Note: * Source: Eurostat 2000; household response[11]

**Source: Eurostat 2002; the attrition of interviewed persons[10]

Level of completed education was used as a measure of socio-economic status. Three education levels were formed based on the International Standard Classification of Education (ISCED)[12]: 1) lower secondary education or less; 2) upper secondary education; and 3) tertiary education, which is constituted by higher vocational and university education. The percentage of the population with the lowest level is given in the Table 2. It should be noted that the percentages of lower educated are relatively high at ages 16-24, because part of this group has not yet finished its education.

Subjects were asked whether they smoked daily, smoked occasionally, used to smoke daily, used to smoke occasionally, or never smoked. No distinction was made between smoking cigarettes, pipes and cigars. We distinguished between 'current daily' smokers and 'ever daily' smokers. While inequalities in current smoking express the current situation, inequalities in ever smoking reflects the situation of preceding years. A current smoker was defined as someone who reported smoking daily at the time of the survey. Subjects who reported to have used to smoke daily were defined as ever smokers. For Germany and the UK, only data on current smoking were available.

Table 2: Number of subjects for each country and sex (N) and the percentage of the population with a lower level of education (%)

Country	16-24		25-44		45-64		65+	
	N	%	N	%	N	%	N	%
MEN								
Finland	600	(38)	1313	(18)	1308	(41)	438	(61)
Denmark	242	(45)	842	(16)	641	(20)	310	(43)
Ireland	625	(34)	1092	(40)	902	(57)	510	(76)
UK	588	(32)	1667	(25)	1159	(34)	655	(54)
Belgium	307	(41)	1012	(21)	741	(33)	430	(54)
Germany	738	(64)	2413	(16)	1771	(19)	653	(15)
Austria	521	(61)	1166	(10)	936	(22)	516	(40)
Italy	1134	(48)	3063	(44)	2380	(65)	1199	(84)
Spain	1234	(47)	2454	(48)	1714	(73)	1238	(88)
Portugal	961	(74)	1851	(78)	1505	(90)	1108	(95)
Greece	698	(29)	1592	(37)	1473	(67)	994	(85)
WOMEN								
Finland	605	(37)	1320	(13)	1306	(41)	491	(68)
Denmark	276	(37)	848	(13)	665	(31)	363	(69)
Ireland	597	(26)	1108	(35)	935	(58)	555	(77)
UK	671	(29)	1856	(27)	1366	(45)	906	(69)
Belgium	330	(33)	1142	(21)	793	(43)	584	(65)
Germany	742	(57)	2512	(18)	1791	(32)	942	(49)
Austria	508	(62)	1189	(23)	1011	(43)	694	(70)
Italy	1154	(40)	3094	(40)	2377	(74)	1533	(92)
Spain	1164	(36)	2440	(47)	1862	(83)	1673	(94)
Portugal	935	(65)	1800	(71)	1783	(90)	1469	(98)
Greece	739	(25)	1670	(39)	1526	(79)	1293	(93)

Prevalence rates were age-standardized according to the direct method with the population of the European Union and Norway of 1995 as the standard.[13] Prevalence odds ratios were determined using logistic regression. Participants with upper secondary or tertiary education (groups 2+3) were combined and used as the reference category in these analyses. The regression analyses were adjusted for age by including a 5-year categorical age variable into the model. Analyses were stratified for gender. To test whether odds ratios significantly differed between countries we also performed pooled analyses combining all countries. In these analyses we used the χ^2 test to judge if the regression model including an interaction term of country by education was significantly different from the model without such an interaction term. All analyses were performed with the SPSS statistical package.[14] We distinguished four age groups: 16-24 years, 25-44 years, ages 45-64 years and ages 65+ years. Odds ratios for 'ever daily' smoking were only determined for the ages 25 years and over, because in the age group 16-24 years the number of ex-smokers was too small to determine educational inequalities with sufficient precision.

8.4 Results

Table 3 shows proportions of current smokers and ever smokers for men and women aged 25 years and older for eleven northern and southern European countries. North-south gradients were observed in the prevalence of 'current daily' smoking and 'ever daily' smoking among women of the ages 45-64 years and 65+ years. This gradient was not observed anymore for the ages 25-44 years. Spanish women aged 25-44 years smoked more compared to women from most other countries. Finland was an exception in all age groups, showing relatively low smoking prevalence rates compared to other northern countries. Among men, similar north-south gradients as among women were neither observed for 'current' nor for 'ever daily' smoking. Spain and Greece ranked among the countries with the highest 'current daily' smoking prevalences in all age groups.

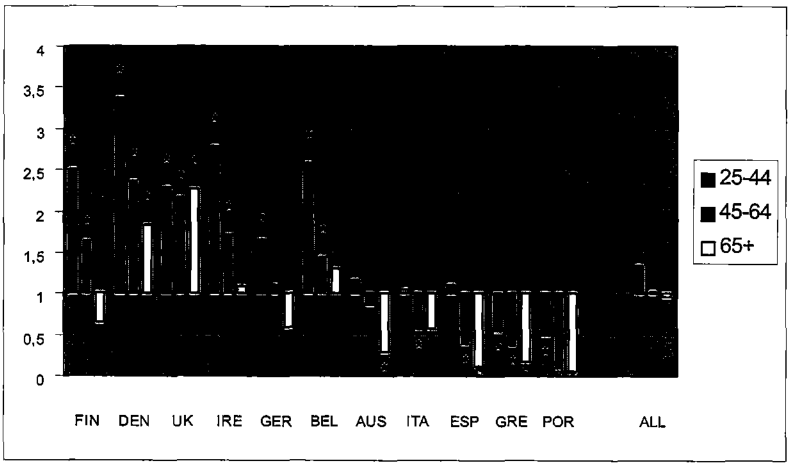
Figure 1 pictures the geographical pattern of educational inequalities in 'current daily' smoking for women of the ages 25 years and older. Odds ratios with values significantly higher than one imply a higher smoking prevalence in lower educational groups. A geographical pattern was observed with inequalities for all three age groups being larger in the northern countries than in the southern countries. Odds ratios larger than one were not observed in any of the age groups for Austria and the southern European countries. In contrast, inequalities were observed for Denmark, the UK and Belgium in all of the age groups, for Finland and Ireland in the age groups younger than age 65, and for Germany in the youngest adults only.

Table 3: Age-standardised proportions of 'current daily' smoking and 'ever daily' smoking for women and men, of all education levels

Country		WOMEN				MEN			
		25-44	45-64	65+	All 25+	25-44	45-64	65+	All 25+
Finland	Current	0.21	0.14	0.03	0.15	0.32	0.24	0.10	0.25
	Ever	0.36	0.26	0.10	0.27	0.49	0.53	0.57	0.53
Denmark	Current	0.39	0.36	0.26	0.36	0.37	0.43	0.32	0.39
	Ever	0.54	0.56	0.49	0.55	0.51	0.67	0.74	0.63
Ireland	Current	0.30	0.23	0.15	0.25	0.33	0.24	0.22	0.28
	Ever	0.40	0.36	0.29	0.37	0.45	0.47	0.57	0.49
U.K.	Current	0.30	0.26	0.15	0.26	0.32	0.26	0.14	0.26
Belgium	Current	0.26	0.22	0.08	0.21	0.36	0.32	0.20	0.32
	Ever	0.38	0.35	0.17	0.33	0.46	0.62	0.67	0.57
Germany	Current	0.30	0.18	0.07	0.21	0.45	0.33	0.13	0.34
Austria	Current	0.25	0.15	0.03	0.17	0.36	0.27	0.13	0.29
	Ever	0.32	0.22	0.07	0.24	0.46	0.48	0.43	0.47
Italy	Current	0.18	0.16	0.04	0.15	0.36	0.35	0.15	0.32
	Ever	0.22	0.18	0.06	0.18	0.42	0.50	0.41	0.45
Spain	Current	0.39	0.12	0.01	0.22	0.50	0.39	0.22	0.41
	Ever	0.49	0.17	0.03	0.28	0.62	0.62	0.59	0.63
Portugal	Current	0.12	0.03	0.00	0.07	0.42	0.29	0.13	0.32
	Ever	0.16	0.04	0.01	0.09	0.51	0.48	0.43	0.49
Greece	Current	0.27	0.13	0.02	0.17	0.59	0.48	0.21	0.48
	Ever	0.29	0.14	0.04	0.19	0.64	0.58	0.40	0.58
All Countries*	Current	0.28	0.20	0.10	0.22	0.38	0.33	0.19	0.33
	Ever	0.38	0.31	0.19	0.32	0.50	0.56	0.57	0.55

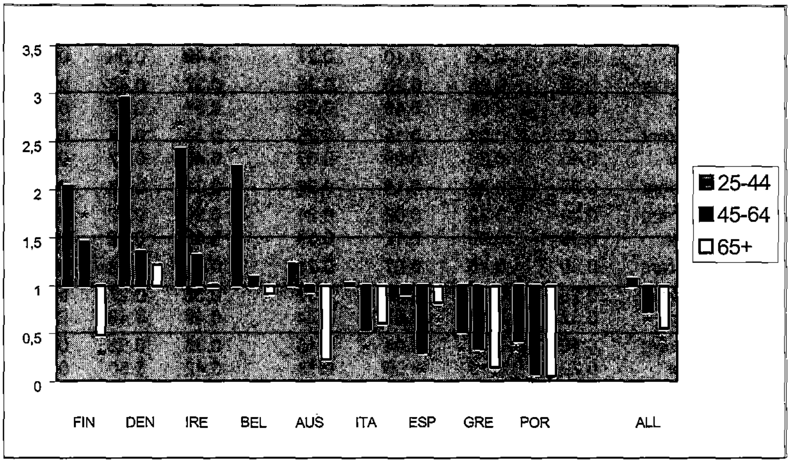
Note: All Countries 'Current' includes all countries; 'Ever'; UK and Germany are excluded; The prevalence estimates for all countries are adjusted for the size of the samples of individual countries.

Figure 1: Educational inequalities in 'current daily smoking', women aged 25 and older. Odds ratios comparing low to high education



Note: χ^2 test p-values for all ages < 0.01; * = the confidence interval does not include a value of 1.00.

Figure 2: Educational inequalities in 'ever daily smoking', women aged 25 and older. Odds ratios comparing low to high education

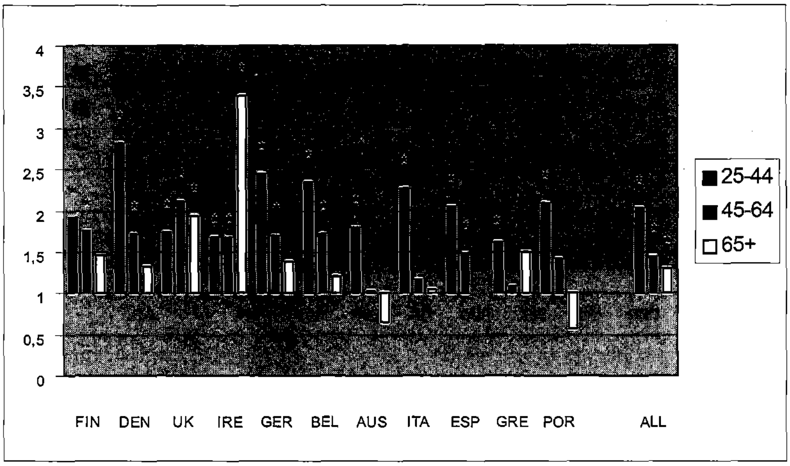


Note: χ^2 test p-values for all ages < 0.01; * = the confidence interval does not include a value of 1.00.

Figure 2 shows the geographical pattern of educational inequalities for 'ever daily' smoking for women aged 25 years and over. A north-south pattern of educational inequalities was also observed for 'ever daily' smoking. There were no odds ratios higher than one for women from Italy, Spain, Greece and Portugal. Instead, smoking was more common among the higher educated in these countries, especially in Greece and Portugal. The odds ratios for all ages in these countries had values significantly lower than one. In the northern countries, most odds ratios were larger than one. Inequalities were observed in Finland in the age groups younger than 65 years, and in Denmark, Ireland and Belgium among the youngest adults only.

The geographical pattern of inequalities in 'current daily' smoking for men is shown in Figure 3. Ireland and the UK showed inequalities in all generations. Finland, Denmark, Germany, Belgium and Spain showed inequalities among men aged 45-59 years and younger. The other countries only showed inequalities among young adults (ages 25-44 years). A p-value of 0.06 of the Chi-Square test for the young adults indicated that differences between countries in the association of smoking and education could not be determined with statistical significance (at the 95% level). North-south patterns in the magnitude of inequalities were not observed. However, among men older than age 44, significant inequalities were observed more often in northern European countries as compared to southern European countries.

Figure 3: Educational inequalities in 'current daily smoking', men aged 25 and older. Odds ratios comparing low to high education

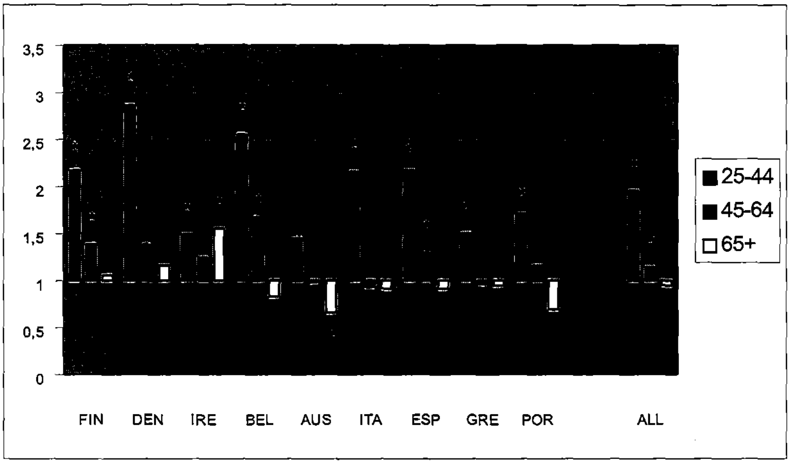


Note: χ^2 test p-values ages 25-44 = 0.06; ages 45-64 and ages 65+ < 0.01; * = the confidence interval does not include a value of 1.00.

The results for 'ever daily' smoking for men are shown in Figure 4. Inequalities in 'ever daily' smoking were observed in Ireland in all generations (although not significantly among ages 45-64 years), in Finland, Belgium and Spain in the age groups 45-64 years and younger, and in Denmark, Austria, Italy, Greece and Portugal in the age group 25-44 years. Negative associations of 'ever daily' smoking with education occurred earlier (i.e.: in older age groups) among men than among women.

For the age group 16-24 years the prevalence rates and odds ratios for 'current daily' smoking are given in Table 4. Prevalence of 'current daily' smoking among women was relatively high in the UK and Spain, followed by Denmark, Ireland, Germany and Belgium. The prevalence among women was relatively low in Portugal and Italy. Among men of this age group, the prevalence was highest in Austria and the UK, but differences between countries in the prevalence of 'current daily' smoking among men were not large.

Figure 4: Educational inequalities in 'ever daily smoking', men aged 25 and older. Odds ratios comparing low to high education



Note: χ^2 test p-values ages 25-44 and 45-64 = 0.01; ages 65+ = 0.15; * = the confidence interval does not include a value of 1.00

With regard to educational inequalities in 'current daily' smoking among women of 16-24 years, countries can be divided into three groups. In the first group, consisting of Finland and the UK, odds ratios were relatively large and statistically significant. In the second group, consisting of Denmark, Ireland, Germany, Belgium, Austria, Italy and Spain, the odds ratios also indicated a disadvantage for the lower educated in terms of smoking, but odds ratios were smaller and not statistically significant. In the third group, consisting of Greece and Portugal, the odds ratios were below one, indicating that the higher educated smoke more. Among men of this age group, the lower educated smoked more in all countries. These inequalities were relatively large and statistically significant in the UK, Belgium, and the southern European countries.

Table 4: Prevalence of 'current daily' smoking and educational inequalities in 'current daily' smoking; women and men aged 16-24

Country	WOMEN				MEN			
	Low	High	OR	95%-CI	Low	High	OR	95%-CI
Finland	0.30	0.16	1.87	1.09-3.22	0.37	0.28	1.32	0.84-2.07
Denmark	0.31	0.30	1.33	0.64-2.74	0.31	0.20	1.77	0.91-3.44
U.K.	0.41	0.27	1.91	1.29-2.82	0.48	0.30	2.16	1.45-3.22
Ireland	0.35	0.24	1.43	0.91-2.23	0.28	0.24	1.20	0.79-1.83
Germany	0.27	0.29	1.20	0.80-1.81	0.35	0.52	1.18	0.80-1.74
Belgium	0.29	0.22	1.41	0.74-2.67	0.48	0.20	3.05	1.65-5.63
Austria	0.25	0.20	1.49	0.87-2.54	0.40	0.60	1.06	0.67-1.68
Italy	0.12	0.09	1.39	0.92-2.12	0.34	0.21	2.35	1.76-3.15
Spain	0.32	0.27	1.26	0.95-1.67	0.40	0.25	2.32	1.77-3.04
Greece	0.13	0.17	0.76	0.46-1.26	0.39	0.29	1.72	1.15-2.58
Portugal	0.07	0.08	0.80	0.48-1.33	0.29	0.19	2.00	1.39-2.87
All Countries	0.27	0.23	1.36	1.19-1.55	0.37	0.32	1.85	1.65-2.08
Interaction country*education	p = 0.04				p = 0.01			

Note: OR=Odds Ratio; 95%-CI=95% Confidence Interval; the prevalence estimates for all countries are adjusted for the size of the samples of the individual countries

8.5 Discussion

This study focused on geographical variations in educational inequalities in the prevalence of 'current daily' smoking and 'ever daily' smoking. We identified countries and age groups where educational inequalities in smoking (more among lower groups) had emerged by 1998. We observed a north-south gradient among women older than 24 years, with higher smoking prevalences and stronger negative associations of education with smoking in the northern countries. For men we did not observe such a geographical pattern. A higher prevalence of smoking among the lower educated occurred later among women than among men (i.e. in younger age groups). This is as it would be expected based on the smoking epidemic model and the diffusion of innovations theory. A higher prevalence of smoking among the lower educated in the youngest age group (16-24 years) was found for all countries, with the exception of women from Greece and Portugal.

Some limitations of the study need to be discussed. One limitation is the use of self-reported data on smoking, which may result in underreporting of smoking, especially among the youngest ages. If underreporting of smoking is differential by educational status, the patterns that were found in this study may be biased. Some studies have investigated underreporting in relation to education in different countries and have shown inconsistent results.[15-17] A review study on self-reporting of smoking behaviour concluded that self-reports of smoking were quite accurate.[18] Still, we cannot exclude the possibility that underreporting did occur and that it was differential according to education. However, we do not think it to be likely that the geographical patterns, especially the north-south patterns, can be explained by underreporting only.

Non-response rates are high in some of the countries. There is no information on the association of baseline non-response with education in the ECHP. We cannot exclude the possibility that response bias has influenced our results. However, we would like to stress that our key results conform to a remarkable degree to the predicted trajectory of the smoking epidemic diffusion model, with inequalities in smoking occurring sooner among men and sooner in northern European countries. In addition, our results are to a large extent in agreement with the findings of studies using national survey data. Therefore, we do not think that selection bias can explain the geographical gradient that is observed in our study.

Another limitation relates to the use of level of education as an indicator of socioeconomic status. The distributions of level of education within the populations of some countries were rather skewed. For instance in Italy, Spain, Portugal and Greece a large proportion of the older, and especially female, populations had a low level of education. Furthermore, education is implicitly skewed towards lower levels in the youngest age group, since a large part of this group has not yet completed their highest level of education. Although these large groups of lower educated are homogeneous in terms of education, variations in terms of income or other socioeconomic indicators may exist within these groups. However, in a forthcoming study on the same data we already reported that income inequalities in smoking almost disappeared after adjustment for education, indicating that education is a stronger predictor of smoking in these countries than income is.[19]

The results of this study are comparable with the results of another international study that described differences between countries around 1990,[6] which were obtained from data of national surveys. Their study reported similar north-south gradients for middle-aged and older women as we did. However, their study also reported a weak gradient for older men, which we did not observe. In addition, their study reported a stronger association between high education and smoking for women from Spain and Portugal. These differences may be due to the ten-year difference between the data and may reflect changing inequalities in smoking during the 1990's, with less favourable trends among the lower educated. Both the former international study and our study show results that are remarkably conform to the smoking epidemic diffusion model and fit with what would be expected on the basis of it. This is the case for the apparent lag time in socioeconomic inequalities in smoking between northern and southern European countries, and also for the lag between women and men in these European countries. These results indicate that men and women in Europe pass through the same basic trends as the smoking epidemic evolves, and similarly experience socioeconomic inequalities in smoking.

Our results for Spain are in agreement with those of a national study which found that initiation of smoking was higher among higher educated than among lower educated men born in 1924-1942, but that this association was reversed among men born in 1944-1962.[20] We observed, for the year 1998, that education and smoking were positively related among men aged 65 years and older (born before 1933), but that they were inversely related among men aged 45-64 years of age (born 1934-1953). For Italy, higher smoking prevalence was observed among lower educated adult men (aged 25-74 years), and among higher educated adult women in the year 1994.[21] These findings are in agreement to our findings, although the broad age range used in the study in the Italian study does not allow for a more detailed comparison of specific generations. Compared to the results of a study on smoking in Portugal in 1999-2000 and variations in smoking by education, we observed similar patterns of smoking by education and sex; i.e. men had a higher prevalence of smoking than women, and among women the higher educated smoked more.[22]

We are among the first to report on socioeconomic inequalities in smoking in countries such as Austria, Belgium, and Greece. Data from these countries strengthened the finding of the north-south gradient in the magnitude of socioeconomic inequalities in smoking. The smoking epidemic was the least evolved in Portugal and Greece. These countries still showed higher smoking prevalence among the higher educated women as compared to the lower educated of all age groups. Austria showed a more southern European pattern, as the reversal of inequalities in this country occurred among men and women only among young adults. The results for Belgium were more alike those of northern European countries, such as Denmark and the UK, as the reversal of inequalities had occurred in all generations of Belgian females.

The inclusion of the age group 16-24 years was an important element of the study. We have discussed the results for these ages separately because we expect that the limitations mentioned above (the use of self-reported data, and education as an indicator of socio-economic status) especially apply to this age group. Nonetheless, some important patterns were observed. Among women in Italy and Spain, smoking was already more prevalent among lower educated women. The large inequalities in smoking among men aged 16-24 years from most countries should warn us that among men, a reduction in smoking inequalities might not be expected to occur automatically in the near future.

This study is the first to accurately show in which age groups the reversal of inequalities in smoking has occurred in several European countries. Our findings may be used to predict educational inequalities in lung cancer two to three decades after the end of the 1990's, and inequalities in COPD somewhat later than that. For instance, they imply a continuation of the educational inequalities in lung cancer that are observed among men in many European countries, and among women in the north,[23] and perhaps an emergence of inequalities in lung cancer among women in the south later.

Tobacco control policies should focus more on the lower educated groups specifically instead of only on national populations at large. Despite differences between countries and men and women in timing and magnitude of the smoking epidemic among different generations, men and women of most countries show the same basic trends as they pass through the smoking epidemic. Such a fact should stress the importance, and the opportunities, of international co-operation in reducing inequalities in smoking by designing appropriate tobacco control measures and learning from other countries' experiences with reducing inequalities in smoking.

There is yet a considerable potential to develop comprehensive strategies aimed at reducing tobacco consumption among lower socioeconomic groups. Even though this potential is not being seized as yet, many tobacco control measures may work to reduce overall smoking prevalence and at the same time achieve the largest reductions among lower socioeconomic groups.[24] This applies to price policies, but may also apply to other measures if they are targeted to lower socioeconomic groups and tailored towards their needs. For example, removal of financial barriers is a key element for the provision of smoking cessation services to poor people.[25] Similarly, a greater enforcement of supply-based measures such as age restrictions on tobacco purchase can have greater effects in poor neighbourhoods, where such restrictions are often enforced less strictly. In addition, geographic targeting may be useful, such as the provision of services or interventions in deprived neighbourhoods. Mass media and public education approaches may achieve greater effects among lower socioeconomic groups by tailoring their messages, materials and channels according to the needs of these groups.

Finally, marketing strategies of tobacco companies play a significant role in the diffusion of smoking.[26] For example, tobacco marketing is taking advantage of the changing roles of women in southern European countries by creating images that link smoking among women with emancipation.[27] If such marketing strategies are allowed to continue, they will have a large impact on the future prevalence of smoking in these populations, including that of the most disadvantaged. A total ban on tobacco advertisement and promotion may therefore be a necessary step to prevent socioeconomic inequalities in smoking, and smoking related disease.

8.6 Acknowledgements

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9

Inequalities in the prevalence of smoking in the European Union: comparing education and income

Huisman M, Kunst AE, Mackenbach JP. Inequalities in the prevalence of smoking in the European Union: comparing education and income. *Preventive Medicine* (in press).

9.1 Summary

Introduction: The aim of the study was to determine whether education or income was more strongly related to smoking in the European Union at large, and within the individual countries of the EU, at the end of the1990's.

Data and Methods: We related smoking prevalence to education and income level by analysing cross-sectional data on a total of 48,694 men and 52,618 women aged 16 and over from eleven countries of the European Union in 1998.

Results: Both education and income were related to smoking within the European Union at large. After adjustment of the other socioeconomic indicator, education remained related to smoking in the EU at large, but income only remained so among men. Educational inequalities were larger than income related inequalities among younger and middle aged men and women. Educational inequalities were larger than income related inequalities among men in all individual countries, and among women in Northern Europe. For women from Southern European countries, the magnitude of education and income related inequalities were similar.

Conclusions: Education is a strong predictor of smoking in Europe. Interventions should aim to prevent addiction to smoking among the lower educated, by price policies, school based programs, and smoking cessation support for young adults.

9.2 Introduction

Several studies have demonstrated that the prevalence of smoking in populations of developed countries is related to socioeconomic status.[1-6] Smoking is an important risk factor for some diseases and causes of death and it has been shown that a substantial part of socioeconomic inequalities in morbidity and mortality can be linked to smoking.[7-9] Studies that describe socioeconomic inequalities in smoking therefore contribute to an understanding of the determinants of smoking and, indirectly, to determinants of health inequalities. Furthermore they serve to identify the subgroups of the population who need most attention in policies aiming to reduce smoking.

In most research in European countries, socioeconomic inequalities in smoking have been described according to level of education. Smoking is often initiated during adolescence, a time in which school environment plays an important role in daily life. School performance[10,11] and peer pressure[12-14] are related to smoking initiation, and are likely to be related to lower educational level. However, after leaving school and moving into the workforce, other socioeconomic determinants, such as income, may have a stronger influence on smoking initiation and continuation. After completion of education, its stability in life thereafter fails to reflect changes in personal circumstances that may be relevant to the initiation and continuation of smoking behaviour. Income is an indicator that more accurately than education reflects an adult's current social position. Some researchers have indeed shown that income is also related to health behaviours, including smoking, after adjustment for education,[15-17] although it has also been reported otherwise.[18] Nevertheless, to our knowledge a direct comparison of educational and income inequalities in smoking has not been reported.

The effects of education and income on smoking can be expected to differ between countries, because the diffusion of smoking within the national population differs between European countries.[3,4] Toward the later stages of the diffusion of the smoking epidemic, when the overall prevalence of smoking is declining, smoking is more and more associated with lower socioeconomic status.[1,3,19] At these stages, smoking as a habit may perhaps be more related to material circumstances and deprivation. Smoking in Britain for instance is concentrated in the lower income groups,[20] and smoking serves to cope with the stress of living in disadvantaged circumstances.[21] In the earlier stages of the epidemic, as smoking is not as widespread in the population, smoking may be more strongly related to education, and smoking as a habit may signal innovation and emancipation among higher educated men and women. This means that results of studies on data from the US, or Northern European countries may not be generalised to express the situation in central and southern parts of Europe.

The aim of this study is to compare educational and income inequalities in smoking in the European Union, including countries from northern, central and southern parts of Europe, at the end of the 1990's. We compare these inequalities for the pooled population of eleven countries of the European Union, and for each of these countries separately. Our specific interest was in determining whether education or income was more strongly related to smoking, and to assess whether each has an independent effect.

9.3 Data and Methods

Data from the fifth wave (1998) of the European Community Household Survey (ECHP) were analysed. The ECHP is a social survey designed for the member states of the European Union, which uses a uniform random sampling design and common blueprint questionnaires for use in all the countries included. For all countries the target population of the survey is the national household population. Data are collected by national statistical institutes or research centres. Data checks, imputation and weighing are performed centrally by the Statistical Office of the European Community (Eurostat), to maximize the quality of the data before these are made available to researchers. In all countries a common design of the survey and questionnaires are used. The survey data collected in 1998 were used in the current study because this was the first year that questions on smoking were included in the ECHP survey. Countries for which information on smoking was not included during the fifth wave were omitted from the study. These countries were: France, Luxembourg and The Netherlands. Table 1 gives information on the sample sizes of the countries included in the study.

Table 1: Characteristics of the samples included in the study

Country	MEN						WOMEN					
	16-24		25-59		60+		16-24		25-59		60+	
	N	%	N	%	N	%	N	%	N	%	N	%
Finland	600	(38)	2374	(26)	685	(60)	605	(37)	2400	(24)	717	(64)
Denmark	242	(44)	1369	(16)	424	(40)	276	(37)	1387	(18)	489	(64)
Ireland	625	(34)	1801	(46)	703	(74)	597	(26)	1847	(43)	751	(74)
UK	588	(30)	2621	(27)	860	(51)	671	(29)	2972	(33)	1156	(65)
Belgium	307	(40)	1605	(25)	578	(51)	330	(32)	1768	(28)	751	(62)
Germany	738	(64)	3773	(16)	1064	(19)	742	(57)	3880	(22)	1365	(47)
Austria	521	(58)	1911	(13)	707	(39)	508	(58)	1982	(28)	912	(67)
Italy	1134	(48)	4883	(50)	1759	(83)	1154	(40)	4965	(52)	2039	(90)
Spain	1234	(47)	3761	(56)	1645	(87)	1164	(36)	3834	(59)	2141	(93)
Portugal	961	(74)	2974	(82)	1490	(96)	935	(65)	3124	(78)	1928	(97)
Greece	698	(29)	2699	(48)	1360	(83)	739	(25)	2790	(53)	1699	(92)

Note: N = Number of subjects per country and sex; % = Percentage of lower educated.

Table 2: Percentages of household non-response and attrition of interviewed persons until wave 5 (1998) of the ECHP

Country	Household Non-Response (first wave)*	Acquired number of interviewed persons	Attrition between 1994-1998**	Number of persons retained from the original sample
Finland	27%	8,173	10%	7,381
Denmark	38%	5,903	29%	4,187
Ireland	44%	9,904	36%	6,324
UK	28%	8,915	2%	8,764
Belgium	16%	6,710	20%	5,339
Germany	52%	12,233	5%	11,562
Austria	30%	7,437	26%	5,511
Italy	9%	17,729	10%	15,934
Spain	33%	17,893	23%	13,779
Portugal	11%	11,621	2%	11,412
Greece	10%	12,492	20%	9,985

Note: * Source: Eurostat 2000; household response.

**Source: Eurostat 2002; the attrition of interviewed persons.

Basic information on response rates and attrition is given in Table 2. This table gives the household response percentages of the first wave of the survey and of the percentage of persons lost to follow-up until the fifth wave. There are large differences between countries in the response rates at the start of the survey (wave 1). Some of those countries with the lower response rates also had higher attrition over the subsequent follow-up periods. Specifically the samples of Denmark, Ireland and Spain suffered high attrition percentages. Analyses have been performed on attrition in the ECHP, which showed that attrition was only weakly related to educational level.[22] Differences between countries were observed in the association of attrition with educational level. Ireland, Italy, Greece, Spain, Austria and Portugal tended to lose disproportionately participants with a higher level of education, while Germany, Denmark, Belgium and the United Kingdom tended to lose more participants with lower education during follow-up. These issues are also commented upon in the discussion section.

We used two indicators of socioeconomic status: level of education and net household income. Subjects were divided into three groups according to their level of educational attainment based on the International Standard Classification of Education (ISCED)[23]: 1) lower secondary education or lower; 2) upper secondary education; and 3) tertiary education, which is constituted by vocational and university education.

Net household income includes all income sources of every person in the household and any income that is received by the household as a whole. The total net household income is calculated from a detailed set of income data, which includes data from self-employment, wage and salary earnings, but also income that is non-work related, such as old age benefits, income from capital, unemployment benefits, and education related allowances. We corrected the total net household income for the number of persons in the household by dividing it by the square root of the number of persons in the household. Subsequently, quintile groups were identified according to income, each representing 20% of the age specific income range. The lowest quintile represented those with the lowest incomes.

Subjects were asked whether they smoked daily, smoked occasionally, used to smoke daily, used to smoke occasionally, or never smoked. In this study we defined those who indicated that they smoked daily at the time of the survey as being a smoker. No distinction was made between smoking cigarettes, pipe and cigars in the current study.

Analyses were first performed on the data of all the countries combined. We distinguished between 10-year age groups (16 to 24 years, 25 to 34 years, 35 to 44 years..., and 75 years and over). Secondly analyses were performed for the individual countries. We only determined the inequalities for the ages 25-59 years for the separate countries, because these are the ages at which smoking has most often become a habit, and where the most health damage is accumulated.

Smoking prevalence rates were determined for all socioeconomic groups. These rates were age standardized according to the direct method, using the pooled population of the European Union (and Norway) of 1995 as the standard.[24] We also determined relative inequalities in smoking with logistic regression analyses, controlled for age by including a nominal variable representing 5-year age group. These relative inequalities were expressed as odds ratios, which represented the odds of being a smoker in the lowest socioeconomic groups (educational level 1, or the lowest two income quintiles) as compared to the highest socioeconomic groups (educational levels 2 and 3, or the highest two income quintiles).

Another measure of relative inequalities that we used was the relative index of inequality (RII).[25] It was important to include this measure in our analyses because by comparing inequalities related to different socioeconomic indicators the difference in the distribution of both indicators over the population should be taken into account, which is what the RII does. The RII uses the slope of a ranking variable of socioeconomic status. This rank variable specifies for each socioeconomic group the mean proportion of the population that has a higher socioeconomic position. As such, the rank of the lowest educational group for instance is the proportion of the population with a middle and high level of education and half of the population with a lowest level of education. The difference with the regular odds ratios is that the outcome does not specify inequalities between specific socioeconomic groups (such as the lower educated as compared to the combined middle and higher educated groups), rather it expresses inequality within the whole socioeconomic continuum. The corresponding outcome measure is a relative risk measure that is interpreted as the odds of being a smoker at the very lowest end of the socioeconomic hierarchy as compared to the very highest end of the socioeconomic hierarchy. These outcome measures can be compared between age groups, between countries and between different indicators of socioeconomic status.

The odds ratios and RIIs were determined first for education and income separately, not adjusted for the other socioeconomic indicator, so that they showed the gross relationships of these indicators with smoking. These measures served to describe socioeconomic inequalities in smoking, and to identify those groups that are most disadvantaged in terms of smoking. In additional analyses we also determined RIIs that were adjusted for the other indicator of socioeconomic status. These measures specified the net effects of education and income on smoking, independent of its association with the other indicator.

9.4 Results

Smoking prevalence rates and relative inequalities according to education are given in Table 3. An inverse educational gradient was found among men of all ages combined, with the prevalence of smoking being higher among the lower educated compared to the higher educated (OR=1.73; CI=1.66-1.81). Relative inequalities in smoking could be demonstrated with statistical significance for all age groups, with the ages 75+ years as the only exception. The educational inequalities were largest in the age groups 16-24, 25-34 and 35-44 years. A weak educational gradient in smoking was also observed for women of all ages (OR=1.20; CI=1.14-1.26). Educational inequalities in smoking were observed for women up to age 44 years. However, among women aged 45-74 years no inequalities were demonstrated, while smoking was most prevalent among the highest educated women of the ages 75+ years.

Table 3: Smoking prevalence and inequalities in smoking by education level

	Age-group	Smoking prevalence (in percentages)				Summary Measures	
		Highest Education	Middle Education	Lowest Education	Total Prevalence	Odds Ratio (95%-CI)	RII (95%-CI)
MEN							
	16-24	24	34	37	30	1.73 1.55-1.92	3.62 2.89-4.53
	25-34	24	39	54	39	2.32 2.10-2.56	5.87 4.92-6.99
	35-44	25	39	48	37	1.78 1.61-1.96	3.73 3.13-4.45
	45-54	27	36	44	36	1.48 1.33-1.64	2.57 2.11-3.13
	55-64	23	30	33	29	1.40 1.23-1.59	2.13 1.67-2.71
	65-74	13	22	24	22	1.37 1.15-1.64	2.05 1.47-2.87
	75+	12	15	16	15	1.05 0.77-1.43	1.15 0.64-2.07
	All ages	22	33	40	32	1.73 1.66-1.81	3.33 3.06-3.62
WOMEN							
	16-24	22	22	27	22	1.36 1.19-1.55	1.95 1.51-2.51
	25-34	20	29	42	27	1.56 1.40-1.73	2.59 2.15-3.12
	35-44	22	31	37	29	1.17 1.06-1.30	1.80 1.50-2.16
	45-54	21	25	29	24	1.01 0.90-1.14	1.19 0.96-1.48
	55-64	15	16	19	16	1.00 0.84-1.19	1.02 0.73-1.42
	65-74	12	11	13	12	1.06 0.83-1.35	0.99 0.62-1.59
	75+	16	7	7	7	0.71 0.48-1.06	0.51 0.24-1.11
	All ages	19	22	28	22	1.20 1.14-1.26	1.72 1.56-1.89

Note: the OR and RII are unadjusted for income.

The results for income are given in Table 4. Among men a clear inverse income gradient was found for all ages combined, in which each lower income quintile had a higher smoking prevalence ((OR=1.35; CI=1.29-1.41) comparing the lowest two income quintiles with the highest two quintiles). This gradient was observed for all separate age groups between age 16 and 64 years. Although the results for all ages combined showed an income gradient for women (OR=1.08; CI=1.03-1.14), this gradient was weak and it could only be demonstrated with statistical significance in the age group 25-34 years.

Table 4: Smoking prevalence and inequalities in smoking by income level

	Age-group	Smoking prevalence (in percentages)						Summary Measures	
		Highest quintile	4th	3rd	2nd	Lowest quintile	Total Prevalence	Odds Ratio (95%-CI)	RII (95%-CI)
MEN									
	16-24	28	30	31	30	35	30	1.03 0.92-1.15	1.11 0.93-1.32
	25-34	34	35	37	41	48	39	1.56 1.42-1.71	2.16 1.86-2.51
	35-44	31	36	37	41	44	37	1.51 1.37-1.66	1.99 1.71-2.31
	45-54	30	33	36	39	44	36	1.33 1.20-1.48	1.66 1.41-1.96
	55-64	24	26	28	34	38	29	1.51 1.33-1.70	1.96 1.62-2.38
	65-74	18	20	23	22	27	22	1.14 0.98-1.32	1.33 1.05-1.68
	75+	11	16	19	16	15	15	1.07 0.83-1.39	1.20 0.80-1.80
	All ages	27	30	32	34	39	32	1.35 1.29-1.41	1.70 1.59-1.82
WOMEN									
	16-24	22	22	20	21	26	22	1.03 0.91-1.17	1.06 0.86-1.29
	25-34	23	24	28	28	33	27	1.30 1.17-1.45	1.53 1.29-1.81
	35-44	28	25	27	30	32	29	1.01 0.91-1.12	1.01 0.86-1.19
	45-54	24	22	22	24	28	24	1.01 0.90-1.14	1.02 0.84-1.24
	55-64	9	15	18	19	18	16	1.13 0.94-1.35	1.21 0.91-1.60
	65-74	9	13	14	11	12	12	0.90 0.71-1.14	1.00 0.69-1.45
	75+	7	4	8	6	7	7	0.96 0.66-1.40	0.93 0.52-1.68
	All ages	19	20	21	22	25	22	1.08 1.03-1.14	1.14 1.05-1.24

Note: the OR and RII are unadjusted for education.

In order to compare the educational and income inequalities for Europe at large, the RIIs for education and income are given per age group in Figures 1 and 2. The RIIs of education in these figures were adjusted for income, and those of income were adjusted for education. These measures can be directly compared between education and income. Figure 1 presents the RIIs for men. The independent effect of education on smoking in the age groups up to 54 years was larger than the independent effect of income. Although the association was much smaller than that of education, income still remained related to smoking up to the ages 64 years. Among women we found similar results, however these were somewhat less pronounced (Figure 2). Inequalities in smoking among women were also larger according to education than according to income in the 16 to 44 years age groups. In the oldest age group among women the effect of education was also stronger than that of income, however in this age group the effect was in the opposite direction. The effect of income on smoking was not statistically significant in any of the age groups among women.

Figure 1: Education and income inequalities in smoking among men of the EU

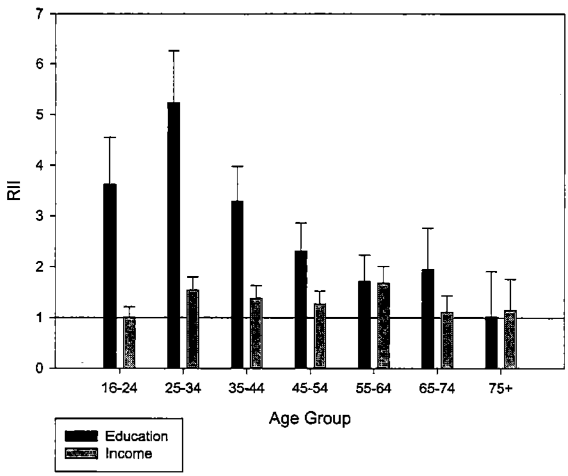


Figure 2: Education and income inequalities in smoking among women in the EU

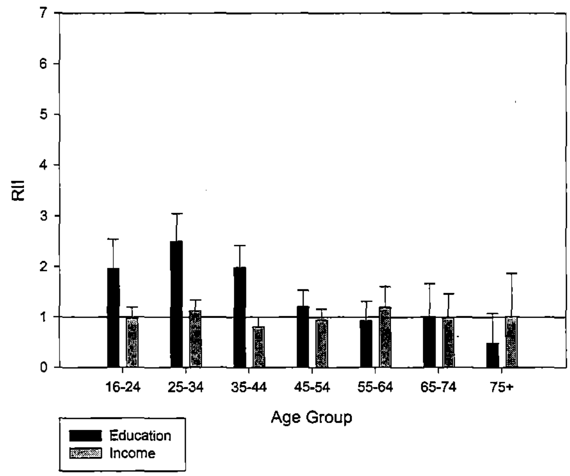


Table 5 shows the results of the country-specific analyses. In this table the results are presented for middle-aged adults only, i.e. ages 25-59 years. These results are the unadjusted effects of education and income. Among men in this age group we found inequalities in smoking in all countries according to both indicators of socioeconomic status, except for Austria for which inequalities in smoking were found in relation to education, but not income. Among women we found substantial educational and income inequalities in the northern European countries, including Finland, Denmark, Ireland, the UK, Belgium, and to lesser extent also in Germany. In the southern European countries inequalities in smoking were reversed according to both of the socioeconomic indicators (all OR's < 1.00).

Table 5: Educational and income inequalities in smoking in European countries, ages 25-59

Country	MEN			WOMEN		
	Total Prevalence	Odds Ratio Education	Odds Ratio Income	Total Prevalence	Odds Ratio Education	Odds Ratio Income
Finland	30	1.82 1.49-2.36	1.72 1.40-2.12	19	2.05 1.60-2.61	1.51 1.19-1.92
Denmark	40	2.48 1.85-3.33	1.50 1.17-1.94	38	2.92 2.18-3.90	1.18 0.92-1.51
Ireland	30	1.75 1.42-2.16	1.89 1.49-2.39	28	2.39 1.92-2.98	2.24 1.75-2.85
UK	30	1.89 1.57-2.27	1.75 1.44-2.11	29	2.30 1.93-2.72	1.86 1.55-2.23
Belgium	36	2.23 1.76-2.83	2.02 1.60-2.56	26	2.15 1.69-2.72	1.96 1.53-2.50
Germany	42	2.07 1.74-2.47	1.70 1.47-1.98	26	1.45 1.22-1.73	1.21 1.02-1.42
Austria	34	1.34 1.01-1.78	1.06 0.85-1.32	22	1.05 0.82-1.35	1.59 1.23-2.05
Italy	36	1.82 1.61-2.05	1.34 1.17-1.53	18	0.85 0.73-1.00	0.66 0.56-0.78
Spain	47	1.88 1.64-2.16	1.53 1.32-1.77	30	0.92 0.79-1.07	0.83 0.71-0.98
Portugal	38	1.90 1.54-2.33	1.33 1.13-1.58	9	0.37 0.28-0.49	0.51 0.38-0.68
Greece	57	1.40 1.19-1.64	1.30 1.10-1.55	23	0.49 0.40-0.60	0.59 0.48-0.73
All Countries	37	1.80 1.71-1.90	1.50 1.42-1.58	26	1.21 1.14-1.29	1.09 1.02-1.15

Note: The Odds Ratios of education and income are unadjusted for the other socioeconomic indicator.

Prevalences are given in percentages.

Figures 3 and 4 show the RIIs of education and of income for each country, also for the ages 25-59 years. These RIIs were adjusted for the other indicator. Figure 3 shows the RIIs for men. This figure demonstrates that in all countries the independent effect of education on smoking was larger than the effect of income, although in Finland, Ireland, the UK, Belgium, Germany and Spain the effect of income remained statistically significant (that of education was significant in all countries). The Figure for women shows a different result. For the Northern European countries the effects of education were again larger than those of income. In the Southern European countries the net effects of education and income did not differ much in magnitude, but they differed in the direction of inequalities in Italy and Spain, where education showed RIIs slightly above one whereas income showed RIIs below one. In Portugal and Greece the women with a higher socioeconomic position (either educational or income related) smoked more.

Figure 3: Education and income inequalities in smoking among men

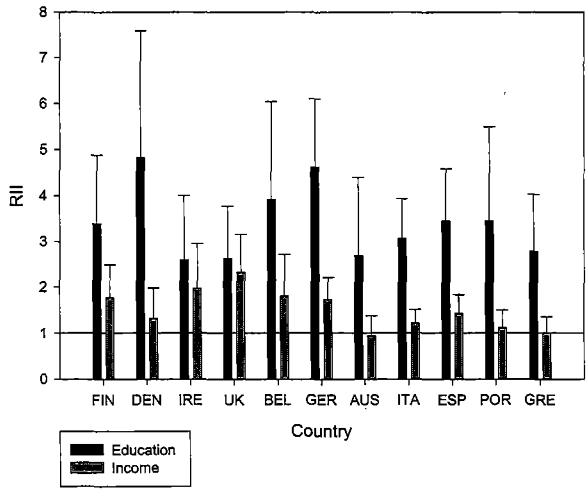
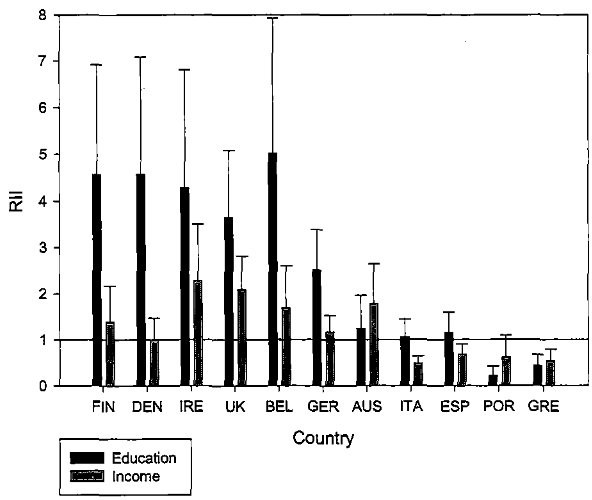


Figure 4: Education and income inequalities in smoking among women



9.5 Discussion

Both education and income were related to smoking in the European Union. Both remained related to smoking after adjustment for the other socioeconomic indicator. Education remained related both among men and among women of the EU at large, whereas income only remained related to smoking among men. The independent effect of education was larger as compared to income, among men up to the ages 54 years, and among women up to the ages 44 years. Inequalities in smoking related to education were generally larger as compared to income inequalities among men of all countries, and among women of Northern Europe. Among Southern European women educational and income-related inequalities in smoking did not differ much in magnitude, but differed in direction in Italy and Spain. In Portugal and Greece the higher educated women and those with a higher income smoked more.

Some remarks about data limitations must be made. First of all, these data are based on self-report. Self-reported smoking has been found to be accurate in case of interviewer administered questionnaires.[26] Nevertheless, bias may have occurred if underreporting of smoking occurred differentially according to socioeconomic status. However studies that investigated underreporting in relation to socioeconomic status either show no effect of social position, or small effects only.[27,28] Differential underreporting and subsequent bias in the inequality measures therefore cannot be ruled out, but are not likely to be very large. Underreporting would have to be large, and would have to be related much more to income than to education if it were to explain the more pronounced relationship of education with smoking as compared to income. We do not expect this to be the case.

Household response rates were low for some countries such as Germany, for which a response of 48 percent was observed (Table 2). Furthermore, attrition of interviewed persons between the first and the fifth wave was relatively high for Ireland, for which household non-response in the first wave was large to begin with, and for Denmark. Another study in which response was rather low (56%), showed that the association of smoking status and socioeconomic status was similar among respondents as compared to the target population,[29] which indicates that high non-response or attrition do not necessarily lead to biased results in studies on socioeconomic inequalities in smoking. Analyses on the issue of attrition in the ECHP showed that attrition was only weakly related to educational level.[22] But although the association was weak, differences between countries were observed in the direction of the association. Ireland, Italy, Greece, Spain, Austria and Portugal tended to lose disproportionately participants with a higher level of education, while Germany, Denmark, Belgium and the United Kingdom tended to lose more participants with lower education during follow-up. This means that educational inequalities in the former group of countries may be somewhat overestimated, while those in the latter group may be underestimated. We think that these effects will not have been large enough to seriously bias our results however, because the association of education with smoking was larger in all countries, also those for which educational inequalities may be underestimated. Furthermore, just as with the issue of non-response, we think it unlikely that attrition is differentially related to education and income to have artificially determined the striking patterns observed in this study.

With regard to adolescents, both education and household income may have limitations in representing social status especially in relation to smoking. Many younger men and women have not yet finished school and may therefore still move socially upward. These future higher educated might smoke less and therefore their inclusion may underestimate the prevalence of smoking of men and women with a low completed educational level. Furthermore, many younger men and women still live with their parents and are thus assigned to the income quintile based on their parents' income. Theoretically their mobility in terms of income may go either way, upward compared to their parent's income level, or downward. Based on this reasoning we expect that the educational inequalities in the younger age groups are most likely to be underestimated, whereas income inequalities may be either under- or overestimated.

Because among older men and women a large proportion has low education only, the measure of educational status loses discriminatory power at older ages. For education we compared 60-90% of the older population (the lower educated) with 40-10% (the higher educated; Table 1). The large group of lower educated is a very heterogeneous group in terms of adult socioeconomic position (income, occupation). Our failure to discriminate within this group may partly explain why no educational inequalities in smoking among the older ages were found.

The association of education with smoking has been reported before in other studies on western societies.[1-4,17,18,21] A new finding of this study is that education showed a stronger relationship with smoking than income did in most countries within the European Union. A study from the United States reported that income inequalities in smoking did not remain after adjusting for education.[18] Other studies from Finland,[17] Canada[15] and the United States[16] found that the independent effects of income were rather small. We observed that the independent effect of income on smoking was rather small among all generations of adult men in the European Union. Among women in the European Union the effect of income remained in none of the generations after adjusting for education.

Our results raise the question why education is more strongly related to smoking than income is. Several explanations may be forwarded for this finding. Education may provide the cultural, intellectual and psychosocial resources necessary to cope with adverse personal circumstances in a more healthy way than through smoking.[21] In addition, since peer pressure and school performance are predictors of smoking initiation among those of school-age,[10-14] educational level may also be an indicator of the social circumstances during the phase of life that is in many ways decisive for one's future smoking status, i.e. adolescence. Finally, childhood living conditions is found to be a determinant of smoking,[29,30] and education may reflect these conditions more accurately than household income does.

The age patterns of inequalities that we observed are in agreement with the smoking epidemic diffusion model. In the first generations that pick up smoking the higher educated smoke more. This may explain why inequalities in smoking among older generations of women were reversed. These reversed inequalities were not observed for men, as should be expected given that the diffusion among men occurs earlier than it does among women.[3,4,19] In later generations the prevalence of smoking among the lower educated exceeds that of the higher educated. Therefore we would expect that smoking inequalities are larger among the younger generations, which is in agreement with our findings.

The geographical pattern that we observed suggests that the Southern European countries lag behind the Northern European countries in the diffusion of smoking. This has also been found by other studies.[3,4] The picture observed for women from Italy and Spain indicate that these are the generations in which prevalence of smoking is shifting from higher toward lower groups in the educational hierarchy, but not yet along the income hierarchy. The higher educated seem to be the forerunners in the diffusion in these countries also. Income inequalities can be expected to follow those of education somewhat later, because much of the income-related smoking inequalities in our study were explained by education. Among women from Portugal and Greece those with a higher education and income smoked more, indicating that a disadvantage of the lower socioeconomic groups may still be prevented among women in these countries.

The results of this study may provide important clues about how socioeconomic inequalities in health arise in populations. The finding that socioeconomic inequalities in health are not smaller in countries with an egalitarian social system than in other countries with a system that is more socially stratified has always been regarded as surprising. Our results show that for one of the most important predictors of health, i.e. smoking, education is a stronger predictor of prevalence than income is. Denmark, Belgium and Germany for instance show some of the smallest gini coefficients in the ECHP data (in 1995),[31] but educational inequalities in smoking in these countries were rather large. The UK and Ireland, as well as the Southern European countries showed larger gini coefficients, whereas educational inequalities were not larger in these countries as compared to those with more equal income distribution. Therefore in some ways, populations with a more egalitarian character additionally in terms of education, and not only in terms of income distribution, may be more successful in reducing inequalities in health than those that are egalitarian only in terms of income redistribution.

Our results suggest that reducing and preventing inequalities in smoking should be of high priority in all countries included in this study, because inequalities in smoking in these countries are large, especially in younger generations. Attention should not only be paid to the poor, but also to the lower educated groups in the population, as these are the groups who are at highest risk of being a smoker. This requires comprehensive policies aimed at adolescents, for whom smoking may not yet have become an irreversible habit, and specifically those of lower educational levels. Such policies may include expanding school-based interventions. In a review of policies aimed at reducing inequalities in smoking Platt et al. (2002) concluded that price policies can be effective in reducing socioeconomic inequalities in smoking.[32] Such policies may be effective especially among adolescents who are often without much financial resources. However such pricing policies need to be backed up by smoking cessation support for those who have a nicotine addiction. These tobacco control policies need to be backed up by broader policies aimed at improving living conditions and resources of disadvantaged families. International collaboration in devising, testing and implementing such strategies should be a priority.

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10

Educational inequalities in lung cancer mortality and the contribution of smoking to inequalities in motality

Mackenbach JP, Huisman M, Andersen O, Bopp M, Borgan J-K, Borrell C, Costa G, Deboosere P, Donkin A, Gadeyne S, Minder C, Regidor E, Spadea T, Valkonen T, Kunst A. Inequalities in lung cancer mortality by the educational level in 10 European countries. *Eur J Cancer* 2004; 40: 126-135.

10.1 Summary

Introduction: Previous studies have shown that, due to differences in the progression of the smoking epidemic, European countries differ in the direction and size of socioeconomic variations in smoking prevalence. We studied differences in the direction and size of inequalities in lung cancer mortality by educational level in 10 European populations during the 1990's.

Data and methods: We obtained longitudinal mortality data by cause of death, age, sex and educational level for 4 northern European populations (England/Wales, Norway, Denmark, Finland), 3 continental European populations (Belgium, Switzerland, Austria), and 3 southern European populations (Barcelona, Madrid, Turin). Age- and sex-specific mortality rates by educational level were calculated, as well as the age- and sex-specific mortality rate ratios.

Results: Patterns of educational inequalities in lung cancer mortality suggest that England/Wales, Norway, Denmark, Finland and Belgium are farthest advanced in the progression of the smoking epidemic: these populations have consistently higher lung cancer mortality rates among the lower educated in all age-groups including the oldest ones in men, and in all age-groups until the age-group of 60-69 years in women. Madrid appears to be less far advanced, with lower educated men in the oldest age-group and lower educated women in all age-groups still benefiting from lower lung cancer mortality rates. Switzerland, Austria, Turin and Barcelona occupy intermediate positions. The lung cancer mortality data suggest that inequalities in smoking contribute substantially to the explanation of educational differences in total mortality among men in all populations except Madrid. Among women, contributions are probably substantial in the northern European countries and in Belgium, small in Switzerland, Austria, Turin and Barcelona, and negative in Madrid.

Conclusions: In many European countries, policies and interventions that reduce smoking in lower educational groups should be one of the main priorities of strategies to tackle socioeconomic inequalities in mortality. In some countries, particularly in southern Europe, it may still not be too late to prevent women in lower educational groups to take up the smoking habit, and thereby to avoid larger inequalities in mortality in the future.

10.2 Introduction

The habit of smoking usually spreads through populations like an epidemic with four stages. In stage 1, smoking is an exceptional behaviour and mainly a habit of men and people in higher socioeconomic groups. In stage 2, smoking becomes ever more common. Rates among men peak at 50%-80% and are equal among socioeconomic groups or higher among higher socioeconomic groups. In women these patterns usually lag 10-20 years behind those of men. Smoking is first adopted by women from higher socioeconomic groups. In stage 3, prevalence rates among men decrease to about 40% since many men stop smoking, especially those who are better off. Women reach their peak rate (35%-45%) during this stage, and at the end of this stage their rates start to decline too. In stage 4, prevalence rates keep declining slowly for both men and women, and smoking becomes progressively more a habit of the lower socioeconomic groups. As a result, during the smoking epidemic there is a reversal from a positive to a negative association between socioeconomic status and smoking.[1]

Different countries are in different stages of the smoking epidemic, as shown by international-comparative studies of smoking prevalence rates by age, sex and socioeconomic status.[2,3] A previous study which we conducted, and which used data from surveys held around 1990 in 12 Western European countries, found positive associations between education and smoking (implying higher smoking prevalence in higher educational groups) among men and women of all ages in Portugal, among younger and older women in Spain, and among older women in Italy and France. This suggested that countries in southern Europe were still in stage 2 (Portugal) or at the beginning of stage 3 (Spain, Italy, France) of the smoking epidemic. On the other hand, we found negative associations between education and smoking among men and women of all ages in Great Britain, Norway, Sweden and the Netherlands. In West Germany, negative associations were only found for men and younger women, while in Finland negative associations were limited to men. This suggested that countries in northern Europe already were in stage 4 (Great Britain, Norway, Sweden, the Netherlands) or at the end of stage 3 (West Germany, Finland).[4]

We now report on a study of socioeconomic inequalities in lung cancer mortality in 10 European countries during the 1990's. Socioeconomic variations in lung cancer incidence and mortality have been reported from a number of European countries, including Italy,[5] the Netherlands,[6,7] Spain,[8,9] Sweden,[10] Switzerland,[11,12] and the United Kingdom.[13,14] A systematic analysis of variations between countries in the size and pattern of socioeconomic inequalities in lung cancer mortality has, however, not yet been performed. Such a systematic analysis may shed further light on, first, the progression of the smoking epidemic and, second, the role of smoking in the explanation of socioeconomic inequalities in total mortality.

Lung cancer mortality rates reflect the exposure of populations to smoking over previous decades, and in a sense summarize that exposure and form a useful complement to survey data, which are not as widely available for comparisons between countries. We will therefore use the socioeconomic patterning of lung cancer mortality to make inferences about the stage of the smoking epidemic that countries find themselves in. We will also use the lung cancer mortality rates by socioeconomic group to obtain an indication of differences in the role of smoking in generating socioeconomic inequalities in total mortality in different populations. Smoking accounts for a considerable proportion of premature deaths in developed countries, partly through its effect on lung cancer (for which etiologic fractions are in the order of 90% or more), partly through its effect on other causes of death (for which etiologic fractions are mostly smaller, but absolute numbers of smoking induced deaths may be larger).[15] Previous studies have indicated that smoking accounts for a considerable part of the excess mortality in lower socioeconomic groups, at least in some countries.[16,17,18] It is likely, however, that the role of smoking differs between countries that are in a different stage of the smoking epidemic. As Peto and colleagues have shown, one can use lung cancer rates in national populations to indirectly estimate the contribution of smoking to premature mortality in these populations,[19,20] and similarly lung cancer rates in different socioeconomic groups can be used to indicate the contribution of smoking to socioeconomic variations in total mortality.

Thus, the aims of the study reported in this paper were: (1) to describe socioeconomic inequalities in lung cancer mortality in different European populations; (2) to make inferences about the staging of the smoking epidemic in different European populations; (3) to make inferences about the contribution of smoking to socioeconomic inequalities in total mortality in different European populations.

10.3 Data and methods

10.3.1 Data

Table 1 presents a summary description of the data used in this study. We obtained data from seven national, one regional (Madrid) and two city-wide (Turin and Barcelona) registrations of mortality, all collected according to a longitudinal design in which persons enumerated during a census in the (early) 1990's were followed-up for various periods of time. Most studies covered the entire national, regional or local population, but the data for England/Wales come from a representative 1% sample of the national population (i.e. the Longitudinal Study of the Office of National Statistics) while the data for Switzerland cover the German-speaking parts only (about 70% of the total). For each population, the data-base used for this analysis includes data on numbers of deaths and person-years at risk by sex, five-year age-group (age specified at start of follow-up, and ranging from age 40 to age 90), and level of education.

Level of education was initially coded according to national classification schemes. Using guidelines from the International Standard Classification of Education[21] and the observed population distributions across national educational categories, we reclassified national levels of education into a common two-class scheme that leads to roughly similar population distributions across educational categories. For example, for England/Wales the distinction is between less-than-A-level ("lower" education) and A-level ("higher" education). It is important to note that the "absolute" level of education in each of these categories (as measured, for example, in years of education) is not the same across countries, and that direct comparisons between countries of the levels of mortality in e.g. the lower educational groups are not advisable. This does not present a problem for the analyses reported in this paper, however, because the emphasis here is on international variation in differences in lung cancer mortality across the educational hierarchy. In the analysis, educational differences in lung cancer mortality are summarized by comparing mortality among those with a "lower" level of education (generally attained by between 60 and 80% of the male and 65 and 88% of the female population) to mortality among all those with a higher level of education. The exception is Switzerland where the only educational classification that we could apply produced a distribution with 22% of the male and 47% of the female population in the "lower" educational group.

Table 1: Data Sources

Population	Follow-up period	Person-years at risk of total male population	Person-years at risk of total female population	Number of male deaths due to lung cancer	Number of female deaths due to lung cancer
England/Wales	'91-'96	587,136	679,078	1,310	673
Norway	'90-'95	3,936,934	4,472,965	5,450	2,205
Denmark*	'91-'95	3,698,337	3,839,716	4,854	3,160
Finland	'91-'95	4,748902	5,739763	7,681	1,839
Belgium	'91-'95	9,329,715	10,924,258	27,137	4,240
Switzerland	'91-'95	4,065,132	4,959,756	6,234	1,517
Austria	'91-'92	1,500,822	1,874,248	2,238	759
Turin	'91-'96	990,986	1,237,383	2,341	617
Barcelona	'92-'96	1,705,174	2,176,193	3,666	468
Madrid	'96-'97	1,400,662	1,706,276	1,984	251

Note: * Ages 40-69

Lung cancer was defined as code numbers 162, 163 and 165 of the ninth revision of the International Classification of Diseases.[22] Although these code numbers include some other tumours of the respiratory tract, the overwhelming majority will be lung cancer in all countries. The Danish data were coded according to the eighth revision (162, 163) and the tenth revision (C33, 34, 39), the Swiss data were coded according to the eight revision (162, 163).

10.3.2 Methods of analysis

We started by looking at age-standardized lung cancer mortality rates by population, sex, 10-year age-group and level of education. These rates were standardized by five-year age groups using the direct method and the European standard population of 1995 as the standard.[23]

We then applied Poisson regression analysis to calculate mortality rate ratios adjusted for age (in five-year age-groups), using the higher educational groups as reference group. These calculations were performed with the SAS statistical package, version 6.12. This resulted in Rate Ratios with 95% Confidence Intervals, that were compared with Relative Indices of Inequality (a measure that, unlike the Rate Ratio, adjusts for differences between countries in the size of higher and lower educational groups).[24] The latter gave almost exactly the same results in terms of the patterning of lung cancer mortality across educational groups.

In order to indicate variations between countries in the proportion of total excess mortality in lower educational groups that is due to smoking, we used a modified version of the estimation procedure developed by Peto and colleagues (see appendix).[19,20] Essentially, our method first estimates the proportion of smokers in each educational group from its lung cancer mortality rate, then calculates the proportion of total deaths due to smoking in each educational group using the general formula for the etiologic fraction, and from this finally calculates the total excess deaths in the lower educational groups that are attributable to smoking.

10.4 Results

Figure 1 presents an overview of age- and sex-specific lung cancer mortality rates in "lower" and "higher" educational groups in the ten populations included in this study. Lung cancer mortality rates generally increase by age, although in many populations the highest mortality rates are not found in the highest age-group(s), suggesting cohort effects with higher mortality rates in more recently born birth cohorts. Lung cancer mortality rates are higher among men than among women, but the size of the difference varies between countries, e.g. in England/Wales women's rates are much closer to the rates of men than in most of the other countries. Lung cancer rates are usually higher among lower educated men and women than among higher educated men and women.

Table 2 presents a summary measure for the size of relative educational differences in lung cancer mortality, calculated for each ten-year age- and sex group in all ten populations included in this study. Among middle-aged men inequalities in lung cancer mortality are found in all populations, although differences are small and 95% Confidence Intervals include 1.00 in Madrid. Among men, inequalities in lung cancer mortality persist into old age in most populations, but the size of the differences diminishes. Only in Madrid an indication is found that in older birth cohorts (now aged 80-89) smoking has been more prevalent in the higher than in the lower educational groups: the rate ratio of lung cancer mortality is much smaller than 1 (although the 95% Confidence Interval includes 1). In Barcelona and Turin inequalities in lung cancer mortality rate are relatively small in this age-group among men.

Table 2a: Educational rate ratios and 95% confidence intervals for lung cancer, men, ages 40-89

Population	Age group				
	40-49	50-59	60-69	70-79	80-89
England/Wales	1.55 (0.75-3.20)	2.85 (1.68-4.83)	2.48 (1.73-3.55)	1.36 (1.01-1.83)	2.27 (1.11-4.63)
Norway	2.56 (1.79-3.66)	1.96 (1.56-2.47)	1.65 (1.41-1.92)	1.39 (1.17-1.64)	1.09 (0.78-1.54)
Denmark	2.47 (1.97-3.09)	1.80 (1.57-2.07)	1.47 (1.34-1.60)		
Finland	1.79 (1.45-2.20)	1.84 (1.61-2.11)	1.97 (1.78-2.18)	1.44 (1.28-1.60)	1.66 (1.31-2.11)
Belgium	1.97 (1.74-2.22)	1.81 (1.68-1.95)	1.68 (1.59-1.78)	1.54 (1.44-1.65)	1.64 (1.43-1.87)
Switzerland	2.15 (1.69-2.74)	1.83 (1.60-2.10)	1.64 (1.50-1.79)	1.39 (1.28-1.52)	1.11 (0.94-1.30)
Austria	3.20 (1.72-5.97)	2.40 (1.67-3.45)	2.08 (1.68-2.58)	1.73 (1.38-2.16)	1.62 (1.19-2.21)
Turin	1.48 (1.01-2.17)	1.68 (1.30-2.17)	1.56 (1.30-1.87)	1.39 (1.12-1.73)	1.40 (0.93-2.10)
Barcelona	1.97 (1.56-2.47)	1.70 (1.45-2.00)	1.45 (1.29-1.63)	1.14 (1.00-1.30)	1.42 (1.08-1.86)
Madrid	1.26 (0.88-1.80)	1.12 (0.88-1.42)	1.39 (1.14-1.69)	1.03 (0.84-1.25)	0.74 (0.54-1.02)

Table 2b: Educational rate ratios and 95% confidence intervals for lung cancer, women, ages 40-89

Population	Age group				
	40-49	50-59	60-69	70-79	80-89
England/Wales	3.23 (0.43-24.49)	3.27 (1.20-8.92)	2.41 (1.28-4.55)	1.35 (0.78-2.31)	0.71 (0.36-1.41)
Norway	2.31 (1.42-3.76)	3.52 (2.06-6.00)	1.26 (0.94-1.68)	1.13 (0.79-1.63)	0.80 (0.44-1.47)
Denmark	1.96 (1.57-2.44)	1.95 (1.66-2.30)	1.32 (1.17-1.94)		
Finland	1.42 (1.00-2.01)	1.48 (1.11-1.98)	1.54 (1.23-1.93)	0.98 (0.80-1.21)	1.17 (0.79-1.72)
Belgium	1.31 (1.04-1.65)	1.44 (1.19-1.74)	1.37 (1.16-1.62)	1.11 (0.90-1.37)	0.86 (0.64-1.15)
Switzerland	1.29 (0.93-1.78)	1.12 (0.90-1.39)	0.94 (0.78-1.14)	0.88 (0.72-1.07)	0.85 (0.62-1.17)
Austria	1.77 (0.91-3.41)	1.06 (0.58-1.94)	1.00 (0.71-1.42)	0.81 (0.59-1.12)	0.67 (0.45-0.98)
Turin	1.19 (0.51-2.79)	0.84 (0.49-1.44)	1.07 (0.67-1.71)	1.18 (0.71-1.97)	0.74 (0.41-1.35)
Barcelona	0.89 (0.49-1.64)	0.93 (0.55-1.57)	1.14 (0.73-1.77)	0.63 (0.44-0.90)	1.30 (0.65-2.59)
Madrid	0.55 (0.23-1.34)	0.38 (0.20-0.74)	0.61 (0.32-1.14)	0.62 (0.32-1.21)	0.64 (0.27-1.49)

For women the pattern is more variable. Among middle-aged women large relative inequalities (favoring the higher educational groups) are found in some populations only (England/Wales, Norway, Denmark), while Madrid has rate ratios of lung cancer mortality that are consistently below 1. At older ages inequalities can rarely be demonstrated, although for women 60-69 years clearly higher lung cancer mortality rates in lower educational groups were found in England/Wales, Denmark, Finland and Belgium. A reversal from inequalities favoring lower educational groups, to inequalities favoring higher educational groups, as one moves from older age-groups (older birth cohorts) to younger age-groups (more recently born birth cohorts) can clearly be observed in Austria, while many other populations also show indications of such a pattern.

Figure 1a. Lung Cancer mortality rates for men and women from England and Wales, per 100000 person years at risk

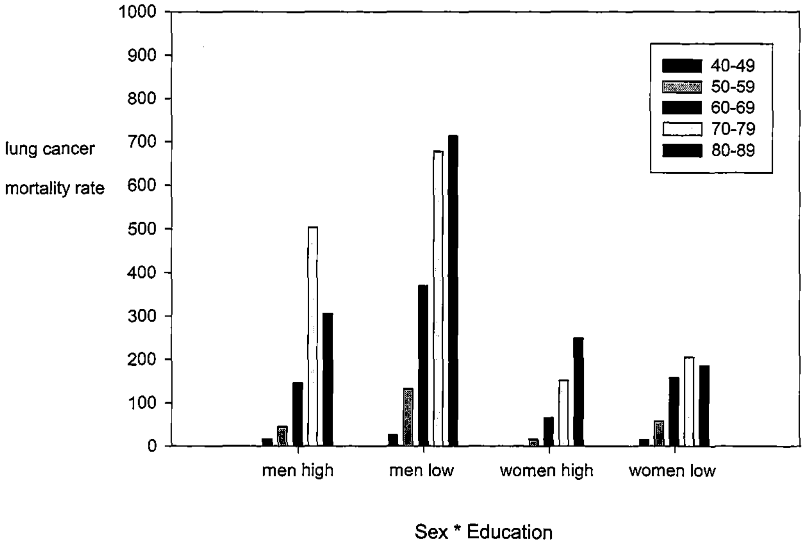


Figure 1b. Lung Cancer mortality rates for men and women from Norway, per 100000 person years at risk

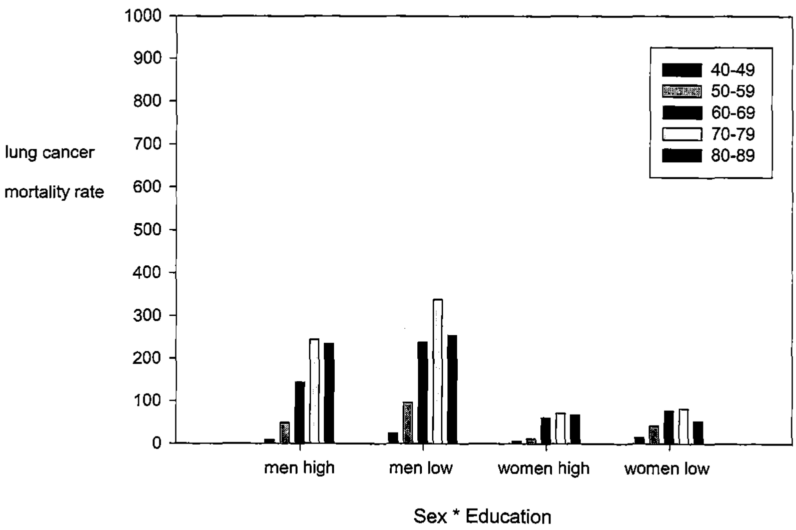


Figure 1c. Lung Cancer mortality rates for men and women from Denmark, per 100000 person years at risk

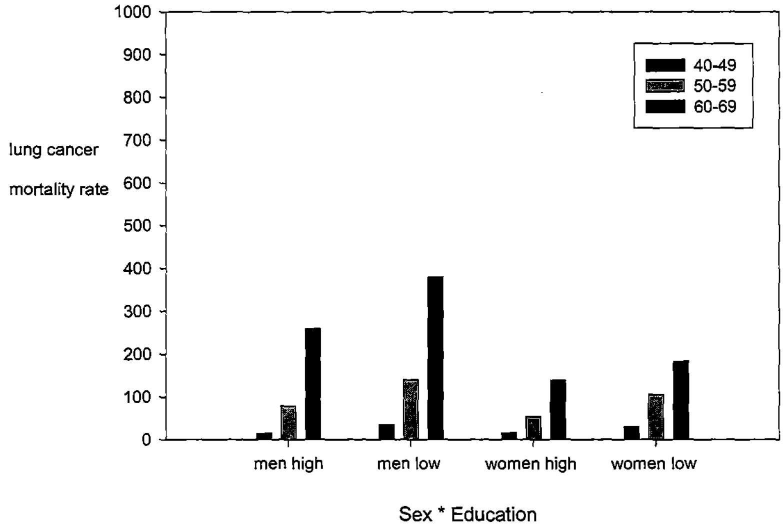


Figure 1d. Lung Cancer mortality rates for men and women from Finland, per 100000 person years at risk

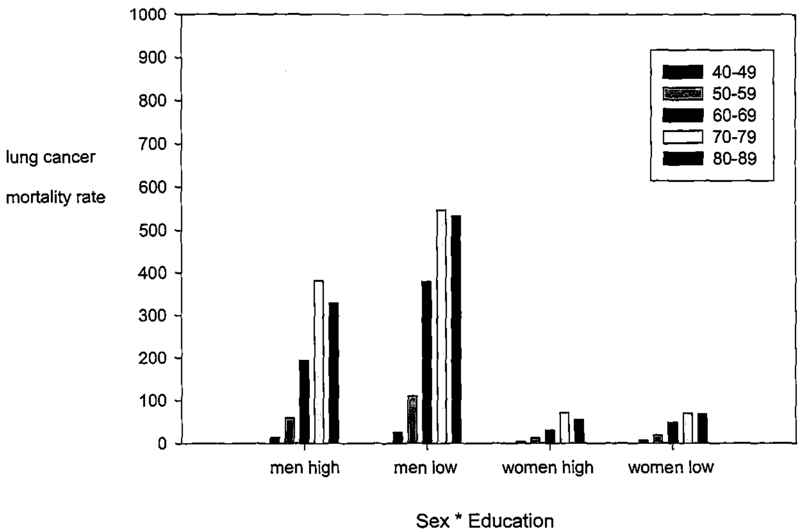


Figure 1e. Lung Cancer mortality rates for men and women from Belgium, per 100000 person years at risk

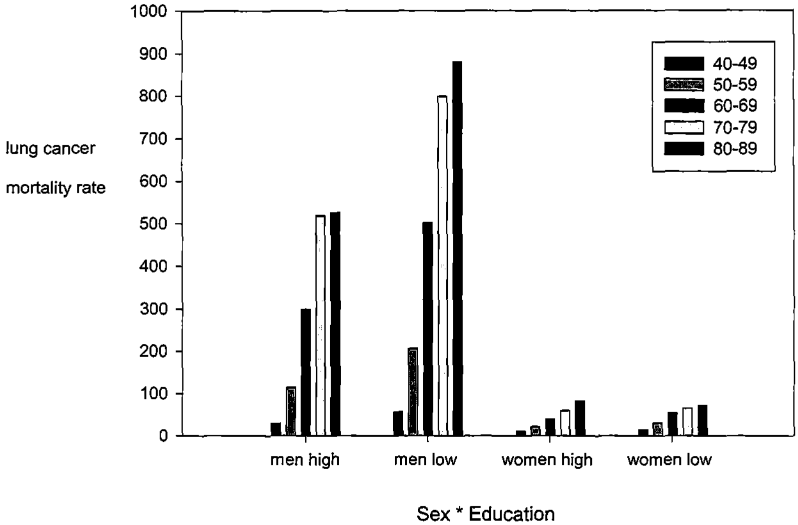


Figure 1f. Lung Cancer mortality rates for men and women from Switzerland, per 100000 person years at risk

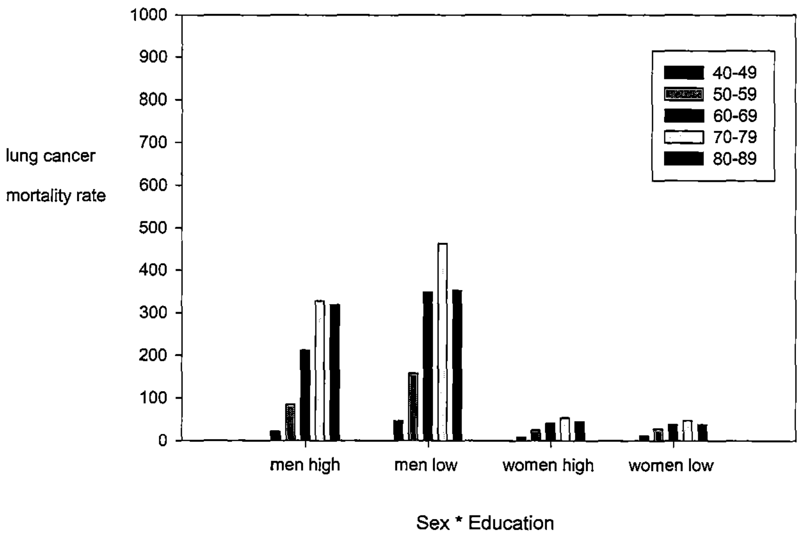


Figure 1g. Lung Cancer mortality rates for men and women from Austria, per 100000 person years at risk

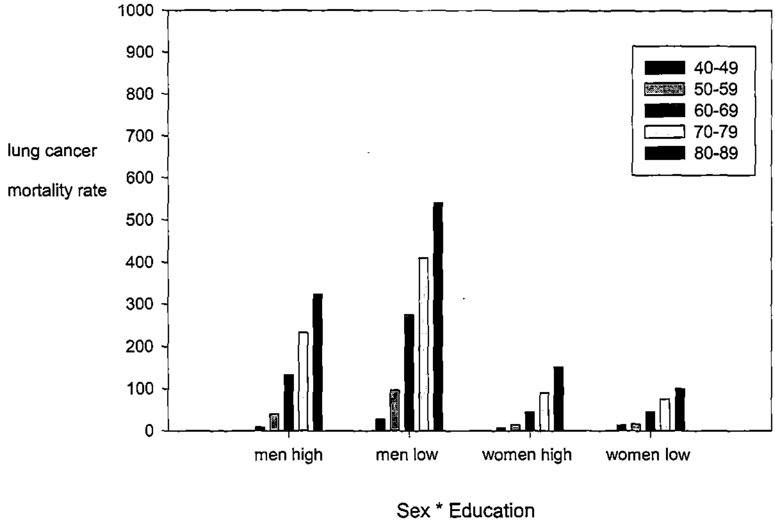
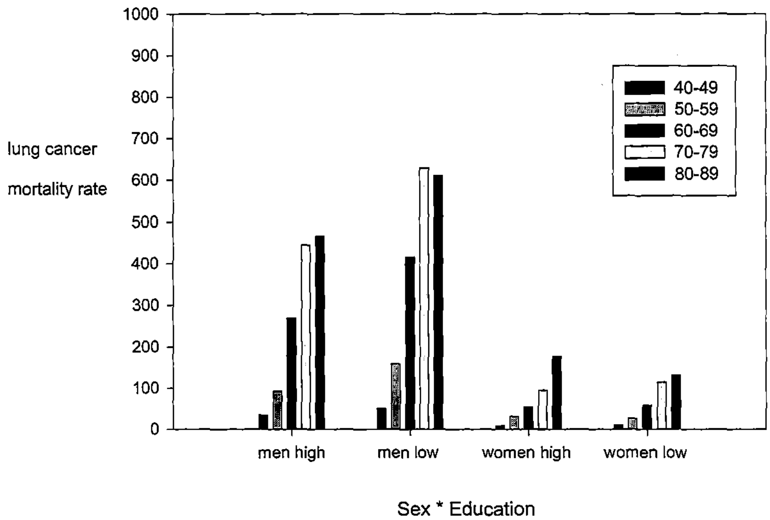


Figure 1h. Lung Cancer mortality rates for men and women from Turin (Italy), per 100000 person years at risk



When all age-groups are combined, lung cancer mortality rates are higher in lower educational groups among men in all ten populations (table 3). The largest relative differences are found in Austria, the smallest in Madrid. Among women, inequalities favoring the higher educational groups are found in five populations only. In Switzerland, Austria, Turin and Barcelona, the rate ratios are close to 1, and 95% Confidence Intervals include 1. Among Madrid women, there is a considerable excess mortality from lung cancer in the higher educational groups.

Table 3: Educational rate ratios and confidence intervals for lung cancer and total mortality, by sex, in 10 populations

	Men		Women	
	Lung cancer	All causes	Lung cancer	All causes
England/Wales	1.95 (1.60-2.36)	1.35 (1.29-1.43)	1.71 (1.23-2.38)	1.23 (1.16-1.32)
Norway	1.63 (1.49-1.80)	1.39 (1.36-1.42)	1.58 (1.31-1.90)	1.29 (1.25-1.33)
Denmark*	1.65 (1.53-1.77)	1.33 (1.30-1.36)	1.60 (1.47-1.75)	1.29 (1.27-1.33)
Finland	1.75 (1.65-1.86)	1.36 (1.34-1.38)	1.29 (1.14-1.45)	1.25 (1.23-1.28)
Belgium	1.69 (1.63-1.75)	1.36 (1.34-1.37)	1.27 (1.16-1.40)	1.30 (1.28-1.32)
Switzerland	1.53 (1.45-1.61)	1.28 (1.27-1.30)	0.98 (0.88-1.09)	1.22 (1.21-1.24)
Austria	1.97 (1.73-2.23)	1.45 (1.41-1.50)	0.92 (0.76-1.10)	1.33 (1.29-1.38)
Turin	1.52 (1.36-1.70)	1.24 (1.19-1.28)	1.00 (0.78-1.28)	1.19 (1.13-1.25)
Barcelona	1.44 (1.34-1.55)	1.31 (1.28-1.35)	0.88 (0.71-1.10)	1.37 (1.33-1.41)
Madrid	1.13 (1.02-1.26)	1.19 (1.15-1.24)	0.55 (0.40-0.75)	1.17 (1.10-1.24)

Note: * Includes ages 40-69 only

Table 3 also shows relative inequalities in total mortality. The rate ratios are remarkably similar between populations, and are always above 1. Among men the rate ratios for total mortality range between 1.19 in Madrid and 1.45 in Austria, and among women the rate ratios range between 1.17 in Madrid and 1.37 in Barcelona.

These patterns of lung cancer and total mortality suggest that the contribution of smoking to the explanation of socioeconomic inequalities in total mortality differs substantially between countries. This is confirmed by figure 2, which presents indirect estimates of the contribution of smoking to excess total mortality in "lower" educational groups for each of the ten countries. These estimates are based on a modified version of the indirect estimation method developed by Peto et al. (see appendix), and while the absolute levels of these estimates have rather wide margins of uncertainty they do provide a basis for comparison between countries. Among men, the estimated contribution of smoking to excess total mortality in the "lower" educational group ranges between 5% in Madrid and 30% in England/Wales and Turin. Among women, the proportion of excess total mortality that is due to smoking ranges between –14% in Madrid (indicating that the effect of inequalities in smoking is to reduce inequalities in total mortality) and 35% in England/Wales.

Figure 2a Percentage of excess total deaths in lower educational groups due to smoking, in total male population

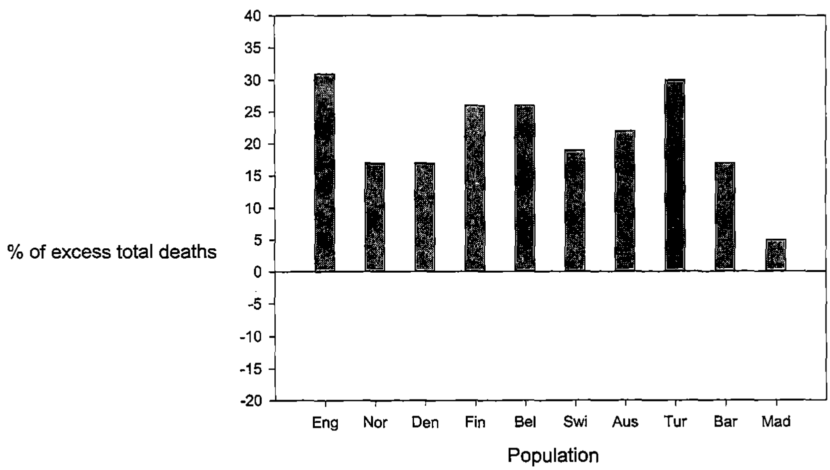
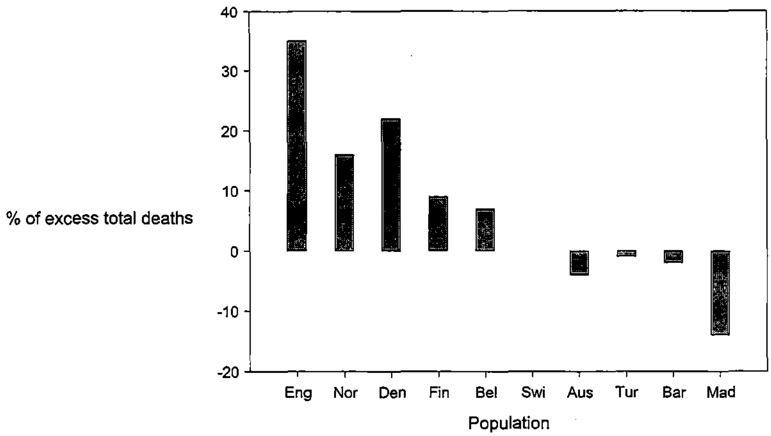


Figure 2b Percentage of excess total deaths in lower educational groups due to smoking, in total female population



10.5 Discussion

10.5.1 Summary of main findings

Our results suggest that England/Wales, Norway, Denmark, Finland and Belgium are farthest advanced in the progression of the smoking epidemic: these populations have consistently higher lung cancer mortality rates among the "lower" educated in all age-groups including the oldest ones in men, and in all age-groups until the age-group of 60-69 years in women. Madrid appears to be less far advanced, with "lower" educated men in the oldest age-group and "lower" educated women in all age-groups still benefiting from lower lung cancer mortality rates. Switzerland, Austria, Turin and Barcelona occupy intermediate positions.

The lung cancer mortality data suggest that in the 1990's inequalities in smoking contributed substantially to the explanation of educational differences in total mortality among men in all populations except Madrid. Among women, contributions of smoking to inequalities in mortality were probably substantial in England/Wales, Norway and Denmark, smaller in Finland and Belgium, close to zero in Switzerland, Austria, Turin and Barcelona, and negative in Madrid.

10.5.2 *Main limitations and sources of bias*

International comparisons of mortality data by cause of death may be subject to bias because of differences between countries in certification and coding of causes of death. Although certification and coding of lung cancer is more straightforward, than that for many other causes of death,[25] we cannot exclude the possibility that some of the differences between populations in levels of lung cancer mortality as observed in figure 1, or as expressed in the estimated contribution of smoking to excess total mortality in lower educational groups, are due to such data problems. It seems unlikely that recognition of lung cancer as a cause of death differs between educational groups, because health care systems provide reasonably equal access to all populations included in this study.[26]

Measurement of socioeconomic inequalities in mortality is not straightforward, and comparisons between countries may be subject to bias because of differences in inclusion of specific population groups, differences in measurement of education, and differences in length of follow-up. Despite our standardization efforts, some differences are bound to remain because data collection systems and educational systems differ between European countries. This applies to Switzerland particularly, because the educational distribution in this country is rather different from that in the other countries (see Data and methods section). Depending on the form of the educational gradient of lung cancer mortality in Switzerland, its Rate Ratios may be biased towards 1 simply because they compare less extreme groups.

Our attempt at quantifying the contribution of smoking to inequalities in total mortality used a modification of a method developed by Peto and colleagues. Despite this simplification, our results are by and large compatible with those published by Peto et and colleagues.[19] For each country we compared the proportions of total mortality that can be attributed to smoking as calculated in our analysis with those published by Peto and colleagues. for the same country in 1990, and found the international patterns to be quite similar (results not shown). It is important to note, however, that our estimates of the contribution of smoking to excess total mortality in the "lower" educational groups are based on a number of assumptions, some of which are common with Peto and colleagues method, some of which are additional.

The most crucial assumption relates to the estimation of smoking prevalence's from lung cancer mortality rates (see appendix). Peto and colleagues method, like ours, uses the lung cancer rate among smokers and non-smokers in a large cohort study conducted by the American Cancer Society (Cancer Prevention Study (CPS)_II) to estimate the (unobserved) proportion of smokers in a population from its (observed) lung cancer mortality rate. This calculation is based on the assumption that the CPS-II smoker and non-smoker lung cancer mortality rates are a valid approximation of the (unobserved) smoking-specific lung cancer mortality rates in the population under study. In our analysis, this assumption not only has to be made for each national population (as in Peto and colleagues analysis), but also for each educational group in each country. Our own data suggest that this assumption is violated in some countries, because observed lung cancer mortality rates sometimes are so high (e.g. in lower educated men in Belgium – figure 1), that CPS-II data suggest a smoking prevalence of higher than 100%. We have, in these cases, arbitrarily fixed the smoking prevalence at 100%, but that only partially solves the problem that the lung cancer mortality rate among non-smokers probably differs between countries and/or between educational groups due to other factors, e.g. air pollution, occupational exposures or diet.[27] Clearly, the results as presented in figure 2 can only be seen as a crude indication of the variation between countries in the contribution of smoking to inequalities in total mortality that is suggested by current inequalities in lung cancer mortality.

10.5.3 Comparison with previous studies

The results of this study correspond well with those of our previous study on the basis of 1990 smoking prevalence data by educational level from national health interview and multipurpose interviews.[4] This previous study suggested that countries in northern Europe already were in stage 4 or at the end of stage 3 of the smoking epidemic, while countries in southern Europe then mostly were at the beginning of stage 3. This is confirmed by the lung cancer mortality patterns presented here that 'integrate' the exposure of these populations to tobacco smoke over previous decades. The current analysis also adds a few continental-European countries of which Belgium seems to be roughly in the same stage as countries in northern Europe, while Switzerland and Austria occupy intermediate positions between northern and southern Europe.

It is interesting to compare the results of these studies of educational differences in either smoking or lung cancer mortality with those of studies comparing time-trends (including cohort patterns) of lung cancer mortality between the same set of European countries.[28,29] The main contrast there is between the United Kingdom, where lung cancer mortality among men and women peaked before all other countries, and Spain, where even among men lung cancer mortality still is rising. The other countries are in between, without a clear advance of Norway, Denmark, Finland and Belgium as compared to Switzerland, Austria and Italy like in our analysis.

There have been a number of longitudinal studies of the contribution of smoking to socioeconomic inequalities in either lung cancer incidence or mortality, or to total mortality, linking smoking as reported during a base-line measurement to mortality in the same individuals as measured during a defined follow-up period.[6,7,14,17,18,30] Among men in northern European populations, higher smoking prevalences in lower socioeconomic groups typically explain between 10 and 20% of the gap in total mortality[14-18] which is not inconsistent with our cruder estimates (figure 2). More interesting, however, is the fact that several studies have found that smoking can only account for a small part of the higher lung cancer incidence or mortality rates in lower socioeconomic groups.[6,7,30] Because smoking is estimated to account for between 80 and 90% of all lung cancer cases in the population, one would expect a very high contribution to the explanation of socioeconomic inequalities in lung cancer as well, but that is not what these studies have found. For example, in two Scottish studies smoking accounted for about 55% of the higher lung cancer mortality rate in manual compared to non-manual men.[30] One possible explanation is that this is due to measurement error: smoking in these cohort studies is usually measured on the basis of self-report on a single occasion, and considerable degrees of misclassification, in terms of the intensity of exposure to tobacco smoke over a relevant part of the life-course, may have occurred, thereby diluting associations with lung cancer. Another possible explanation, however, is that other risk factors play a more important role than previously thought, particularly in lower socioeconomic groups (see above). This is clearly an area for further research, and until individual-level studies confirm the quantitative contribution of smoking as suggested in figure 2 the latter should be seen as a very first approximation only.

10.5.4 Implications

To the extent that socioeconomic inequalities in lung cancer mortality reflect differences in smoking behavior, they also point to important entry-points for interventions and policies to tackle inequalities in health. According to a recent review, interventions and policies that have been shown to be effective in reducing smoking in lower socioeconomic groups include raising tobacco taxes, smoking restrictions in work-places and nicotine replacement therapy.[31] Implementing such measures should be a top priority for public health throughout Europe.

The model of the smoking epidemic suggests that socioeconomic inequalities in lung cancer mortality are likely to widen further, particularly among women and in southern European countries. It may still not be too late to prevent lower educational groups from taking up the smoking habit, and effective public health action may thereby avoid larger inequalities in mortality in the future.

10.6 Appendix: Estimation of the proportion of excess total mortality in the lower educational group that is due to smoking

In a first step we used the lung cancer mortality rates in lower and higher educational groups to indicate the approximate proportions due to smoking of total mortality in these groups, and in a second step we used these proportions to calculate the proportion of total excess mortality in the lower educational group that is attributable to smoking.

For the first step, the procedure was as follows. As suggested by Peto and colleagues, the prevalence of smoking can be estimated indirectly from the lung cancer mortality rate, by comparing the lung cancer mortality rate in the population of interest with the lung cancer rate among smokers and non-smokers in a large cohort study conducted by the American Cancer Society (CPS-II), and by fitting the proportions of smokers and non-smokers to the observed lung cancer mortality rate.[19,20] This was done separately for each educational group, ten-year age-group, and sex. The assumption here is that the CPS-II smoker and non-smoker lung cancer mortality rates are a valid approximation of the (unobserved) smoking-specific lung cancer mortality rates pertaining to these various populations.

With the proportions of smokers and non-smokers so obtained, the proportion of total mortality in each educational group, ten-year age-group, and sex that is attributable to smoking was calculated. Here we simplified Peto and colleagues procedure which uses information on mortality from a range of other smoking-related causes of death that was not available in our study. Instead we used the fact that the etiologic fraction (the proportion of all cases of disease or death in a population that can be attributed to a particular determinant) is a function of the proportion of the population that is exposed (i.e. the proportion of smokers that we already obtained) and the relative risk: $EF= p(RR-1)/\{p(RR-1)+1\}$.The relative risk for smoking of total mortality is appr. 2 in many epidemiologic studies, including the CPS-II.[19,20] We have assumed that this relative risk applies to all population groups included in this study. Similarly to the original method proposed by Peto and colleagues, we halved these etiologic fractions to remove residual confounding and to obtain conservative estimates of the numbers of deaths attributable to smoking.

In the second step, we used the etiologic fractions for smoking of total mortality (by educational group, ten-year age-group and sex) and the total mortality rate to calculate the absolute rate of mortality that is due to smoking in each educational group and sex (aggregated over age-groups). The difference between high and low educational groups in these rates was then used to calculate the proportion of the total excess death rate in lower educational groups that is attributable to smoking.

10.7 Acknowledgements

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11

Educational inequalities in COPD mortality, and the contribution of smoking

Huisman M, Kunst AE, Bopp M, Borgan J-K, Borrell C, Costa G, Deboosere P, Gadeyne S, Glickman M, Minder C, Regidor E, Spadea T, Valkonen T, Mackenbach J. The contribution of smoking to educational inequalities in COPD mortality in nine Western European populations. (Manuscript).

11.1 Summary

Introduction: Smoking is an important factor in the causal pathway linking socioeconomic position to COPD mortality. Because the history of smoking differs so much between countries and gender the question is to what extent smoking contributes to socioeconomic inequalities in COPD mortality in different Western European populations. The aim of this study was to estimate the contribution of smoking to educational disparities in COPD mortality in several Western European populations.

Data and Methods: We analyzed data from longitudinal studies in COPD mortality. We determined educational inequalities in COPD mortality, occurring among men and women aged 45 years and older in nine Western European populations. Using data on lung cancer mortality and the Peto method for quantifying the contribution of smoking to mortality, we determined the contribution of smoking to educational disparities in COPD mortality.

Results: Educational rate ratios of COPD mortality in the populations ranged from 1.72 to 2.40 among men, and from 1.20 to 1.79 among women. These rate ratios were significantly larger than 1.00 in each of the populations, except for women from Turin. Etiologic fractions of smoking among lower educated men ranged from 0.71 to 0.82; and among higher educated men from 0.59 to 0.78. For women the etiologic fractions were between 0.12 and 0.80, and 0.28 and 0.67 respectively. Despite cross-country and gender variations in the magnitude of total educational inequalities in COPD mortality, that part of the differences that was not attributed to smoking showed very little variation in magnitude between countries and gender.

Conclusion: In order to reduce inequalities in COPD mortality in Western European populations, policies should prioritise aiming at reducing inequalities in smoking. Concerted European collaboration in exchanging experiences with interventions and policies may be of benefit to each of the individual populations.

11.2 Introduction

Smoking constitutes an important part of the mechanism linking socioeconomic status and health. Socioeconomic inequalities in lung cancer mortality in populations mimic inequalities in smoking that occurred two to three decades earlier. Such a strong association with socioeconomic inequalities in smoking may also be expected for socioeconomic inequalities in COPD mortality. After lung cancer, COPD is the disease that is probably the most determined by smoking. In the UK, the population attributable risk of smoking is about 80%, which is 10-15% lower than the PAR of smoking in lung cancer.[1]

However there are a number of reasons why we may need to be cautious in predicting that socioeconomic inequalities in COPD in Western European populations are determined primarily by earlier patterns of socioeconomic inequalities in smoking. There are a multitude of factors other than smoking contributing to socioeconomic inequalities in COPD.[2] The link between socioeconomic status and COPD includes such factors as prenatal exposures, lower respiratory tract infections during childhood, housing conditions, air pollution, and diet. The existence of a high burden of COPD in Britain even before cigarettes were introduced in that country (COPD was called the 'British disease' because of that), demonstrates that high COPD mortality in a population does not solely depend on a high prevalence of smoking. Similarly, in an earlier attempt to link patterns of COPD mortality to patterns of smoking it was found that international variations in smoking could not explain the international variations in COPD mortality levels.[3]

Most studies assessing the relationship of socioeconomic status to COPD adjusted for smoking.[2,4] In a Norwegian study, where socioeconomic status was defined as the educational level, it was found that it remained a significant risk factor after adjustment for smoking and occupational exposure,[4] probably the two most important contributing factors to inequalities in COPD. That education is a predictor of respiratory mortality, including COPD mortality, independently of smoking was also observed in a Danish study.[5] These results suggest that an important part of the excess COPD cases occurring among groups in lower social positions cannot be attributed to smoking, but need to be attributed to other causes.

To investigate this point we aimed to quantify the contribution of smoking to education inequalities in COPD mortality. For this purpose we analysed a comprehensive set of vital registry data from a number of different Western European populations, from northern, central and southern parts of Western Europe. Such an international comparison may be informative because the history of smoking differs so much between countries.

In this study we address the following research questions: 1) What is the magnitude of educational inequalities in COPD mortality among men and women of several Western European countries? 2) To what extent does smoking contribute to these inequalities in COPD? And 3) are there differences between the countries in the contribution of smoking to inequalities in COPD?

11.3 Data and Methods

We used data from the following Western European populations: Finland, Norway, England and Wales, Belgium, Switzerland, Austria, Barcelona and Madrid, and Turin. During a follow-up of several years mortality data were collected for all persons enumerated in population censuses in the beginning of the 1990's. Data for England and Wales were a nationally representative 1% of the population, and data for Switzerland covered the predominantly German speaking parts of the country (i.e. approximately 70% of the total Swiss population). We acquired aggregated data on the number of deaths by 5-year age groups, sex and level of education. Basic information on the data that are included in this study is given in Table 1.

Table 1; Follow-up periods and the number of deaths occurring per 100000 person years of observation

	Years of observation	Total number of person years at risk of men aged 45+ years	COPD deaths among men aged 45+ years	Total number of person years at risk of women aged 45+ years	COPD deaths among women aged 45+ years
Finland	1991-1995	3,637,351	3,581	4,696,096	1,340
Norway	1990-1995	3,175,803	3,828	3,775,370	2,492
England & Wales	1991-1996	480,387	930	573,234	627
Belgium	1991-1995	7,622,256	15,393	9,326,088	6,328
Switzerland	1991-1995	3,338,227	3,998	4,232,462	1,565
Austria	1991-1992	1,238,305	1,162	1,632,381	727
Turin	1991-1996	844,365	893	1,082,801	584
Barcelona & Madrid	Barcelona: 1992-1996 Madrid: 1996-1997	2,645,763	3,388	3,409,966	1,343

Level of education was used as indicator of socioeconomic position. Information on the educational attainment was acquired from the censuses. We reclassified the national classifications of education into two broad groups, approximately corresponding with the following levels of the International Standard Classification of Education (ISCED): 0-3 (pre-primary, primary and lower secondary education; labelled 'lower'), and 4-6 (upper secondary education and post-secondary education; labelled 'higher'). Missing information on education was less than 4% in each of the populations. The proportion of 'lower' educated men was between 66% and 84% of the total male population, and that of 'lower' educated women was between 71% and 96% of the total female population (Table 2).

Table 2; Distribution of the educational variable over the populations, ages 45+, in percentages

	Percentage of the **Male** population		Percentage of the **Female** population	
Country/City	Low	High	Low	High
Finland	66	34	71	29
Norway	84	16	90	10
England & Wales	82	18	89	11
Belgium	75	25	83	17
Austria	78	22	80	20
Switzerland	79	21	96	4
Barcelona	74	26	87	13
Madrid	71	29	76	24
Turin	76	24	86	14

COPD mortality rates were calculated for men and women of the ages 45 years and older. The mortality rates were age-standardised according to the direct method, with the pooled population of the European Union plus Norway of 1995 as the standard. We determined relative inequalities in COPD mortality by calculating the ratio of the mortality rates of the lower versus the higher educational groups by means of Poisson regression analyses. These analyses were controlled for age.

The contribution of smoking to educational differences in COPD mortality was determined using the Peto-Lopez method.[6] This is an indirect method for determining the accumulated hazards of smoking in a population based on its experience of lung cancer mortality. The method as it was applied in this study consisted of three steps. In the first step the prevalence of smoking in the education groups was determined on the basis of lung cancer rates of these groups. This was done in the same manner as Peto et al. suggested it; i.e. by relating the lung cancer mortality observed for the populations under study (in this case for lower and higher education groups separately) to information on lung cancer mortality occurring in smokers and non-smokers in a chosen reference population (i.e. the CPS-II population), and using this information to construct a composite population of smokers and non-smokers.

In the second step the estimate of the prevalence of smoking, and the relative risk of smokers versus non-smokers of COPD was used to calculate the etiologic fraction of smoking to COPD mortality. Again this was done separately for each of the education groups. We used the relative risks of smokers versus non-smokers of COPD from a study by Thun et al. (2000) that was also based on CPS-II data.[7] These relative risks were controlled for several important confounders such as asbestos exposure, alcohol use, obesity, and employment grade. A correction factor of 30% was applied to the relative excess risk of smokers, following recommendations of Ezzati et al. (2003),[8] to obtain conservative measures of the contribution of smoking. By multiplying the COPD mortality rates of each of the education groups by the etiologic fraction of smoking to COPD we derived estimates of the number of COPD deaths that could be attributed to smoking.

Finally, educational differences in smoking attributed COPD mortality were determined by subtracting the number of smoking related COPD deaths of the higher from the lower education groups. For a more detailed step-by-step description of the application of the Peto-Lopez method in this study we refer to the appendix.

11.4 Results

The COPD mortality rates and relative mortality differentials are shown in Table 3. The results for men indicate that COPD mortality was highest in Belgium and in England and Wales, and lowest in Austria. Relative inequalities (rate ratios) among men were considerable and significant in all countries. No differences between countries were demonstrated in the magnitude of relative inequalities because the confidence intervals of the estimates for each of the populations overlapped. However, the results indicated that the inequalities among men from Norway, England and Wales and Belgium were relatively large. For women, all countries showed higher COPD rates among the lower groups, although the differences were not statistically significant in the Turin study. The results suggested that relatively large inequalities occurred among women from Norway and England and Wales.

Table 3; COPD mortality rates and relative educational inequalities in COPD mortality

	MEN			WOMEN		
	Rates Low	Rates High	RR	Rates Low	Rates High	RR
Finland	168	92	2.01 (1.82-2.22)	31	23	1.47 (1.26-1.72)
Norway	144	70	2.12 (1.85-2.43)	61	37	1.79 (1.45-2.21)
England & Wales	290	122	2.40 (1.84-3.13)	105	83	1.41 (1.01-1.95)
Belgium	299	145	2.13 (2.02-2.25)	69	43	1.66 (1.50-1.83)
Austria	135	83	1.72 (1.45-2.03)	40	28	1.42 (1.12-1.80)
Switzerland	160	89	1.92 (1.72-2.14)	35	26	1.49 (1.04-2.14)
Turin	179	94	1.91 (1.55-2.35)	58	50	1.20 (0.89-1.62)
Barcelona & Madrid	172	98	1.84 (1.67-2.04)	35	27	1.37 (1.10-1.70)

The etiologic fractions of smoking to COPD are listed in Table 4. Clearly, etiologic fractions of the lower educated groups were higher than those of the higher groups for men of all countries. In contrast, this was not always the case for women. Etiologic fractions for the higher educated were higher than those for the lower groups from Barcelona and Madrid and from Austria; the etiological fractions were equal among women from Turin.

Table 4; Etiologic fractions of smoking to COPD

Country	MEN		WOMEN	
	Low	High	Low	High
Finland	0.80	0.69	0.47	0.34
Norway	0.71	0.59	0.62	0.47
England/Wales	0.82	0.69	0.80	0.67
Belgium	0.86	0.78	0.52	0.42
Austria	0.75	0.59	0.48	0.52
Switzerland	0.74	0.61	0.40	0.28
Turin	0.82	0.75	0.61	0.60
Barcelona/Madrid	0.76	0.71	0.12	0.32

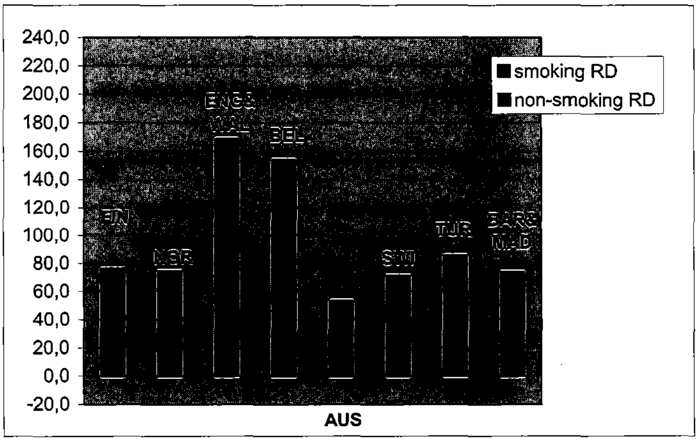
The results of the next step in the analyses are presented in Table 5. This table shows the COPD mortality rates for men and women of higher and lower groups, split up into those that were attributed to smoking, and those that were not. For men, in each of the countries, the smoking attributable COPD rates were much higher than those that were not smoking attributable. These results indicate further that two of those countries that showed the largest rate ratios, i.e. England and Wales and Belgium (but not Norway) also showed the highest rates of smoking attributable COPD mortality, among the lower as well as the higher education groups. For women, the smoking attributable COPD rates were not in all populations higher than those that were not attributed to smoking. For Finland, Switzerland and Barcelona and Madrid the rates that were not attributed to smoking actually appeared to be the highest. For England and Wales, Turin and Norway (lower educated) the reverse was found.

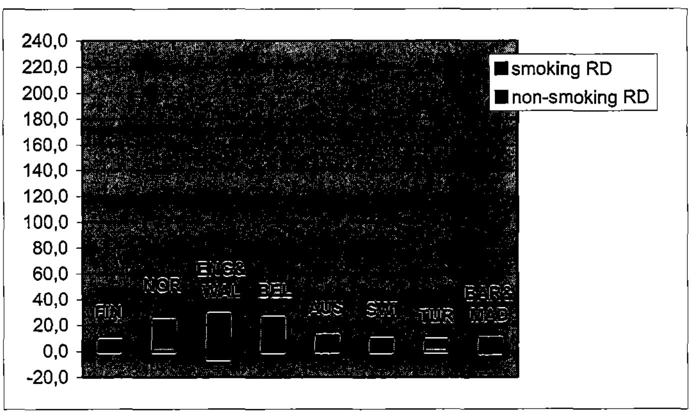
Table 5: (Non-) Smoking attributable COPD mortality among lower and higher educated men and women per 100,000 person years at risk; ages 45+ years

	MEN				WOMEN			
	Smoking attributable		Non-smoking attributable		Smoking attributable		Non-smoking attributable	
	Rates Low	Rates High	Rates Low	Rates High	Rates Low	Rates High	Rates Low	Rates High
Finland	134	63	34	28	15	8	17	15
Norway	102	41	42	28	37	18	23	20
England & Wales	238	84	52	38	84	56	21	27
Belgium	256	113	42	32	36	18	33	25
Austria	102	49	33	34	19	15	21	14
Switzerland	119	54	41	35	8	3	27	22
Turin	148	71	31	23	35	30	23	20
Barcelona & Madrid	131	69	41	29	1	2	34	25

The rate differences, that resulted from subtracting the rates of the higher education groups from those of the lower groups (presented in Table 5) are shown in Figures 1 (men) and 2 (women). By far the most of the educational differences were attributed to smoking (red bar). For men large differences were observed between countries in the magnitude of the total rate difference (red and blue bar), however, the part of the rate difference that was not attributed to smoking (blue bar) hardly differed in magnitude between the countries. Rate differences for women were of a much smaller magnitude, and more varying patterns were observed between countries. For Barcelona and Madrid, although little, smoking contributed negatively to the rate difference; meaning that the higher smoking prevalence among the higher educated women in that country resulted in a (small) reduction of educational differences in COPD mortality. In general it was found that a very large part of the relationship of education to COPD mortality was due to smoking.

Figures 1 & 2: Educational COPD rate differences per 100,000 person years for men (Figure 1) and women (Figure 2), and the contribution of smoking to the rate difference (top bar)





11.5 Discussion

The results of this study pointed toward a much larger burden of COPD mortality occurring in lower education groups of nine Western European populations. Further, using the Peto-Lopez method of calculating the contribution of smoking to mortality, we found that smoking was associated with most of the inequalities in COPD mortality occurring among men of all populations, and among women of most populations. Despite cross-country variations in the magnitude of total education differences, the results suggested that those differences that were not attributed to smoking showed very little variations in magnitude between countries and gender.

11.5.1 Limitations of the study

Our data, and the methods that we used, have some limitations that need to be discussed before conclusions can be drawn from these results. In principle we divided the education groups by defining those with at most first stage of secondary education or less (ISCED codes 3 or less) as being lower educated, and those who attained at least the second stage of secondary education as being higher educated (ISCED codes 4 and higher). For some countries this cut-off could not be made because of differences in educational systems and the coding of educational attainment in the population censuses. When this was the case we tried to use a cut off that would result in the most comparable education distributions between the countries. This approach resulted in quite comparable distributions of the population by education. Nonetheless we should be careful in our comparisons of the results between populations and in drawing conclusions about the relative position of populations in terms of the magnitude of the observed inequalities.

Any cross-country comparison of cause specific mortality levels may be biased to some degree because of international differences in the coding and certifying of the underlying cause of death. Our results rely on the comparability of the classification of lung cancer, because lung cancer rates were used to determine the prevalence of smoking, and of COPD mortality. It should be noted that a significant proportion of our data consisted of older men and women, and determining the underlying cause of death becomes increasingly difficult with increasing age due to competing causes of death. For example in the Netherlands, the diseases of the respiratory system were highly overestimated in the certification of the underlying cause of death in the presence of concurring causes.[9] Even though the certification of lung cancer (but not COPD) is relatively straightforward as compared to other causes of death,[10] we cannot exclude the possibility that international variations in certification practices have contributed to our findings. However the most important issue would be whether our findings of educational differences are also biased by this problem, and we believe that certification practices in these populations will not have been implemented differentially by educational status. It is more likely that any over- or underestimation of the number of lung cancer and COPD deaths have occurred equally among the lower and the higher educated, thereby minimizing the bias with regard to education differences.

11.5.2 Assumptions relating to the use of the Peto-Lopez method in this study

The validity of using the Peto-Lopez method in this study stands or falls with a number of assumptions, relating to the first two steps that were described in the methods. In the first step lung cancer rates for smokers and non-smokers that were observed in the CPS-II study, of the American Cancer Society, were assumed to be valid approximations of smoking exposures occurring in the populations of this study. We had to make this assumption in addition also for each of the educational groups. This assumption is probably violated for some cases because of differences between western countries and/or education groups in lung cancer due to other factors that influence the occurrence of lung cancer, such as occupational exposures, diet or other factors. Therefore we may have either underestimated or overestimated the prevalence of smoking in the populations under study.

We have compared the educational inequalities in smoking prevalence as derived with the Peto-Lopez method with those that were calculated from international survey data.[11] We compared relative educational inequalities in 'ever-smoking' rates instead of 'current-smoking' inequalities, because these probably more accurately specify the accumulated hazard of smoking. Compared to the results from the international survey data the Peto-Lopez method of determining smoking prevalence from lung cancer rates resulted in an overestimation of educational inequalities in smoking. Subsequently we assessed what the effect was of substituting the prevalences found in our study with those observed from the international survey data. This could be done for the following countries: Finland, Spain, Austria and Belgium. It was found that the contribution of smoking was overestimated generally. The largest overestimation occurred for Austrian men, where the contribution of smoking changed from 100% to 73%. For women from Barcelona and Madrid it was found that the contribution of smoking changed from –12% to –34%. For all other populations the overestimation was about 10% for both genders. Therefore, although the contribution of smoking is probably overestimated in this study, this problem alone does not challenge the conclusion that by far the largest share of inequalities in COPD can be attributed to smoking in most populations.

In the second step in the methods we assumed that the relative risk of COPD of smokers versus non-smokers, that was adopted from the CPS-II study, equally applies to each of the countries and both genders, as well as to the lower and to the higher education groups in each of the populations. Depending on the country and on sex, the lower educated may have higher COPD risk as those observed in the whole CPS-II population. The CPS-II population consists of an affluent segment of the US population, including many physicians and health care workers.[12] In contrast to the lower educated groups of some European countries these are unlikely to have been exposed to lung damaging occupational or environmental exposures. Both the lower educated smokers and the lower educated non-smokers will have been affected by these exposures. These exposures may modify the relative risk of smoking on COPD, but it is difficult to assess in which direction and in what magnitude this modification works. The non-smokers may have a higher relative risk of COPD due to these exposures, but these exposures may also work in synergy with smoking to elevate the relative risk of COPD of the smokers. Given the possible violations of our assumptions on the relative risk, we warn against taking the results of this study any further than approximate evaluations of the contribution of smoking to educational inequalities in COPD.

11.5.3 Previous research

Several other studies have determined the relationship of socioeconomic position to chronic respiratory outcomes. All these studies treated smoking as a confounder of the relationship. In a recent Danish study on socioeconomic status and respiratory disease mortality it was observed that the lower educated had about 1.39 (males) and 1.60 (females) times the risk of respiratory deaths than the higher educated had, after adjustments for smoking.[5] In a study on social class and respiratory symptoms in the general population of the United Kingdom it was shown that social class is linked to the severity of respiratory symptoms, independently of smoking. The odds ratio of reporting severe respiratory symptoms of social class V compared to social class I was about 2.4.[13] In a third study, from Norway, it was also found that educational level was associated with physician's diagnosis of obstructive lung disease, after adjusting for smoking and occupational exposure.[4] Odds ratios were about 4.9 among men older than 40 years, and 2.3 among women older than 40 years, of college and university graduates compared to those with primary school education only. The results of this study are in agreement with these findings, because it was shown that not all of the education differences were attributable to smoking. However, this study is the first to estimate the contribution of smoking to educational inequalities in COPD mortality. We have demonstrated that first in the causal pathway linking education and COPD mortality is smoking and that discussion of results from studies adjusting for smoking should not lead to disregarding the dominant effect of smoking on inequalities in COPD mortality.

11.5.4 Implications of the findings

The results of this study suggest that reducing inequalities in smoking is probably the most effective way of reducing inequalities in COPD mortality in most Western European populations. We should not turn a blind eye to other factors that work in synergy with smoking to increase the risk of COPD, and that focusing on smoking as the primary contributor to inequalities in COPD should not result in turning a blind eye to inequalities in other important factors such as occupational exposures, diet, alcohol and any other factors that may be more prevalent among the lower educated groups. Nonetheless, although there is ample evidence of a social gradient in smoking,[14,15] few initiatives have been employed to tackle inequalities instead of reducing smoking in the population.[16] Devising and implementing policies to reduce inequalities in smoking should therefore be considered as having the highest priority for public health policies.

11.6 References

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11.7 Appendix; calculation of smoking attributable COPD mortality differences

Step 1: We determined for each educational group, for men and for women split up into three age groups: 45-59, 60-74 and 75+ years, the rates of lung cancer and the rates of COPD mortality. Using the rates of lung cancer and data from the CPS-II study we determined the prevalence of smoking in each of the subgroups by applying the following equation:

1) $$\frac{Clc - Nlc}{Slc - Nlc} = pS$$

Where Clc is the rate of lung cancer in the concerning subgroup; Nlc is the rate of lung cancer of non-smokers in the CPS-II study; and Slc is the rate of lung cancer of smokers in the CPS-II study.

Step 2: Using the relative risks of smokers versus non-smokers for COPD we determined a modified relative risk of COPD mortality in each of the subgroups. This modified relative risk was determined as follows:

2) $1 + ((RR-1) * 0.7)$

Where RR is the relative risk of smokers as compared to non-smokers of COPD mortality. We obtained estimates of the relative risks from a study of Thun et al., using CPS-II data. These relative risks were controlled for a number of important confounders, such as occupation type (blue collar), alcohol use, obesity, and others. Subsequently we multiplied these excess risks by 0.7 (a correction factor of 30%) in order to obtain conservative measures of smoking attributable mortality in the light of possible residual confounding of the relative risk. Although we used relative risks that were controlled for a number of confounders it is not likely that all factors that contribute to the risk of smokers versus non-smokers differentially with educational status were adjusted for. Therefore we applied the correction factor of 30% to these excess risk estimates. Here we followed the procedure of Ezzati and colleagues (2003) who have proposed this 30% correction instead of the halving of the excess risk that was initially proposed by Peto, because of recent evidence for the robustness of the CPS-II relative risks to adjustment for confounding.

Step 3: The estimates of the modified relative risk and the prevalence of smoking were then used to calculate the population attributable risk of smoking to COPD mortality in each of the subgroups, and multiply the number of COPD deaths by PAR. The PAR is determined as follows:

3) $$\frac{pS*(RR-1)}{pS*(RR-1)+1}$$

Where pS is the prevalence of smoking, and RR the modified relative risk. Estimates of the Population Attributable Risk (or Etiologic Fraction) thus obtained are shown in Appendix 4.

Step 4: We subtract the COPD deaths attributable to smoking of the higher educated group from that of the lower educated group. This smoking attributable COPD rate difference is then subtracted from the total COPD rate difference in order to acquire an estimate of both a smoking attributable COPD rate difference and a COPD rate difference non-attributable to smoking. The numbers of COPD deaths attributable to smoking as well as those not attributable to smoking are given in appendix 5.

Difference with the previous analyses of lung cancer inequalities: In the present analyses we have made an adjustment, as compared to the analyses as they were performed for the paper on lung cancer inequalities in the contribution of smoking to all-cause mortality differences. This time we more closely followed later developments of the Peto method, and instead of dividing the etiological fraction by 2 to obtain conservative measures of the contribution of smoking (as was done for the lung cancer analyses) we applied a correction factor of 30% to the relative risk. This procedure has been described in a paper published in 2003 by Ezzati & Lopez.

Part V

General discussion

12

Discussion

The purpose of this study was to determine the magnitude of socioeconomic inequalities in health among middle-aged and older men and women within Europe, and to contribute to the explanation of these inequalities. The contribution of smoking to socioeconomic inequalities in health was estimated as one approach to explaining socioeconomic inequalities in health in European countries.

In this discussion section a summary of the results and comments on the validity of the study will be given. This will be followed by a discussion of possible explanations of the findings. At the end, implications for public health policy will be formulated, and some guidelines for future research will be given.

12.1 Summary of the results

12.1.1 Socioeconomic inequalities in mortality

Mortality was about 50% higher among lower educated middle-aged men, as compared to higher educated middle-aged men, and about 30% among middle-aged women. Middle-aged men and women who rented their house had about 80% and 60% higher mortality than those who were owner-occupiers. Socioeconomic status as indicated by educational level showed a relationship with mortality among older men and women as well, also among the oldest old (90+). Among the oldest old the lower educated still experienced about 20% higher mortality than those with a higher level of education. Housing tenure showed a relationship with mortality up to the ages 80-89 years among men and ages 70-79 years among women.

Inequalities were also observed specifically for most of the different causes of death, indicating that inequalities in mortality are not limited to a few of the largest causes only. Among men and women older than 75 years cardiovascular mortality was about 20% higher among the lower educated. Cancer mortality was 10 to 15% higher, and 'other diseases' mortality was about 20 to 30% higher.

Among middle-aged and older men, cardiovascular diseases accounted for a large part of the excess mortality among the lower educated groups (39%), followed by other diseases (32%), cancer (24%) and external causes (5%). Among women, these contributions were 60%, 29%, 11% and less than 0% respectively. Specific causes of death that contributed much to all cause mortality differences at old age were COPD, lung cancer and pneumonia. It was found that cardiovascular diseases contributed more to inequalities in mortality, and cancer much less, among the elderly as compared to those of middle age.

Remarkably, the magnitude of relative inequalities in total mortality among the elderly was not very different between countries. Differences were observed however in the age pattern of socioeconomic inequalities in mortality. In some countries the (relative) inequalities decreased with age, while in others they did not. In Belgium, Switzerland and Austria, middle-aged women did not show larger relative inequalities in mortality than older women.

There were striking differences between countries in the pattern of the causes of death that contributed most to these inequalities. The contribution of IHD to inequalities in total mortality showed a north-south gradient, with much larger contributions of this specific cause of death to inequalities in total mortality in the north, than in the southern parts of Western Europe. This finding corresponds with previous international comparisons that covered middle-aged men and women in earlier periods (the beginning of the 1980s).[1] A geographical gradient in inequalities in lung cancer mortality that was observed in this study largely mirrored this IHD gradient. Substantially larger lung cancer inequalities were observed for England & Wales, Norway, Denmark, Finland and Belgium, as compared to Switzerland, Austria, Turin and Barcelona. Madrid even showed reversed educational inequalities in lung cancer.

12.1.2 Socioeconomic inequalities in morbidity

Both of the socioeconomic indicators included in the study, education and income, were related to less than good self-assessed health, self-reported cut down in daily activities and self-reported suffering from long-term disabilities among older men and women. It was hard to compare the magnitude of inequalities between countries because of methodological issues. One important finding was that inequalities were observed in each of the countries. It was observed that men from Greece, Ireland, Italy and the Netherlands most often showed large inequalities in morbidity, as did women from Greece, Ireland and Spain.

It was found that educational inequalities in the prevalence of self-reported and performance based measures of disability among older men and women from The Netherlands and Italy mirrored inequalities in the incidence of disability rather than inequalities in recovery from disability, or mortality. This finding fits with findings from other studies, of different countries.[2-5] This suggests that education may serve to postpone disability, or to avoid it, rather than to provide more advantage when disability has set in. A new finding was that this was demonstrated with self-reported as well as performance-based measures of disability.

Finally, using the multi-state life table method we found that there was no evidence of a moderating effect of mortality selection occurring at earlier ages on socioeconomic inequalities in health among the elderly. Men and women with a lower level of education were found to have a life expectancy after their 75th birthday that was about one year less than those with a higher education. The proportion of the life expectancy lived with disability was larger among the lower educated. In our simulations with the multi-state life table we showed that removing mortality from earlier ages, and thereby removing the possible effect of mortality selection, did not change these differences.

12.1.3 Socioeconomic inequalities in smoking; and the contribution of smoking to inequalities in mortality

Substantial socioeconomic inequalities in smoking were observed among young adult and middle-aged men and women of most countries of the European Union in 1998. Smoking inequalities among older age groups were mostly small, if any inequalities were observed at all. Exceptions to the latter finding were the northern European countries Denmark and the UK. Both the socioeconomic indicators education and income were related to smoking in the European Union. Generally, educational inequalities in smoking were larger than income related inequalities. After adjustment for the other socioeconomic indicator education remained related to smoking, whereas income only remained weakly related to smoking among men. These findings suggest that education had a larger independent effect on smoking than income.

The magnitude of inequalities in smoking differed between countries from northern and southern parts of Europe. This was the case especially for women, but less for men. Among women older than 24 years of age, inequalities in smoking appeared to be larger in northern European countries than in countries from southern Europe. Different patterns in the relationship of education and income with smoking among women were also observed between northern and southern European countries. In northern countries the magnitude of educational inequalities was larger than the magnitude of income inequalities. Among women from southern European countries, the magnitude of education and income related inequalities was similar.

Our indirect estimations on the basis of lung cancer mortality suggested that smoking contributed a considerable amount to the explanation of educational inequalities in total mortality among men in western European countries. The results of the study further suggest that smoking contributed substantially to inequalities in total mortality among women in northern European countries and Belgium, but less in Austria, Switzerland, Barcelona and Turin. In Madrid a lower prevalence of smoking among the lower educated women had a protective effect. Similar indirect estimations of exposure to smoking on the basis of lung cancer mortality further suggested that smoking also contributed substantially to inequalities in COPD mortality specifically in most countries among middle-aged and older men and women, with few exceptions. Although other factors probably do play a role in this pathway, the results of this study suggest that smoking causes a majority of educational inequalities in mortality.

The findings of this study generally suggest that smoking plays an important role in generating inequalities in health among men and women, including older men and women, of many western European populations. In those countries where smoking did not appear to contribute much to inequalities in total mortality among women, such contribution should probably be expected in the (near) future. Our findings further suggest that education has a larger impact on smoking than income.

12.2 Validity of the study

In this section the main validity problems of each part of the study will be discussed.

12.2.1 Validity of the mortality analyses

There were two characteristics of the mortality data that may have had an impact on the validity of the data to some extent. These characteristics were the differences in the educational classification between countries, and possible inaccuracies of certifying and coding of the underlying cause of death.

The population distribution according to the national educational classifications in the mortality data differed a lot between countries. These classifications were collapsed into three broad educational groups, reducing the amount of detailed information, while gaining more comparable distributions of education across the different populations. Especially the lowest educational group consisted of a large proportion of the (older) population. Relative to a situation in which more extreme socioeconomic groups could have been distinguished; the use of education, with the relatively large lowest socioeconomic group, may have underestimated the observed inequalities in mortality. Sensitivity analyses were performed that showed that the relative and absolute inequalities in mortality were somewhat larger when a further division of this large group was possible, but that such division did not lead to different age patterns of inequalities in mortality. A further division of the lowest educational group might have resulted in slightly different contributions of specific causes of death to total mortality inequalities. It is, however, unlikely that the contributions of the large groups of causes would have changed much.

There is evidence that the presence of concurring causes of death makes the certification of the underlying cause of death difficult, and that the prevalence of concurring causes of death varies by underlying cause of death.[6] Among older people, pneumonia often occurs among those who suffer from other underlying chronic conditions, such as cardiovascular diseases and COPD.[7,8] This makes it likely that a part of the deaths ascribed to pneumonia may be misclassified, and that the contribution of this specific cause of death to inequalities in total mortality is overestimated.

Inaccuracies in the reporting of cause of death might be differential by socioeconomic status. This may be most likely to occur if there are inequalities in the access to medical care in a country. The countries included in the mortality studies all provide reasonably equal access to health care,[9] although differences do remain. If people from different social groups come into varying contact with medical care in the case of similar health problems, the person who certifies the cause of death (a hospital clinician, or a GP) may differ, leading to differences in classification. It cannot be ruled out that certifying of causes may be differential according to socioeconomic status, but further research evaluating this problem is necessary to estimate its effect on cause-specific mortality rates by level of education.

Cause of death certification and coding practices might differ systematically between countries, which may also lead to reduced validity of the findings. There is evidence of differences in the certification of specific causes of death between countries, of which IHD is one example.[10] The geographical gradient that is observed for the contribution of IHD to inequalities in total mortality could be biased if IHD was consistently more reported in northern European countries than in southern and continental European countries. This problem might have played a role in this study, but it is unlikely that it can explain the pronounced geographical gradient, because the geographical gradient also overlaps with international gradients in inequalities in risk factors for IHD, such as smoking, obesity and diet, lending credibility to the existence of such a gradient in IHD mortality.

It cannot be excluded that the issues described in this section have contributed to some of the observed findings, but the influence of these issues is likely to be limited mostly to cross-country comparisons of the contribution of specific causes of death, such as pneumonia and/or IHD. The more robust combined groups of causes (cardiovascular, cancer, other and external causes) should be less biased by these problems, and differences between countries in the contribution of these groups to total mortality inequalities are not likely to be completely explained by problems in the certifying and coding of the underlying cause of death.

12.2.2 Validity of the morbidity analyses

Two issues may be of importance especially for the validity of results based on the morbidity data. These are the issues of non-response and attrition, and the self-reported nature of most of the morbidity indicators.

Some of our analyses used data of the European Community Household Panel (ECHP). An important benefit of the ECHP is that its aim is to generate comparable economic, social and demographic data across countries of the EU.[11] However, the ECHP is hampered by low response rates for some countries and some high attrition rates. For the present study this might be problematic if non-response is selective by socioeconomic position in one or more countries. Indeed, this is found to be the case. For instance, from an analysis of non-response in relation to the income data of the ECHP it was observed that non-response is differential by income level in Belgium and France, but less so in Ireland and the Netherlands.[12] In the present study it was concluded that Greece, Ireland, Italy and the Netherlands most often show large inequalities in morbidity among men, and Greece, Ireland and Spain among women. This conclusion might be biased if underestimation due to selective non-response in other countries than these was larger, suppressing the magnitude of inequalities in each of the three health outcomes. The conclusion should, therefore, be drawn with care and further evidence for this finding should be gathered to support it. It is expected that the main finding, that inequalities in morbidity among the elderly exist in each of the individual countries, is robust against these problems.

Because of non-response and attrition a number of participants were left out of the analyses of the transitions in disability on the data from ILSA and LASA, and (therefore also) of the multi-state life table analyses. If non-response and attrition were differential according to educational status and disability status the effect would be to underestimate differences in disability and mortality, and to overestimate the rate of recovery among the lower educated as compared to the higher educated. It cannot be excluded that this has biased the results of the study to a certain extent. However, previous studies that evaluated the ILSA and LASA data observed that non-response and attrition did not vary strongly by educational level.[13,14] Also, in the life-table analyses of the LASA data it was observed that missing information on disability did not differ strongly between the educational groups. Therefore, it seems unlikely that the conclusions of the study should have to be otherwise if non-response and attrition were not of issue.

The self-reported nature of the morbidity indicators might be another problem that reduces the validity of the findings of the study. Several criteria for achieving good comparability of self-reports between countries and age-groups should be considered. Respondents from different countries, age groups, and/or different socioeconomic groups should interpret the question and the response categories identically, and the responses that are given should bear a close relation to the underlying health status in all countries, age groups, and/or socioeconomic groups. Deviations from these ideals should be expected. That indicator for which the comparability might be the most uncertain is self-assessed general health. This measure may be differentially valid between countries, age groups and socioeconomic groups.[15,16] In a recent report, Van Doorslaer and Gerdtham discuss this issue with the use of Swedish data.[17] To judge the validity of the measure of self-reported general health, or self-assessed health, they determined the predictive power of this measure for survival. It was observed that self-assessed health indeed predicts survival, and that there are no differences by income and education in the predictive power. If these results are generalisable to the situation in other countries, then the problems that arise from using self-assessed health in international studies should not present many problems. One study examining the validity of self-assessed health, including data from 27 countries, reported that a respondent's health rating was a powerful predictor of subsequent mortality.[18] On the other hand, data from the European Community Household Panel suggests that self-reported 'very good' health is about six times more prevalent in Denmark than it is in the Portuguese population,[19] and it is uncertain whether this difference is due to differences in the underlying level of health. These findings suggest that when absolute and relative inequalities in self-reported health are compared between countries and/or age-groups, it should be done with great caution.

The ILSA and LASA data also contained self-reported measures of disability. However all analyses performed with these data also used performance based measures of disability. The analyses of the performance-based measures did not yield results that were substantially different from those based on the self-reported disability measures.

12.2.3 Validity of the analyses on smoking

For the study on socioeconomic inequalities in smoking we used the ECHP data. Therefore also for some of the analyses on smoking non-response and attrition, as well as the self-reported nature of smoking in the ECHP are possible threats to validity. The issue of non-response is already covered in the previous section on morbidity, but because the data on smoking of the ECHP are from the fifth wave (1998), it is important in this respect also to pay some attention to attrition in the ECHP from baseline to 1998. Eurostat performed analyses on attrition in the ECHP, which showed that education was only weakly related to attrition, suggesting that the problem of differential attrition is limited. However, some differences between countries in the association of education with attrition could be observed. Whereas some countries tended to lose slightly more people with a lower level of education, other countries showed higher attrition rates for the higher educated.[20] These differences in turn might have resulted in differential under- or overestimating of the observed inequalities in smoking.

Comparisons of the magnitude of inequalities in smoking were made, but these were mostly limited to observations of differences between inequalities in northern parts of Europe and inequalities in southern parts of Europe. North-south differences were observed in the magnitude of educational inequalities in smoking among women, with larger inequalities in northern European countries. This finding might have resulted from bias due to differential selective attrition if selective attrition were higher in the southern countries. However, an inspection of the attrition rates shows that attrition is high in some southern European countries (e.g. Spain 23%; Greece 20%), but that it is higher still in some northern European countries. On the other hand attrition is relatively low in Italy and Portugal, which also fit into the north-south gradient. Together with the finding that attrition in the ECHP is only weakly related to education, these numbers suggest that the observed north-south gradient of educational inequalities in smoking among women cannot be explained completely by the problem of attrition.

The second issue that might have threatened the validity of the results of smoking might be that people sometimes misreport their smoking status when they are asked about their smoking behavior. It is difficult to assess the probability of misreporting in the ECHP, because of the lack of objective measures of exposure to smoke in the survey. Other studies concerned with the validity of self-reported smoking status have addressed this issue before and their results do not consistently point toward the same conclusion.[21,22] A review of several studies concluded that self-reports of smoking were quite accurate.[23] The likelihood of misreporting should be regarded for each study specifically however, and for the ECHP it cannot be excluded that misreporting of smoking status occurred. It is difficult to assess the possible effects on the conclusions of our study, but similar north-south gradients in inequalities in smoking have been observed by other studies as well. These studies used data from different surveys.[24,25] Therefore it is not likely that misreporting fully explains the geographical gradients in smoking inequalities that were observed, or the differences between education and income in the relation to smoking.

Peto's method to estimate the accumulated hazard of smoking in a population, and to determine the contribution of smoking to mortality[26] was applied in this study to estimate the contribution of smoking to educational inequalities in total mortality and in COPD mortality. In our estimates we assumed that lung cancer rates for smokers and non-smokers that were observed in the CPS-II study of the American Cancer Society[26] were valid approximations of lung cancer rates occurring in the populations of this study, and equally of the rates among lower and among higher educational groups. Because countries and socioeconomic groups will differ in the prevalence of other factors that are related to lung cancer, such as occupational exposures, this assumption is likely to be violated in some cases. Therefore the smoking prevalences that were obtained through the Peto method may have been either overestimated or underestimated. A comparison of these derived smoking prevalences with smoking prevalences obtained from the ECHP showed that the Peto method may have overestimated smoking among the lower educated somewhat, or may have underestimated smoking among the higher educated. It should therefore be acknowledged that the results of this study are approximations of the contribution of smoking, and that they may have overestimated the contribution of smoking to educational inequalities in mortality.

Another assumption that was implicit in the modification of the Peto method was that the relative risk of smokers versus non-smokers of COPD as observed in the CPS-II study would equally apply to the lower and to the higher educated groups in all of the populations of the present study. This assumption is also likely to be violated to some extent, although it is difficult to assess in what direction such a violation would work. In some countries the lower educated may have been exposed to other risk factors for COPD more than in others, thereby having an increased background risk of COPD that applies to the lower educated smokers as well as the lower educated non-smokers. The relative risk of smokers versus non-smokers would then only be the same as the one observed in the CPS-II study if smoking would interact with other COPD risk factors to generate a further increased risk among the smokers as compared to the non-smokers. This is not an unlikely assumption.[27] Nonetheless, the relative risk of COPD that is applied in this study is likely to remain differentially inaccurate by country, and therefore a comparison of the contribution of smoking to educational inequalities in COPD based on the results of this study is ill advised. In conclusion, our lung cancer based estimations of the contribution of smoking to educational inequalities in total mortality and COPD should not be interpreted as being more than approximations. However, these approximations do suggest that smoking makes a large contribution to mortality inequalities.

12.3 Explanations of socioeconomic inequalities in health

Since the publication of the Black Report four types of explanations for socioeconomic inequalities have been recognized. These types are: artefact explanations, social selection, cultural and behavioural factors, and factors concerning material deprivation (e.g. living standards).[28] Most value at present is attached to the latter two types of explanation.[29] Therefore, in this part of the discussion, these are the two types that will be focused on primarily.

12.3.1 Explanations of socioeconomic health inequalities in old age

Undoubtedly, smoking plays a major role in the observed inequalities in mortality among older men and women in most of the countries included in this study. But explanations of socioeconomic inequalities in health at older age should move beyond smoking, because almost all causes of death are related to socioeconomic status, and not just the ones that are related to smoking. One cause of death provides a particularly interesting case, i.e. IHD, because this cause showed a marked geographical gradient in the contribution of this cause to socioeconomic inequalities in total mortality; also among older age groups. In populations from southern parts of Europe this cause appeared to contribute much less to overall inequalities than in populations from northern parts. Such a geographical gradient in inequalities in IHD was reported also in previous mortality studies.[1] Inequalities in life style risk factors such as smoking, physical exercise, diet and obesity show similar geographical gradients as IHD inequalities do.[1,30-33] Although this is indirect evidence, the similarities in the geographical patterning of inequalities in IHD and the most important known risk factors for this cause of death suggest that life style risk factors may have a large effect on international variations in socioeconomic inequalities in health among older people.

Explanation of the persistence of inequalities in mortality and morbidity until old age requires focusing also on 'material' factors, such as exposure to physical hazards, due to for instance work or housing. In this study we observed rather large inequalities in mortality according to housing tenure. Although these inequalities decreased after early old age, these results may be taken partly as evidence for the role of material disadvantage in generating inequalities in health. The effect of housing tenure is likely to reflect the influence of housing and neighborhood conditions on health.[34] One factor that may be related to the observed housing tenure inequalities in mortality is the effect of low quality or damp housing on respiratory symptoms.[35] We found that educational inequalities in respiratory causes of death were relatively large in old age, and these may partly reflect the effects of living in poor housing conditions.

Another type of explanation of inequalities in health involving 'material' factors is exposure to occupation related hazards. It is not likely that direct exposure to such hazards can explain the inequalities in health among older people, who are older than retirement age and are mostly not in paid employment anymore, although exposure to such hazards that occurred earlier in the life course might. Occupational exposure to physical hazards may explain part of inequalities in health occurring at old age through accumulation of disadvantage over the life course. Physical stress of manual labour earlier in life may predispose the lower educated to increased levels of disability in late middle-age and old age,[36-39] and this may explain why the higher educated were more successful in avoiding or postponing the onset of disability in old age. The accumulation explanation fits with the finding that inequalities in health persist until the oldest ages. Because of continuing accumulation of disadvantage over the life course the deleterious effects on health build up among the lower socioeconomic groups to a higher degree than among the higher groups, causing continuing inequalities in morbidity and mortality at the end of the life course.

At first instance, the finding of this study that in many countries (although not all) the inequalities in mortality decreased with increasing age might seem at odds with this explanation. However, the decrease of relative inequalities with increasing age should be viewed in the light of increasing overall risk of dying with increasing age, which may explain the decreasing relative inequalities. In this rationale regardless of increasing health disadvantage among the lower socioeconomic groups the relative inequalities do not increase because the background risk of dying increases as well. It should be noted however that although relative inequalities sometimes (but not always) decreased with increasing age in this study, absolute inequalities increased with age.

12.3.2 Explanations for socioeconomic inequalities in smoking

'Material' and behavioral factors often work in synergy, and explanations based on the one, do not rule out explanations based on the other. Even if it can be concluded that smoking, or another lifestyle factor, is responsible for a large part of the observed inequalities in health, we are left with the question why lower socioeconomic groups show this behavior disproportionately. To answer this question it is important to realize that although performing unhealthy behavior may to some extent be a personal choice, it is one that is shaped by economic, historical, political and cultural contexts.[40] The finding of this study, and of others that there are striking geographical gradients in socioeconomic inequalities in smoking in Europe actually provides evidence for this.

One study specifically demonstrated that the material context determined the smoking behavior of low-income women.[41] Smoking served as a mechanism to cope with the high pressures of caring for others with little financial resources. As such, smoking appears in the pathway linking material deprivation to health. In our study smoking was strongly related to income, but it did not remain equally so after adjustment for education. It may be that education shapes the psychosocial and cognitive resources that allow people to deal with material disadvantage that are either more or less beneficial to health. When effective coping resources are unavailable, smoking (or other health-related behavior) may serve as a mechanism to control in stressful situations. Education may provide the cultural, intellectual and psychosocial resources necessary to cope with adverse personal circumstances in a more healthy way than through smoking.[42] Educational level may also be an indicator of social circumstances during school-going age, such as peer pressure and school performance, which are predictors of smoking initiation among those of school-going age.[43-47] Finally, education may also partly reflect childhood living conditions more accurately than income, and these conditions are determinants of smoking.[48,49]

12.4 Recommendations for public health policy

In this section some policy recommendations will be given relating to possibilities for reducing inequalities in health in old age, and for reducing inequalities in smoking.

12.4.1 Recommendations for reducing inequalities in health in old age

One conclusion that can be drawn from this study is that policies aimed at improving the health of people with a lower socioeconomic status remain crucial for improving the population's health. Interventions that are successful in reducing inequalities in health earlier in the life course are also likely to reduce inequalities at old age. Some specific results of this study suggest that prevention of inequalities in health that is targeted among younger age groups may also prevent inequalities in health among the elderly. Firstly, it was found that smoking contributed largely to inequalities among older men and women. For such diseases as lung cancer and COPD the lag time between smoking and onset of disease is several decades. Inequalities in old age in these causes of death are generated mostly during young adulthood and middle age. Secondly, education was related to smoking independently of income, but not the other way around. The level of education is acquired mostly early in the life course, and therefore its influence on health, through life style factors such as smoking (but also other health behavior) may also begin relatively early in the life course. Thirdly, those causes of death that are the most important contributors to inequalities in mortality at later ages have etiological backgrounds firmly rooted earlier in the life course. For example, harmful exposures dating back to early childhood conditions may increase the risk of a stroke at old age,[50,51] and stroke was one of the causes of death that contributed a substantial amount to inequalities in total mortality in western European countries. Policies targeting exposure during earlier ages with the aim of reducing inequalities in later life will not show results in the short term. Nonetheless such policies may be the most promising in the long term.

In our study on the effects of mortality selection we observed that also after the 75th birthday, those who had a lower level of education spent a larger part of their remaining life with disability. Therefore it should be aimed to reduce the burden of morbidity for those who have reached old age, so as to add quality to the later years of people's lives. Some of the causes of death that contributed much to inequalities in mortality among the elderly, such as COPD and cardiovascular diseases are associated with preceding limiting symptoms such as reduced respiratory function and fatigue. Encouraging physical exercise might be one way to prevent or reduce the effect of such morbidity on the quality of older people's lives. Physical training is one of the main components in reducing disability, symptoms and handicap and improving functional independence in people with chronic lung disease.[52]

In the report of the independent inquiry into inequalities in health in England some more specific recommendations were given to reduce inequalities in health among older people.[53] To my knowledge these are the only policy recommendations that have been formulated specifically with the situation of the elderly in mind. Therefore it may be most informative to discuss these recommendations in the light of the present findings.

Firstly it was recommended to devise policies that promote the material well being of older people; and specifically to reduce income inequalities, improving living standards of poor households, up rating benefits and pensions and increasing uptake of these benefits among those who are entitled to them. These are important goals, and the results of this study do not contradict these recommendations. However, the results do suggest that reducing inequalities in material well being only is not likely to remove socioeconomic inequalities in health. This argument has been voiced before,[54] and is strengthened by the results of the present study. Income inequalities in morbidity among the elderly were not larger than educational inequalities in morbidity for instance. The results suggested the reverse, i.e. that educational inequalities were somewhat larger. In addition, educational inequalities in mortality were observed among the oldest old, whereas inequalities related to housing tenure decreased among the oldest men and women. Because education is often thought of as representing cognitive, social and cultural aspects of socio-economic status the results of this study suggest that in addition to raising the material well being of disadvantaged older people, the cognitive, social and cultural resources should also be improved.

Improving housing conditions figures prominently in the recommendations of the Acheson report. It is stated that insulation and heating of housing should be amended, as well as regulations on space and amenities in the home to reduce accidents in the home. Improving of insulation and heating in the homes of older tenants may reduce respiratory conditions, and thereby reduce inequalities in morbidity, but in other European countries the need to improve on insulation and heating may not be that pressing as it is in the UK. Respiratory conditions are associated with a high burden of morbidity, and respiratory causes of death contributed importantly to total mortality inequalities among older people. Although the role of smoking should not be dismissed with regard to these causes, adverse housing conditions may aggravate the consequences of those causes. The elevated mortality levels of tenants that were observed in this study may partly reflect the effect of such adverse housing conditions. Preventing accidents by improving housing conditions of the disadvantaged elderly may reduce inequalities in disability. However it should be noted that the effect on inequalities in mortality may be modest, because it was found in this study that external causes of death contributed very little to inequalities in total mortality among older men and women.

Two other recommendations are made in the Acheson report. It is recommended that the maintenance of mobility, independence and social contacts is promoted, and that access to health and social services for older people is developed and that these services are distributed according to need. It is suggested in the report that improving access to public transport and encouraging physical exercise activities may be good ways to stimulate the maintenance of mobility, independence and social contracts. Lowering of fees for eye sight tests and dentures, and for social services such as home cleaning, shopping etc., is suggested as a way to increase a distribution of care according to need. It is difficult to judge the effects of these recommendations for inequalities in mortality and morbidity from the results of this study. However, the results of this study do not refute the possible importance of these recommendations.

12.4.2 Recommendations for reducing socioeconomic inequalities in smoking

Reducing inequalities in smoking would be an obvious recommendation for reducing inequalities in health in general, and also for reducing inequalities in health at old age specifically. To this end there are a lot of possibilities available to policy makers. However, to phrase it in the words of Platt et al., who recently conducted a review of the available evidence for interventions to reduce inequalities in smoking: "at present there is a conspicuous failure to seize this opportunity."[55]

The European Commission recognizes that reducing smoking is one of the priorities for public health action in the European Union,[56] but little mention is being made of specifically reducing socioeconomic inequalities in smoking. Such a goal is important nonetheless because, as this study showed, it is the lower socioeconomic groups that smoke disproportionately much. This is the case among men of northern and southern European countries, among women of northern European countries, and possibly in the near future also among women of southern European countries.

Future policy and interventions should take notice of the lessons that are learnt by programs that have attempted to tackle smoking among disadvantaged people. The most important lessons up to date are the following: 1) reducing smoking among low income groups should not be attempted without addressing also the context of poverty and disadvantage that influence smoking, 2) people with a low income who want to quit smoking need strong social support, and health services should be geared toward stimulating people quitting smoking, 3) long-term funding of interventions is needed to have an impact on the prevalence of smoking, 4) low income groups should also be provided with opportunities for developing self-esteem and skills, 5) evaluation of interventions is important and the best use should be made of diverse methods for doing so. Further it is important to stimulate research on the effects of interventions using community approaches in order to increase the effectiveness of future efforts to reduce smoking among disadvantaged communities.[55] Although most experience with interventions to reduce smoking is concentrated in northern European countries, these lessons should be relevant for most countries in which smoking has become highly prevalent among the lower socioeconomic groups.

Although there is no doubt about the necessity of reducing smoking among low income groups, the results of this study show that the educational background is an important predictor of smoking. Therefore people with a lower level of education should be targeted specifically as well. Reaching lower educated groups as early as possible might be effective for preventing inequalities in smoking, and schools may be the first place to start with preventing uptake of smoking. School-based programs should therefore be sensitive to the different needs and attitudes toward smoking of children from different social backgrounds.

It is further advised that national European governments and the European Commission acknowledge that reducing socioeconomic inequalities in smoking specifically is an essential approach to reducing socioeconomic inequalities in health in general, and that it should be a public health priority as such.

12.5 Recommendations for future research

A considerable part of this study focused on describing inequalities in health among older people. Such descriptive analyses are needed continuously in order to monitor socioeconomic inequalities in health among the elderly as well as inequalities in smoking. The socioeconomic distribution in future cohorts of older people will differ from those cohorts that were analyzed in the present study, as may the social distributions of risk factors and material resources. A description of time trends in inequalities in health among the elderly would provide an important contribution to the present evidence base, especially if such description is performed with an international focus. Additionally, there are several aspects of health that are not yet, or less covered in the descriptive literature, including inequalities in mental health and emotional wellbeing, and inequalities in specific chronic diseases. Studying inequalities in the incidence or prevalence of chronic diseases may provide useful tools for explaining inequalities in health in addition to analyses of cause specific mortality

Descriptive studies should not concentrate on just one indicator of socioeconomic status. For example, this study determined the association of education with incidence and recovery of disability, and observed that education was mostly related to incidence and not to recovery. However, other studies found similar results for education before, but also concluded that income was more important for the development of disability, once disability was present. Furthermore, the results for housing tenure and mortality showed different patterns with age than did education in this study, suggesting that the link between education with health on the one hand, and housing tenure and health on the other hand partly runs through different pathways. Grundy and Holt suggested pairing an educational variable with a measure of deprivation (such as housing tenure) to counter one of the problems that arose with the use of education alone, i.e. the lack of differentiation among a large proportion of older people.[57] Future studies that follow this suggestion might indeed be better equipped to describe the extent of socioeconomic inequalities in health among the elderly better.

Most challenges lie in providing explanations for inequalities in health among older people. Unfortunately, as yet the explanations of these inequalities are far from complete. In addition, these explanations are likely to be time related, similar to descriptions of inequalities in health at a given moment. In this light, the many longitudinal studies of ageing that have been set up in the US and Europe within the past decades are promising. The analyses of the ILSA and LASA data in this study provide a good example of the potential of these studies for explaining inequalities in health. Longitudinal studies that follow the life course of specific birth cohorts also are likely to yield valuable clues, e.g. about the role of exposures earlier in the life course, even as far back as childhood. If possible, those studies should document the courses of the educational, occupational and financial careers of people, the major life events and transitions (such as deaths of family members, loss of a job and migration), and life style factors that may be health enhancing or reducing. Such research may further the explanation of inequalities in health by assessing the pathways linking material deprivation to ill health and mortality and the role that life style factors other than smoking play in different countries.

Our study is the most recent one in a line of international comparative studies on inequalities in health. Three types of contribution of international comparative studies are distinguished. These are benchmarking, evaluation of policies, and explanation of inequalities in health.[58] Of these potential contributions, evaluation of policies was not one of the explicit aims of this study. Not many, if any, structured attempts to reduce inequalities in health among older people have been attempted yet, and therefore evaluation of such policies through international comparisons is not yet possible. Future studies may have the opportunity to study the effects of targeted policies to reduce inequalities in health among the elderly if these are being taken in several countries in the future.

Part of the aim of the study was the benchmarking of countries in terms of the magnitude of inequalities in mortality, and in the magnitude of inequalities in smoking. The path of caution was taken in the case of inequalities in self-reported morbidity because of the possible effects of cultural conditions, and data problems such as non-response and attrition on the comparability of the data between countries. Benchmarking can remain a focus of future research with an international focus. For instance, it might be informative for possible efforts from the level of the European Commission to determine 'priority areas' within Europe that should receive targeted interventions for reducing inequalities in health. However, it should be kept in mind that the validity of benchmarking relies strongly on the comparability of the data used to determine inequalities in health in different countries, including the measurements of socioeconomic position and of the health outcome variables. This means e.g. that conclusions based on results of studies that used self-reported data on health, especially self-assessed general health, should be taken with caution. If the availability of appropriate comparable data is given, then international comparisons remain essential contributions to explaining inequalities in health.

12.6 References

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Summary

Summary

This thesis is about a cross-national study of socioeconomic inequalities in health among middle-aged and older men and women in Europe. Furthermore, the magnitude of socioeconomic inequalities in smoking in European countries is estimated, and the contribution that smoking makes to socioeconomic inequalities in health is determined. The research questions of the study are as follows:

1. What is the magnitude of socioeconomic inequalities in mortality among middle-aged and older men and women of Western European countries? What is the contribution of specific causes of death to these socioeconomic inequalities in mortality? Can variations be observed between countries?
2. What is the magnitude of socioeconomic inequalities in self-assessed poor health and disability among older European men and women? Can socioeconomic inequalities also be observed in the incidence of disability and/or the recovery from disability? Does the mechanism of mortality selection in early old age reduce socioeconomic inequalities in health in later life?
3. What is the magnitude of socioeconomic inequalities in smoking among several generations of European men and women? How much do these inequalities in smoking contribute to inequalities in mortality in Europe? Can variations be observed between countries in the magnitude of inequalities in smoking and in the contribution of smoking to inequalities in mortality?

The data and methods of the study are laid out in *Chapter 2* of the thesis. Several types of data are used in this study. Firstly, mortality data from a number of populations in Western Europe are used for answering the first and the third research question. These mortality data consist of combined information on the number of deaths among socioeconomic groups occurring within a given period (from vital registries), with information on the number of persons that were at risk of dying within these socioeconomic groups (from population census). Information on the number of deaths was acquired for total mortality and also for a number of specific causes of death.

To answer the second research question data are analysed from a European social survey and from two longitudinal studies on ageing. The European Community Household Panel (ECHP) is a social survey that is designed for the member states of the European Union. Because of comparability of the data between countries, and because the survey includes detailed information on socioeconomic variables and self-reported health, the ECHP is used to estimate socioeconomic inequalities in morbidity. The longitudinal studies are the Italian Longitudinal Study on Aging (ILSA) and the Longitudinal Aging Study Amsterdam (LASA). They include data on disability, both self-reported and performance based, as well as on socioeconomic status. These data are analysed to determine socioeconomic inequalities in the prevalence, the incidence and the recovery of disability. The LASA data are subsequently used in models to estimate the effect of mortality selection on inequalities in health in old age.

For answering the third research question data are used from both the ECHP (self-reported smoking behaviour), and from specific smoking-related causes of death that are available from the mortality data sets.

Chapters 3 and 4 present our analyses of the mortality data. ***Chapter 3*** provides an overview of socioeconomic inequalities in mortality in eleven European countries, specifically focusing on the magnitude of inequalities among the elderly. The results suggest that in Europe in general (all the individual populations pooled together) the relative inequalities in mortality related to educational level and housing tenure status decrease with increasing age, but persist until old age. Absolute educational inequalities in mortality are found to increase with age.

When the focus is on each of the populations individually it appears that the decrease in relative inequalities in mortality with increasing age that is observed for the pooled data, is not observed for all populations specifically. In contrast to other Western European populations, England & Wales (men), Belgium, Switzerland, Austria and Turin (all women) showed inequalities of about similar magnitude among the elderly as among the middle-aged. However, socioeconomic inequalities in mortality are demonstrated for each of the populations, among both men and women. These results point toward socioeconomic mortality inequalities among older western Europeans as being an important public health problem.

The results of the analyses of cause specific mortality are described in ***Chapter 4***. We determined the contribution that specific causes of death make to educational inequalities in total mortality. Our analyses showed that cardiovascular causes of death contribute the majority to educational inequalities in mortality in Western Europe, among middle-aged and older men (39%) and women (60%). In order of magnitude this is followed by the contribution of 'other causes' (not cancer, not cardiovascular and not external causes), with 32% among men, and 30% among women. Cancers contribute about 24% and 11% respectively. External causes of death contribute 5% and 0% to the educational inequalities in total mortality in this study.

Although the magnitude of educational inequalities in total mortality was not very different between countries, some interesting variations could be observed between countries in the contributions of specific causes of death to these total mortality inequalities. A north-south gradient appeared in the contribution of IHD to inequalities in total mortality, i.e. the contribution of IHD appeared to be larger in the northern European countries as compared to central and southern countries of Western Europe. However, this was just one of the many variations in the experience of educational inequalities in cause-specific mortality, between countries and between age groups.

These results strongly suggest that it is important to opt for including older populations and countries from different parts of Europe, as well as various causes of death, in explanatory research on socioeconomic inequalities in health.

Socioeconomic inequalities in morbidity and disability are discussed in chapters 5 to 7. ***Chapter 5*** gives an overview of socioeconomic inequalities in self-reported morbidity in the European Union (in 1994). Income and educational inequalities are described for three measures of morbidity, all self-reported. These measures are: self-assessed health, whether or not needing to cut down in daily activities due to a physical or mental health problem, and suffering from long-term disability. We observed that both income and education are related to self-reported morbidity, also among the oldest old, and in all countries of the EU. Inequalities were found to decrease with increasing age among women, but not always among men.

Differences between countries in the magnitude of absolute and relative inequalities were observed. We counted the times that a country was among the two countries with the highest inequalities and observed that men from Greece, Ireland, Italy and the Netherlands showed the largest inequalities most often, and that women from Greece, Ireland and Spain did. For men and women from Belgium and Germany we observed most often the smallest inequalities. Nonetheless, reducing socioeconomic inequalities in morbidity are important for all the countries that are included in this study.

We also estimated educational inequalities in disability; not only in the prevalence of disability, but also in incidence and recovery of disability. The results of this study are described in *Chapter 6*. For this study we used the data of the longitudinal studies ILSA and LASA. Both self-report measures of disability as performance based measures of disability were included. The results of the study suggest that educational inequalities in incidence of disability rather than inequalities in recovery are most important in generating educational inequalities in disability.

This finding fits with results from previous studies, and strengthens the hypothesis that a high education helps postponing disability, or avoiding it, but that it looses much of its protective effect once disability is present. Despite some differences in the magnitude of inequalities in disability between self-reported and performance based measures, the two types of measures led to similar conclusions about the association of incidence and recovery of disability with educational level.

We investigated the effect of mortality selection on inequalities in health among the oldest men and women with data from the LASA. The results of this study are described in *Chapter 7*. With estimations of educational differences in incidence of disability, recovery from disability, and mortality among disabled and non-disabled men and women we modeled the health expectancy of the population with the multi-state life table technique, applying several scenarios of mortality risk.

The lower educated appeared to have lower life expectancies at the 75th birthday than the higher educated, and to have a larger proportion of life with spend with disability. Applying the scenario of complete removal of mortality between the ages 57-74 (no mortality selection) did not lead to substantial deviations from the observed educational differences in health expectancy at the 75th birthday, suggesting that the mechanism of mortality selection hardly influenced educational inequalities in disability among the oldest ages.

Our analyses of socioeconomic inequalities in smoking, and the contribution of smoking to socioeconomic inequalities in mortality are described in chapters 8 to 11. *Chapter 8* describes the results of cross-sectional analyses with the ECHP data on the magnitude of educational inequalities in smoking prevalence in the EU. The aim of the study was to describe the diffusion of smoking by estimating educational inequalities in smoking among four generations of men and women in the EU countries. Larger inequalities in smoking were observed in northern European countries than in southern European countries among women aged 25+ years. The diffusion of smoking seems to be least advanced among women in general and especially women of southern European countries. The results of the study indicate that educational inequalities in smoking related causes of death are likely to persist or arise in all countries of the EU in the future if no adequate steps are taken to reduce and prevent these inequalities.

We compared the association of education and of income with smoking in the EU countries, using the ECHP data. The results of this study are discussed in *Chapter 9*. Both education and income were related to smoking, but the independent effect of education on smoking appeared to be larger than the independent effect of income. After adjustment for education, income remained weakly related to smoking among men only. These results indicate that attempts to reduce inequalities in smoking should not only be aimed at the lower income groups, but also to those with a lower level of education.

Chapter 10 provides an overview of educational inequalities in lung cancer mortality, and estimates of the contribution of smoking to educational inequalities in total mortality in ten European populations during the 1990's. Firstly we determined the lung cancer rates of the higher and the lower educated groups in these populations, and educational inequalities in lung cancer. Subsequently, using the lung cancer rates as input we applied the Peto method for assessing the accumulated hazard of smoking, and estimated the contribution of smoking to educational inequalities in total mortality.

We observed the largest inequalities in lung cancer for England/Wales, Norway, Denmark, Finland and Belgium, suggesting that these countries are the furthest advanced in the progression of the smoking epidemic. Switzerland, Austria, Turin, Barcelona and Madrid were less advanced, showing smaller, or in the case of Madrid even reversed, educational inequalities in lung cancer mortality. The lung cancer mortality data suggested that inequalities in smoking contributed substantially to inequalities in mortality among men in all populations, with the exception of Madrid. The contribution of smoking among women was also large in the northern European countries and Belgium, but not in Switzerland, Austria, Turin, Barcelona and Madrid.

In *Chapter 11* we demonstrate that smoking also contributes substantially to educational inequalities in COPD mortality among men of all the populations included in the study, also in the southern European populations. Only among women from Barcelona and Madrid did smoking contribute negatively to inequalities in COPD mortality. This study was also the first to estimate the magnitude of educational inequalities in COPD mortality in other countries than the northern European countries. It is observed that these inequalities are substantial, especially among men and also in the southern European populations (Turin and Barcelona & Madrid), where COPD mortality is sometimes two times as high among the lower educated as among the higher educated groups.

These results should be judged against the background of recent studies that aim to disentangle the causes of socioeconomic inequalities in COPD mortality. Although these are important studies, our study shows that they should not serve to distract attention from the important role of smoking in generating educational inequalities in COPD mortality.

In *Chapter 12* we summarized the results of the studies that are described in the previous chapters, the most important threats to validity are discussed, and explanations for socioeconomic inequalities in health among older people and inequalities in smoking are given.

Finally recommendations for public health policy are given and some recommendations for future research.

The results that are presented in all the previous chapters indicate that there are substantial socioeconomic inequalities in mortality among middle-aged and older men and women in European countries, as well as in morbidity among older men and women. There were important differences between countries in the pattern of socioeconomic inequalities in health, for instance in the contribution of specific causes of death to inequalities in total mortality, and in the magnitude of inequalities in morbidity. Based on our findings it can be concluded that older populations should be included in studies that aim to describe or to explain socioeconomic inequalities in health, and that the current evidence base should be extended to include information on southern parts of Europe, in addition to northern European countries, in which socioeconomic inequalities in health are traditionally studied the most. Smoking currently plays an important role in the causation of socioeconomic inequalities in health, and our results show that this role is not likely to reduce in the near future if interventions and policies do not succeed in reducing and preventing socioeconomic inequalities in smoking.

We argue that it is important to adopt a life course approach in explaining socioeconomic inequalities in health in old age, and in inequalities in smoking, because a considerable part of both will be determined by factors occurring earlier in the life course, such as working in physically demanding jobs, or being exposed continuously to adverse housing conditions and other material 'stress'. Partly as a result of these factors, inequalities in smoking arise, contributing substantially to inequalities in health occurring among older people.

This means that those interventions that are successful in reducing inequalities in health earlier in the life course are also likely to carry their effects through to inequalities in health among the elderly as well. However, interventions aimed at older people specifically might still be warranted, for instance to reduce inequalities in the onset of disability. Although there is evidence that inequalities in smoking can be successfully reduced if adequate interventions and policies are designed, as yet little is done to devise and implement these interventions and policies. It should be recognized by national and European governments that reducing socioeconomic inequalities in smoking is essential for reducing socioeconomic inequalities in health. Reducing socioeconomic inequalities in health in turn is essential for improving the population's health.

Samenvatting

Het onderwerp van dit proefschrift betreft een internationaal vergelijkende studie van sociaal-economische verschillen in gezondheid onder Europese mannen en vrouwen van middelbare en oudere leeftijd. Tevens is de mate van verschillen in roken tussen sociaal-economische groepen vastgesteld, en is de bijdrage van roken aan de sociaal-economische gezondheidsverschillen bepaald. De onderzoeksvragen die in dit proefschrift centraal staan luiden als volgt:

1. Wat is de mate van sociaal-economische verschillen in sterfte onder mannen en vrouwen in West-Europese landen van middelbare en oudere leeftijd? Wat is de bijdrage van specifieke doodsoorzaken aan deze sociaal-economische verschillen in sterfte? Kunnen hierin verschillen tussen landen worden vastgesteld?
2. Wat is de mate van sociaal-economische verschillen in zelfgerapporteerde gezondheid en disability onder oudere Europese mannen en vrouwen? Kunnen sociaal-economische verschillen ook worden vastgesteld in de incidentie en/of het herstel van disability[1]? Leidt het sterfteselectie mechanisme in de vroege oudere jaren tot een reductie in sociaal-economische verschillen in gezondheid later in het leven?
3. Wat is de mate van sociaal-economische verschillen in roken in verschillende leeftijdsgroepen mannen en vrouwen in Europa? In hoeverre dragen deze verschillen bij aan sociaal-economische verschillen in sterfte in Europese landen? Kunnen hierin verschillen tussen landen worden vastgesteld?

De gegevensbronnen en de methoden van onderzoek worden uiteengezet in ***Hoofdstuk 2*** van dit proefschrift. Verschillende soorten van gegevens zijn voor dit onderzoek gebruikt. Ten eerste zijn sterfte gegevens van een aantal bevolkingsgroepen van West-Europese landen verkregen. Deze gegevens zijn gebruikt om antwoorden te formuleren op de eerste en de derde onderzoeksvraag. Deze sterfte gegevens zijn opgebouwd uit een combinatie van informatie over het aantal doden die zijn geschiedt in verschillende sociaal-economische groepen binnen een afgebakende periode (deze informatie is afkomstig van sterftestatistieken), en informatie over

[1] Disability is hier voor het gemak onvertaald gelaten omdat een evenredig woord in het Nederlands ervoor ontbreekt. Disability kan worden gedefinieerd als: het hebben van moeilijkheden in een of meerdere willekeurige levensdomeinen (van hygiene tot hobbies, van huiselijke taken tot slaap), als gevolg van een gezondheids- of lichamelijk probleem. (Zie 'Verbrugge LM, Jette AM. The Disablement Process. *Soc Sci Med*; 1994:38:1-14.')

het totale aantal personen binnen de sociaal-economische groepen (waarvan de informatie afkomstig was van volkstellingen). Er werd een onderscheid gemaakt naar totale sterfte van alle doodsoorzaken gecombineerd, en naar sterfte als gevolg van specifieke doodsoorzaken.

Om de tweede onderzoeksvraag te beantwoorden hebben we gegevens geanalyseerd van een Europese sociale survey, en van twee longitudinale studies die beogen het ouder worden te bestuderen in twee Europese landen (Nederland, Italië). De 'European Community Household Panel' (ECHP) is een survey die speciaal is opgezet voor de lidstaten van de Europese Unie. De gegevens van de deze databron zijn gebruikt omdat ze relatief goed vergelijkbaar zijn tussen de landen, en omdat ze gedetailleerde informatie bevatten over sociaal-economische status, alsmede zelfgerapporteerde gezondheid. De twee longitudinale studies waar gegevens van zijn geanalyseerd zijn de 'Italian Longitudinal Study on Aging' (ILSA), en de Nederlandse 'Longitudinal Aging Study Amsterdam' (LASA). Beide studies bevatten gegevens over disability, gemeten door zowel zelfrapportage als performance tests, en over sociaal-economische status. Deze gegevens zijn geanalyseerd opdat sociaal-economische verschillen in het voorkomen van disability, de incidentie van disability, en het herstel van disability werden bepaald. LASA gegevens zijn vervolgens nog gebruikt in modelmatige analyses die het effect van het sterfteselectie mechanisme op sociaal-economische verschillen in gezondheid op oudere leeftijd beoogden te bepalen.

Voor het beantwoorden van de derde onderzoeksvraag zijn wederom gegevens van de ECHP gebruikt, namelijk die gegevens over rookgedrag (zelfgerapporteerd). Voor het vaststellen van de bijdrage van roken aan sterfteverschillen zijn de gegevens van de sterftebestanden gebruikt.

De hoofdstukken 3 en 4 beschrijven de analyses van de sterftegegevens. ***Hoofdstuk 3*** geeft een overzicht van sociaal-economische verschillen in sterfte onder mannen en vrouwen in elf Europese landen, waarbij speciale aandacht besteed wordt aan de oudere bevolking. De resultaten van deze analyses geven aan dat binnen Europa als geheel (of eigenlijk: binnen de bevolking van alle elf landen samen) de relatieve verschillen in sterfte tussen opleidingsgroepen, en tussen mensen die een eigen huis bewonen en mensen die een huis huren, afnemen met het toenemen van de leeftijd van bevolkingsgroepen. Niettemin tonen de resultaten dat de relatieve verschillen blijven bestaan, ook onder de oudste ouderen. Absolute verschillen in sterfte blijven over het algemeen toenemen met de leeftijd.

Wanneer we de landen afzonderlijk bestuderen blijkt het dat de afname van de relatieve verschillen in sterfte met toenemende leeftijd niet voor ieder land wordt gevonden. In tegenstelling tot andere West-Europese landen blijken de verschillen onder ouderen ongeveer van dezelfde grootte als verschillen onder mensen van middelbare leeftijd bij mannen uit Engeland en Wales, en bij vrouwen van België, Zwitserland, Oostenrijk en Turijn. Niettemin kunnen er verschillen in sterfte tussen sociaal-economische groepen worden vastgesteld onder de ouderen van alle landen, waaruit blijkt dat ook onder oudere bevolkingsgroepen in Europa sociaal-economische verschillen in gezondheid een belangrijk probleem zijn binnen de maatschappelijke gezondheid.

De resultaten van de doodsoorzaak specifieke sterfte analyses worden beschreven in ***Hoofdstuk 4***. Voor een reeks van specifieke doodsoorzaken hebben we vastgesteld welke bijdrage zij leveren aan de sociaal-economische verschillen in totale sterfte. Het bleek dat de cardiovasculaire doodsoorzaken het grootste gedeelte van de verschillen in sterfte tussen hoger en lager opgeleidde bevolkingsgroepen bepaalden. Cardiovasculaire doodsoorzaken 'bepaalden' 39% van de verschillen onder West-Europese mannen, en 60% onder vrouwen. De groep 'andere doodsoorzaken' (d.w.z. geen cardiovasculaire, geen kanker en geen externe doodsoorzaken) bepaalden 32% onder mannen en 30% onder vrouwen. Kanker bepaalde respectievelijk 24% en 11%, terwijl externe doodsoorzaken (waaronder verkeersongevallen en suïcide) respectievelijk 5% en 0% van de verschillen bepaalden.

Hoewel de grootte van de relatieve verschillen tussen groepen met verschillende sociaal-economische status (in dit geval geoperationaliseerd als opleidingsniveau) in totale sterfte niet veel blijkt te verschillen tussen landen, kunnen we belangwekkende verschillen tussen landen aanduiden in de mate waarin verschillende doodsoorzaken daaraan bijdragen. We vinden bijvoorbeeld een noord-zuid gradiënt in de bijdrage van ischemische hartziekte aan de sociaal-economische verschillen in totale sterfte. Die specifieke doodsoorzaak blijkt voornamelijk in de noordelijke landen van West-Europa relatief veel aan die verschillen bij te dragen, en veel minder in de zuidelijke landen.

De resultaten van deze deelstudie geven aan dat het belangrijk is om zoveel mogelijk informatie mee te nemen in onderzoek naar sociaal-economische gezondheidsverschillen. Die verschillen dienen niet alleen bestudeerd dienen te worden in slechts enkele landen binnen Europa, niet alleen voor selecte groep doodsoorzaken, en niet alleen onder bevolkingsgroepen van middelbare leeftijd, maar bijvoorbeeld ook onder ouderen.

Sociaal-economische verschillen in een ander aspect van gezondheid, namelijk morbiditeit en disability, staan centraal in de hoofdstukken 5 tot en met 7. ***Hoofdstuk 5*** geeft een overzicht van verschillen in zelfgerapporteerde gezondheid tussen groepen met een verschillend opleidingsniveau, en een verschillend niveau van inkomen in landen van de Europese Unie. Mensen werd gevraagd naar hun algemene gezondheid, of zij moesten minderen in werkzaamheden in het dagelijkse leven vanwege een psychisch of fysiek probleem, en of zij aan een chronische mentale of lichamelijke ziekte leden. Uit ons overzicht blijkt dat zowel inkomen als opleiding gerelateerd zijn aan zelfgerapporteerde gezondheid op oudere leeftijd, zelfs onder de alleroudsten (80 jaar en ouder), en dat dit het geval is voor alle landen van de EU (in 1994). Verschillen in gezondheid blijken veelal af te nemen met de leeftijd onder vrouwen, maar niet in altijd onder mannen. Het overzicht wijst tevens op enkele verschillen tussen landen. Griekenland, Ierland, Italië en Nederland vertonen vaak relatief grote verschillen in zelfgerapporteerde gezondheid onder mannen, en Griekenland, Ierland en Spanje onder vrouwen. Niettemin kan worden gesteld dat het terugdringen van deze gezondheidsverschillen een prioriteit zou moeten zijn in alle landen, omdat voor elk van hen verschillen in gezondheid vastgesteld kunnen worden.

We hebben ook verschillen tussen opleidingsgroepen in disability bepaald. Niet alleen verschillen in voorkomen van disability, maar ook in de incidentie en het herstel ervan. Van deze analyses zijn de resultaten beschreven in ***Hoofdstuk 6.*** Voor deze deelstudie hebben we de gegevens van de longitudinale ILSA en LASA studies gebruikt. Zowel zelfgerapporteerde maten als performance tests maten zijn in de analyses opgenomen. De resultaten van deze studie geven aan dat verschillen tussen opleidingsgroepen voornamelijk groot zijn in de incidentie van disability en minder in het herstel. Op grond van deze uitkomsten kan worden gesteld dat een hogere opleiding vooral een beschermende rol heeft wanneer disability nog niet is opgetreden, maar dat deze de beschermende rol voor een groot deel verliest wanneer het eenmaal aanwezig is.

De invloed van het sterfteselectie mechanisme op ongelijkheid in gezondheid op latere leeftijd hebben we onderzocht met behulp van de gegevens van de LASA. Hiervan zijn de resultaten weergegeven in ***Hoofdstuk*** *7*. Met de schattingen van de opleidingsverschillen in incidentie en herstel van disability, zoals die voor de deelstudie van hoofdstuk 6 zijn bepaald, en met schattingen voor de sterfte onder mensen met disability en onder mensen zonder disability hebben we de levensverwachting van de bevolking geschat. Hiervoor is de multi-state life table methode gebruikt. Door de sterftekansen op verschillende leeftijden te modelleren zijn de effecten van verschillende scenario's geschat op gezondheidsverschillen.

Het is gebleken dat de lager opgeleidde bevolkingsgroepen een lagere levensverwachting hebben op hun 75e dan de hoger opgeleidden dat hebben. Hiervan leven de lager opgeleidden ook nog een langer deel van met disability. Bij het toepassen van het scenario waarbij sterfteselectie op jongere leeftijden (57-74 jaar) werd uitgeschakeld blijkt dat het sterfteselectiemechanisme weinig invloed heeft op de gezondheidsverschillen op latere leeftijd (75+).

Ons onderzoek naar de rol van roken in sociaal-economische gezondheidsverschillen wordt beschreven in de hoofdstukken 8 tot en met 11. ***Hoofdstuk 8*** geeft daartoe allereerst een dwarsdoorsnede van de mate van opleidingsverschillen in roken onder vier generaties in de EU landen in 1998. Hieruit is af te lezen in welke landen de diffusie van de rookepidemie het verst is gevorderd, en in hoeverre opleidingsverschillen in roken daardoor worden bepaald. Het blijkt dat in Noord-Europese landen de opleidingsverschillen in roken onder vrouwen groter zijn dan die onder vrouwen in meer zuidelijk gelegen bevolkingsgroepen. Onze resultaten suggereren dat de diffusie van roken het minst ver gevorderd is onder vrouwen in het algemeen, en onder vrouwen in Zuid-Europese landen in het bijzonder. Een verontrustende bevinding is dat ook onder adolescenten en jong volwassenen in de meeste Europese landen wederom sprake is van opleidingsverschillen in roken. Deze bevinding duidt erop dat ook in de toekomst sociaal-economische verschillen in doodsoorzaken die aan roken zijn gerelateerd moeten worden verwacht in alle landen in de EU.

De associatie van roken met twee sociaal-economische indicatoren, opleiding en inkomen, hebben we vergeleken voor de landen van de EU. De resultaten van deze vergelijking staan beschreven in ***Hoofdstuk 9***. Zowel opleiding als inkomen blijken aan roken te zijn gerelateerd, wat inhoudt dat de lager opgeleiden en mensen met een laag inkomen relatief vaker roken dan de hoger opgeleiden en mensen met een hoger inkomen. Echter, wanneer we bij de relatie van inkomen met roken controleren voor het opleidingsniveau dan neemt de relatie van inkomen met roken grotendeels af, zowel onder mannen als onder vrouwen (alleen onder mannen blijft er nog een zwak significant verband van inkomen met roken). Deze resultaten geven aan dat pogingen om verschillen in roken terug te dringen niet alleen gericht moeten worden op de lagere inkomensgroepen, maar vooral ook op de lager opgeleiden.

Hoofdstuk 10 geeft een overzicht van opleidingsverschillen in longkankersterfte in tien Europese bevolkingen gedurende het begin van de jaren negentig. Tevens geeft het de resultaten weer van onze berekeningen van de bijdrage van roken aan opleidingsverschillen in totale sterfte in die tien bevolkingen. Voor het bepalen van de bijdrage van roken aan opleidingsverschillen in totale sterfte hebben we de Peto-methode gebruikt, die op basis van longkankersterfte in een bevolking de expositie aan roken in de betreffende bevolking schat. Met kennis van het relatieve risico van rokers ten opzichte van niet-rokers op sterfte, en met de expositie aan roken in de bevolking, kan met deze methode vervolgens de bijdrage van roken aan sterfte worden geschat Wanneer dit apart wordt berekend voor hoger en voor lager opgeleidden kan de bijdrage van roken aan sterfteverschillen tussen de opleidingsgroepen worden bepaald.

Op grond van de grootte van opleidingsverschillen in longkankersterfte blijkt dat Engeland/Wales, Noorwegen, Denemarken, Finland en België het meest ver gevorderd zijn in de rookepidemie van de bevolkingsgroepen in onze studie. Zwitserland, Oostenrijk, Turijn, Barcelona en Madrid blijken minder ver gevorderd. In Madrid blijkt de hoger opgeleide bevolkingsgroep nog meer te roken dan de lager opgeleide groep. Met behulp van deze gegevens over longkankersterfte en de Peto-methode kunnen we concluderen dat roken een substantiële bijdrage levert aan de opleidingsverschillen in totale sterfte onder mannen van de tien bevolkingen, behalve in Madrid. Onder vrouwen blijkt de bijdrage vooral groot in de noordelijke Europese landen, maar niet/minder in Zwitserland, Oostenrijk, Turijn, Barcelona en Madrid.

Al eerder is uit onze resultaten gebleken dat een groot deel van de hogere sterfte onder de lager opgeleiden in Europese landen wordt opgemaakt uit sterfte aan chronisch obstructieve longziekte (COPD). In ***Hoofdstuk 11*** worden de resultaten beschreven van een wat gedetailleerder onderzoek naar opleidingsverschillen in deze doodsoorzaak in de betreffende Europese landen. Roken blijkt substantieel bij te dragen aan hogere sterfte aan COPD onder lager opgeleide mannen van alle bevolkingen die in het onderzoek zijn opgenomen. Alleen bij vrouwen van Barcelona en van Madrid draagt roken nog bij aan een verhoogde sterfte onder hoger opgeleiden. Deze studie is de eerste die de bijdrage van roken aan verschillen in COPD sterfte tussen verschillende opleidingsgroepen getalsmatig weergeeft. De resultaten suggereren dat pogingen om de verschillen in COPD sterfte terug te dringen zich vooral zouden moeten richten op het terugdringen van verschillen in roken.

In ***Hoofdstuk 12*** tenslotte worden de resultaten van de deelonderzoeken nog eens op een rijtje gezet. Tevens worden de belangrijkste mogelijke validiteitproblemen besproken en worden verklaringen aangedragen voor sociaal-economische verschillen in gezondheid onder ouderen en voor verschillen in roken in Europa. Ook worden op grond hiervan enkele implicaties voor beleid ten aanzien van het terugdringen van gezondheidsverschillen geformuleerd.

De resultaten die in dit proefschrift worden gepresenteerd geven aan dat er substantiële sociaal-economische verschillen in gezondheid zijn onder mannen en vrouwen van middelbare leeftijd en ouderen in Europese landen. Er blijken belangrijke verschillen tussen landen te zijn in het patroon van die gezondheidsverschillen. Dit blijkt vooral uit de bijdrage van verschillende doodsoorzaken in de sociaal-economische verschillen in totale sterfte in de verscheidene landen. Aangezien de verschillen in gezondheid ook onder ouderen groot blijken te zijn, en vanwege het feit dat de verklaring van gezondheidsverschillen onder ouderen gedeeltelijk afwijkt van die van jongere leeftijdsgroepen kan worden gesteld dat toekomstige studies ook aandacht moeten besteden aan de situatie van de oudere bevolkingsgroepen. Dit geldt ook voor het opnemen van gegevens uit andere landen dat alleen uit noordelijke delen van Europa, waarin traditioneel meer onderzoek wordt verricht naar sociaal-economische verschillen in gezondheid. Het blijkt dat roken een belangrijke rol speelt in de huidige gezondheidsverschillen. De resultaten van ons onderzoek wijzen uit dat deze rol ook in de toekomst nog groot zal blijven wanneer geen adequate stappen worden ondernomen om de sociaal-economische verschillen in roken tegen te gaan.

Voor het komen tot een verklaring van sociaal-economische verschillen in gezondheid onder ouderen, en voor verschillen in roken is het van belang dat het ontstaan van die verschillen wordt bezien vanuit een levensloop perspectief. Het ontstaan van die verschillen gebeurt voor een belangrijk deel eerder gedurende de levensloop dan de leeftijd waarop zij worden openbaard. Hierbij kan gedacht worden aan blootstelling aan fysiek zware arbeid, aan het leven in ongezonde huiselijke omstandigheden en/of het moeten leven met aanhoudende of terugkerende materiële ‘stress’. Mede als gevolg van dergelijke factoren ontstaan verschillen in roken en verschillen in gezondheid onder oudere mannen en vrouwen.

Dit houdt in dat die interventies die succesvol zijn in het reduceren van sociaal-economische verschillen in gezondheid eerder in de levensloop ook een positief effect kunnen hebben op het reduceren van verschillen in gezondheid op oudere leeftijd. Dit neemt echter niet weg dat er ook interventies specifiek voor oudere bevolkingsgroepen nodig zijn, bijvoorbeeld wanneer de bedoeling is om disability te voorkomen. Voor verschillen in roken geldt dat er een groot potentieel is om die verschillen terug te dringen, maar dat de huidige stand van beleid en interventies in Europese landen hier nog niet op is gericht. In Europa zal het erkend moeten worden dat het terugdringen van verschillen in roken een noodzakelijke stap is voor het reduceren van verschillen in gezondheid. Het reduceren van verschillen in gezondheid is op zichzelf weer een vereiste voor het verbeteren van de volksgezondheid.

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Curriculum Vitae

Curriculum Vitae

Martijn Huisman was born in 1975. After finishing secondary school he studied for one year at the School for Journalism in Utrecht. He switched to study psychology in Leiden, where he obtained his Master of Arts in Clinical and Health Psychology in 1999. His graduation research project was about multidisciplinary treatment of patients with chronic pain. He wrote a dissertation about the underlying 'factor structure' of personality disorders. Subsequently he worked for a few months as a 'guest worker' at TNO-Prevention and Health, where he learned a bit about the research 'business'. This strengthened his ambition to do a PhD, and in the year 2000 he started working as a PhD student at the Department of Public Health on a project on socio-economic determinants of healthy ageing. During the four years of his PhD project Martijn obtained a Master of Science degree in Epidemiology at the Netherlands Institute for Health Sciences. Since May of 2004 he has worked as a postdoc at the Department of Public Health.

In het jaar 1975 is Martijn Huisman geboren. Vanaf dat moment volgde hij het opleidingstraject zoals dat de gewoonte is in Nederland, tot en met de middelbare school, waar hij in 1993, als leerling van de Blaise Pascal te Spijkenisse, zijn VWO diploma haalde. Na zijn VWO examen volgde hij een jaar onderwijs aan de Hogere School voor Journalistiek en Voorlichting te Utrecht. Daarna is hij psychologie gaan studeren in Leiden. Hij studeerde af in 1999 in de afstudeerrichting Klinische en Gezondheids Psychologie. Hij liep stage binnen een onderzoek naar multidisciplinaire behandeling van patiënten met chronische pijnklachten. Zijn scriptie ging over de onderliggende 'factorstructuur' van persoonlijkheidsstoornissen. Hierna heeft hij enkele maanden als 'gastmedewerker' gewerkt bij TNO-PG, waar hij enkele 'do's and don'ts' van het onderzoeksvak kon afkijken. Hierna is hij als AIO gaan werken aan het instituut voor Maatschappelijke Gezondheidszorg aan een project over sociaal-economische determinanten van gezond ouder worden. Gedurende die tijd heeft hij zijn Master of Science behaald in de Epidemiologie aan het Netherlands Institute for Health Sciences. Sinds mei van het jaar 2004 werkt hij als postdoc bij het instituut voor Maatschappelijke Gezondheidszorg.