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INCOME AND MORTALITY – THE DYNAMICS OF DISPARITY

**A STUDY ON THE CHANGING ASSOCIATION BETWEEN
INCOME AND MORTALITY IN FINLAND**

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ACADEMIC DISSERTATION

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ABSTRACT

Disparities in longevity by income level have been reported in numerous studies in Western industrialized societies, including the Nordic welfare states. It has been found that the association between income and mortality is influenced by other aspects of socioeconomic position, namely education and occupation, as well as by other individual characteristics over the life course including employment status and living arrangements. However, few studies have focused on the possible changes over time in the association. The widening disparity in mortality by education and occupation, together with changes in the distribution of predictors of mortality attributable to changes in Finnish society imply that income disparity in mortality does not remain static over time.

The main aim in this thesis is to describe mortality trends in Finland by household income quintiles, and to investigate the age- and cause-of-death structure of any changes among these groups in 1988-2012. A further aim is to investigate the income-mortality association independently of the individual socio-demographic factors that are present in childhood and adulthood, and how this association has changed over time. Given the identified differences in income disparity by cause of death, being particularly pronounced in alcohol-related causes, the study also focuses on the possibly changing effect of the socio-demographic explanatory factors on income disparity with regard to alcohol-related mortality.

The study data derives mainly from nationally representative samples of 80 per cent of all deaths in Finland in 1988-2007, including individual-level annual information on socio-demographic characteristics. The data originates from various administrative registers linked to cause-specific mortality records in 1988-2012, and also includes data linking these registers to 1950 census information. Disparities in mortality among those aged over 35 were analysed by calculating life expectancies and their decomposition, and fitting survival regression models to the data.

Life expectancy among the highest four quintiles increased substantially over the study period, but stagnation among men and a very slow and minor increase among women caused the disparity with other quintiles to increase markedly in the lowest quintile. The increasing disparity originated to a slightly greater extent from 35-64-year-olds than from older age groups, mainly due to increasing or stagnating mortality in the lowest quintile. Alcohol-related causes of death were the main drivers of the adverse mortality trend in the lowest quintile, although disparities in cancer mortality and ischaemic heart diseases among men also increased the gap in life expectancy between the highest and lowest income quintiles.

The absolute disparity in mortality between the highest and lowest quintiles increased markedly among 35-64-year-olds in 1988-2007.

Mortality relative to the highest quintile increased between 1988-91 and 2004-07 in all other quintiles even following adjustment for individual socio-demographic characteristics including education, occupation, economic activity, and living alone. Changes in the socio-demographic composition of the income quintiles did not explain the increasing or stagnating mortality level in the lowest quintile in 2004-07 among men and women.

The disparity in mortality between individual income quintiles among those aged 35-72 also persisted following adjustment for observed and unobserved factors of childhood family background shared by siblings. In other words, the income-mortality association occurred also within families. Adulthood socio-demographic characteristics were considerably more relevant explanatory factors than childhood characteristics, but the disparity remained even when both were controlled for. This observation was consistent over three cause-of-death groups: cardiovascular diseases, alcohol/violent/accidental causes, and other causes.

The income-mortality association in 1988-2012 originated increasingly from alcohol-related causes in all quintiles, but particularly due to a substantial increase in alcohol mortality in the lowest quintile. Education, occupation and employment status explained 50-60 per cent of the excess alcohol-related mortality in the lowest quintile among men despite the increasing mortality. The proportion even declined among women over the study period, from roughly 70 to 30 per cent.

The individual socio-demographic characteristics in question and their increased prevalence in the lowest quintile did not explain the observed increasing or stagnating mortality among those with a low income. The change in the cause-of-death composition of the disparity in mortality towards alcohol-related causes implies that mental and behavioural problems such as alcohol abuse are increasingly connected to low economic resources. This development may be attributable to the increasingly harmful effects of being on a low income. On the other hand, unobserved personal characteristics harmful to health may increasingly accumulate among those on a low income, and this could be the result of the strengthening selection of persons with poor health and alcohol-use disorders into low income. Both causal and selective paths are likely to be affected by the increasing affordability of alcohol. In any case, the failure of education, occupation and employment status to explain the increasing disparity in alcohol mortality points to a need for research concentrating on other factors associated with processes leading to increasing excess mortality at the low end of the income-distribution scale, particularly in terms of alcohol-related deaths.

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In Kruununhaka, Helsinki
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Lasse Tarkiainen

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

- I Tarkiainen, L., Martikainen, P., Laaksonen, M., & Valkonen, T. 2012. Trends in Life Expectancy by Income from 1988 to 2007: Decomposition by Age and Cause of Death. *Journal of Epidemiology and Community Health* 66: 573–78.
- II Tarkiainen, L., Martikainen, P. & Laaksonen, M. 2013. The Changing Relationship between Income and Mortality in Finland, 1988–2007.” *Journal of Epidemiology and Community Health* 67: 21–27.
- III Tarkiainen, L., Martikainen, P. & Laaksonen, M. & Aaltonen M. 2015. Childhood Family Background and Mortality Differences by Income in Adulthood: Fixed-Effects Analysis of Finnish Siblings. *The European Journal of Public Health* 25 (2): 305–10.
- IV Tarkiainen, L., Martikainen, P. & Laaksonen, M. 2016. The contribution of education, social class and economic activity to the income-mortality association in alcohol-related and other mortality in 1988-2012. *Addiction* 111 (3): 456–64.

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

ABBREVIATIONS

BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular disease
HR	Hazard ratio
ICD	International Classification of Diseases
IHD	Ischaemic heart disease
ISCED	International Standard Classification of Education
KHB	Karlsen, Holm, Breen -decomposition method
OR	Odds ratio
RR	Rate ratio
WHO	World Health Organization

1 INTRODUCTION

Numerous studies conducted in Western industrialized countries in recent decades have documented socioeconomic disparities in mortality (Mackenbach et al., 2003). Elevated mortality generally occurs in the lower categories of each of the interrelated main dimensions of socioeconomic position, which are most commonly considered to be education, occupational social class and income (Backlund et al., 1996; Lynch and Kaplan, 2000; Martikainen et al., 2009). Increasing relative and, to some extent, absolute disparities in mortality by socioeconomic position have also been identified in several European countries, particularly in the northern and eastern parts of the continent. Most studies exploring trends in mortality and changes in socioeconomic differentials in recent decades have concentrated on occupational social classes and educational groups. (Kunst et al., 2004; Mackenbach et al., 2003; Mackenbach et al., 2015b; Martikainen et al., 2001a; Strand et al., 2014; Valkonen et al., 2009; Valkonen and Martikainen, 2006; Wamala et al., 2006) In terms of income, most studies focusing on disparity in mortality take a rather static temporal perspective. Many of them are cross-sectional, or have only a short follow-up, although a few include indicators of mortality differences among income groups covering several periods (Kondo et al., 2014; Rognerud and Zahl, 2006; Wamala et al., 2006). With regard to the US and New Zealand, income has been more widely used in exploring disparity trends (Blakely et al., 2004, 2008; Cristia, 2009; Pappas et al., 1993; Wamala et al., 2006).

There are advantages in using income as a measure of socioeconomic position. Theoretical explanations of socioeconomic disparities in health and mortality emphasize the material factors and their physical and psychological impact on processes determining health status and longevity. Income is a relatively accurate measure of an individual's current material living conditions, and in allowing the identification of individuals experiencing material disadvantage is well in tune with the theoretical explanations. Economically disadvantaged groups are also specifically targeted in programmes tackling the disparity in mortality. The WHO Health 21 programme for the European region aims to reduce the gap in life expectancy between socioeconomic groups by at least 25 per cent by 2020 (World Health Organization, 1999). Accordingly, a similar goal has been adopted on the national level in many European countries, including Finland (Ministry of Social Affairs and Health, 2001).

The association between income and both mortality and morbidity is affected on the individual level by a variety of factors during the person's life course. Childhood family background, events during early adulthood in terms of educational choices, and occupational and employment status in the labour market are among the characteristics that are linked with the income-

mortality association observed in adulthood (Kawachi et al., 2010). These characteristics and their prevalence in income groups differ between cohorts and time periods. Including the temporal aspect in exploring the association between income and mortality also gives insight into the mechanisms behind the income-mortality relationship.

Given the close association of these factors with income, the growing disparity in mortality between educational and occupational groups in Finland implies increasing disparity in mortality by income. Moreover, little is known about the characteristics of this possibly changing association between income and mortality in the international context. The strong post-World War II educational expansion in Finland has continued since the late 1980s, coinciding with changes in economic and occupational structures. The severe recession of the early 1990s increased the unemployment rate sharply and led to cutbacks in social and unemployment benefits. Income inequality grew substantially during the period of economic growth following the recession (Statistics Finland, 2014a). These societal changes have affected not only income distribution but also the distribution of factors associated with income and mortality (e.g. low education and unemployment) among income groups. It is therefore possible that changes in the income-mortality association originate from these factors, and that their explanatory role has changed over time.

The aim in this thesis is to enhance understanding of mortality trends in income groups in Finland, and to investigate the age- and cause-of-death structure of changes in mortality in 1988-2012. The intention is to concentrate on the individual socio-demographic factors that are present in childhood and adulthood and are related to both income and mortality, and to find out how the income-mortality association has changed over time independently of these factors. Moreover, given the evidence of varying income disparity in mortality by cause of death, being particularly pronounced in alcohol-related causes, the analyses also focus on the possibly changing influence of the explanatory socio-demographic factors on income disparity in alcohol-related mortality. The study is based on nationally representative and internationally unique data, which includes individual-level annual information on socio-demographic characteristics. The data originates from various administrative registers linked to cause-specific mortality records covering the period 1988-2012.

Given these aims, the study also contributes to monitoring progress towards the goals set in public health programmes drawn up to tackle disparities in mortality, and identifies and analyses the processes behind the increasing levels of disparity. The findings provide relevant information for those developing policies tackling the disparity and directing resources to interventions targeting groups with excess mortality.

2 INCOME DIFFERENCES IN MORTALITY – THE THEORETICAL FRAMEWORK AND EMPIRICAL EVIDENCE

2.1 SOCIOECONOMIC DETERMINANTS OF MORTALITY

Socioeconomic position is a multifaceted concept describing an individual's position in the societal structure in terms of material and social resources, including status and prestige, normally measured by education, occupation or income, or composite measure of these. It has been found that each of these indicators is negatively associated with mortality (Krieger et al., 1997; Lynch and Kaplan, 2000). Such socioeconomic disparities in mortality have been under extensive scrutiny since the seminal studies of Kitagawa and Hauser, and Townsend and colleagues' Black report describing the socioeconomic patterning of mortality and changes in this patterning over time in the contexts of the United Kingdom and the United States (Kitagawa and Hauser, 1973; Townsend and Davidson, 1982).

Observations of disparity in mortality by each of the indicators of socioeconomic position are largely consistent, but the interrelations among them are complex. This is logical given that education, occupation and income have differing and partially overlapping roles in the system producing the stratified structure of society and the individual's position in it. Stratification processes define certain goods as valuable or desirable, how these goods are allocated to various jobs, and how people end up in these jobs. The resulting uneven distribution of resources concerns not only economic assets, but also the dimensions of social, cultural, honorific and power resources (Grusky and Weisshaar, 2014). Education precedes occupation and income from a temporal perspective, reflecting cognitive resources and knowledge including health-related issues, but is also related to beneficial social networks and status. These qualities are beneficial not only in terms of health but also in attaining a favourable position in the labour market. They are not necessarily the result of education, however, as education may partially mediate or modify the effects of personal general intelligence or personality factors (Calvin et al., 2011; Chapman et al., 2010). Moreover, educational level represents the qualifications needed for attaining a certain occupational status. Occupational class emphasizes employment relations and working conditions (e.g. physical conditions and autonomy in terms of planning and carrying out tasks). Occupation is also related to status and prestige, which do not completely overlap working conditions and employment relations (Bartley, 2004). Of these three dimensions of socioeconomic position income is most directly associated with the individual's access to material resources and services, although there are also indirect non-material aspects of high income in terms of status

and freedom of choice (Lynch and Kaplan, 2000). Non-material aspects such as these are also intertwined with education and occupation.

Events and processes occurring over a person's life course determine a significant proportion of his or her income at any given time in adulthood. These processes, in turn, originate from educational and occupational choices embedded in the childhood-background context, including parental socioeconomic status and other individual characteristics and resources. Hence, socioeconomic dimensions are associated not only within but also across generations. This is reflected in the fact that parental socioeconomic background and childhood conditions are associated with income in adulthood to varying degrees in Western industrialized societies (Jäntti et al., 2006).

Each of the above-mentioned dimensions of socioeconomic position, although overlapping and interrelated, are also independently associated with health and mortality and therefore are suggested to be part of a different aetiological mechanism (Braveman et al., 2005; Geyer et al., 2006). It is necessary to understand the role of these socioeconomic dimensions in the explanatory mechanisms in studying the association between mortality and one particular dimension, namely income, and any temporal changes in the association.

2.2 EXPLANATIONS OF THE SOCIOECONOMIC GRADIENT IN MORTALITY AND HEALTH

The association of socioeconomic position with health and mortality is widely documented in Western industrialized societies, but the mechanisms linking socioeconomic position to mortality and morbidity, and the possible causation between them are debated. The pathways that appear to link each aspect of socioeconomic position to health and mortality generally involve explanatory mechanisms in the form of material, psychosocial, behavioural factors, and a life-course perspective (Bartley, 2004). Income asserts its effect on health mainly via these pathways by processes formulated in the absolute-income and relative-income hypotheses (Kawachi et al., 2010). These hypotheses and explanatory mechanisms are therefore introduced in the following sub-sections, with an emphasis on the income hypotheses that are most relevant to the particular mechanism, and the explanations that do not imply direct causality are then presented. The observed association between socioeconomic position and mortality may result from selection in that other unobserved confounding factors explain both the level of income and mortality risk, or then deteriorating health preceding death may negatively affect income. Furthermore, the processes resulting in overrepresentation of those with poor health in the lowest socioeconomic strata operate at various stages of the life-course. This section concludes with the construction of a theoretical explanatory framework accounting for the

various mechanisms. The framework is used in the rest of the study to assess temporal changes in the income-mortality association in the context of Finland.

2.2.1 MECHANISMS LINKING SOCIOECONOMIC POSITION TO HEALTH

Material explanations and the absolute income hypothesis

Material explanations of the relationship between socioeconomic position and health emphasize access to material resources given that greater economic resources facilitate the purchasing of more and higher-quality goods and services, including housing, food, health care, and recreational and physical activities. These material resources give some protection against environmental risk factors and help in overcoming illness and maintaining health. Material factors tend to be emphasized when income is used as a socioeconomic measure, although its health-related advantages in these material terms diminish as the income level increases given that one can acquire neither complete resistance to disease nor immortality by such means. However, there are still disparities in material conditions across all income groups (Lynch and Kaplan, 2000). The absolute income hypothesis relies mainly on the dependence of these health-promoting aspects of consumption on the level of absolute income (Kawachi et al., 2010). On the other hand, lower income also restricts access to health damaging goods including alcohol and tobacco.

Low level of absolute income is also likely to have deleterious effects on health even if basic material conditions are fulfilled in that a low income restricts opportunities for social participation and decreases the level of control over one's life. These aspects are related more strongly to the psychosocial and behavioural mechanisms introduced in the following sections (Bartley, 2004; Marmot, 2002). Material explanations cover risk factors that are present not only in the sphere of consumption but also in production. Individuals in the lower socioeconomic strata are more highly exposed to occupational health hazards such as physically strenuous work, dangerous substances and work-related accidents (Bartley, 2004).

The neo-materialist approach emphasizes the public provision of services, unemployment benefits and housing subsidies on the general level of public health in addition to these material factors on the individual level. Such societal-level measures offset material deprivation to some extent in that individuals with a low income have access to health services and proper housing irrespective of income (Bartley, 2004; Lynch et al., 2000). The neo-material perspective generally relates to population-level health differences between countries, but in as far as the provision and coverage of subsidies

and benefits may change over time within a country, the neo-material perspective is also relevant for studying country-specific mortality trends.

The majority of studies report a non-linear association between absolute income and mortality. A decrease in age-adjusted mortality has been found in line with increasing absolute income, but only to a limited extent: there appears to be no decrease in risk among the higher-income groups despite the increase in income, resulting in a curvilinear income-mortality relationship (Backlund et al., 1996; Dowd et al., 2011; Martikainen et al., 2009; Rehkopf et al., 2008). This implies that a low level of income in particular is relevant to an increased mortality risk and thereby providing some support for the absolute hypothesis. However, there is some evidence that the shape of the association depends on the cause of death, a non-linear shape being more pronounced in accidental and violent causes (Martikainen et al., 2001b; Rehkopf et al., 2008).

Material resources are emphasized when income is used as the indicator of socioeconomic position. Various definitions of income basically describe access to services and material resources, but there are conceptual and empirical differences between the measures. Individual income emphasizes personal aspects of income in terms of status, whereas household income represents the material-consumption potential of an individual. Disposable income accounting for taxation and income transfers yields more accurate information about consumption potential given the differing redistributive systems of welfare states. It should nevertheless be borne in mind that income during a particular period does not fully depict access to material resources, in that wealth accumulated in previous years from income, investments or inheritance affects real consumption potential. Given the observed positive association between wealth and health, also to some extent net of income, it seems that wealth partially modifies the income-mortality association. This is particularly pronounced in older ages as incomes drop due to retirement (Aittomäki et al., 2010; Martikainen et al., 2003; Semyonov et al., 2013).

Psychosocial explanations and the relative income hypothesis

The psychosocial environment, which includes social support, control and autonomy at work, the balance between both home and work, and efforts and rewards, is considered to be one mechanism linking socioeconomic position and health (Bartley, 2004). On the theoretical level it is linked to an individual's self-efficacy and self-esteem, as well as to feelings of inequality, grief and loneliness (Elstad, 1998; Siegrist and Marmot, 2004). It is suggested that people in a low socioeconomic position are more exposed to the negative aspects of the aforementioned factors. These factors may cause psychological stress, the adverse health effects of which constitute the aetiological basis of the psychosocial mechanism. Stress may affect the development of somatic diseases directly through the biological stress

responses of the central nervous system, which happens if the stress response is triggered too often and for too long. The resulting cumulative physiological burden, the allostatic load, is linked to several health outcomes (Beckie, 2012). However, the association between socioeconomic position and allostatic load is evidently not straightforward in general, but disparity regarding the cardiovascular and metabolic components of allostatic load has been reported. On the other hand, these components are also influenced by health behaviour and not necessarily directly by psychosocial stress (Dowd et al., 2009). The other more indirect effect of psychological stress is mediated through health-damaging behaviour intended to alleviate stress, smoking and extensive alcohol consumption in particular being mentioned as ways of reacting to an adverse psychosocial environment (Elstad, 1998).

Stress reactions and a high allostatic load may be attributable to experiences of economic uncertainty and hardship. It has been found, for example, that material factors explain the association between socioeconomic position and allostatic load to a substantial extent (Robertson et al., 2015). Although this is in line with the absolute income hypothesis, it is the relative income hypothesis that tends to be identified with psychosocial mechanisms. It is implied in the latter that health is affected by the relative gap between an individual's own income and the income of some reference group, whether it be neighbours, the average population or the highest income quintile. In this case the income gap has a negative effect on health irrespective of the income level, and the effect does not have a specific limit: the larger the gap, the stronger the effect (Kawachi et al., 2010). It is suggested that this relative deprivation is linked to psychosocial aspects such as self-efficacy, self-esteem and experiences of inequality and imbalance between efforts and rewards. Disentangling these relative and absolute income hypotheses is difficult in that both are theoretically relevant and consistent with material and psychosocial mechanisms, and are difficult to identify independently in empirical terms due to evident collinearity between them (Gravelle and Sutton, 2009; Kawachi et al., 2010).

The identification of relative deprivation empirically tends to rely on indices measuring the gap between a person's own income and the income of the selected reference group. Different approaches in calculating these measures allow for comparison with those on higher or lower incomes. These relative-deprivation measures are used to predict mortality while controlling for the absolute level of a person's income. Studies utilizing such techniques generally report at least a weak individual-level association between relative deprivation and health. However, the variation in results by the chosen reference group and the fact that a relatively low income may be the result of poor health compromise the evidence obtained from these studies (Adjaye-Gbewonyo and Kawachi, 2012; Gravelle and Sutton, 2009). Given these caveats, an association between relative deprivation and health has been found on the individual level in Finland, Sweden and Norway (Åberg Yngwe et al., 2005), and with regard to mortality among men and women in

Sweden, and men in Japan (Åberg Yngwe et al., 2012; Kondo et al., 2015). In the Swedish case the effect of relative deprivation turned out to be weak among the poorest, implying that the psychosocial effects of social comparison may be stronger among those not experiencing absolute financial hardship.

Not all aspects of the psychosocial environment are equally related to income: psychosocial aspects such as control and autonomy at work, for example, exert their influence through occupational position and conditions although these are often correlated with income. Social support is directly connected to marital status, living arrangements and social networks, but not necessarily to income. These aspects are relevant given the evidence identifying social isolation and living alone as a mortality risk (Koskinen et al., 2007; Pantell et al., 2013). On the other hand, economic hardship may hinder the maintenance of social networks. In general, it appears that accounting for psychosocial aspects does attenuate disparities in mortality by income to some extent. It was found among Norwegian men with no reported health problems that psychosocial factors (feelings of loneliness, dissatisfaction, unhappiness and tiredness, and marital status) explained 30-40 per cent of the relative excess mortality in the lowest income quartile, and 30 per cent in the second and third quartiles compared to the highest quartile (Skalická et al., 2009, 2015). In the Finnish context, psychological distress (depression, stress and insomnia) explained 31 per cent of the excess mortality attributable to alcohol-related causes, suicide and accidents among unemployed men, and 26 per cent among women. However, the explained proportion of excess mortality attributable to these causes in the lowest household income tertile was 16 and 14 per cent among men and women, respectively. These factors had only negligible explanatory power in disparities attributable to coronary heart disease (Talala et al., 2011).

Behavioural and cultural explanations

Low-level income, education and occupational class seem to be associated with consumption patterns and behaviour that are detrimental to health, including poor diet, lack of exercise, smoking and harmful use of alcohol. According to the psychosocial perspective people react to adverse circumstances by engaging in health-damaging behaviour via excessive alcohol consumption and smoking, for example (Bartley, 2004; Elstad, 1998). Cultural and behavioural explanations of health inequalities posit that health behaviour is embedded in the social structure of socioeconomic groups, but given the difficulty in defining culture and its characteristics with regard to socioeconomic strata, the emphasis of the cultural approach tends to be on education and the intergenerational transmission of educational level and health behaviour (Bartley, 2004).

More direct behavioural explanations tend to relate health behaviour and life-style to personality characteristics. Characteristics such as external locus of control, neuroticism, low conscientiousness and negative coping styles are related to poor health and mortality (Bosma et al., 1999; Jokela et al., 2013). On the other hand, it is also possible that a low level of economic resources, and experiencing financial difficulties in particular, have a negative effect on cognitive control and therefore lead to harmful health behaviour through lowered self-regulation (Buckley et al., 2014; Mani et al., 2013). In this case the economic hardship would have independent adverse effects on health behaviour, and further exacerbate the negative effects of certain personal characteristics on health (e.g. susceptibility to substance addictions).

Generally, the proportion of excess relative disparity in mortality explained by health behaviour in the lowest income group varies in different populations and studies. For example, explanatory percentages of 27 and 20 were reported among Norwegian men and women, respectively, compared with 56 per cent among British civil servants and 23 per cent among the French employed population (Skalická et al., 2015; Stringhini et al., 2011), and according to a nationally representative survey in the US, health behaviours explained 68 per cent of the relative excess mortality of the lowest socioeconomic group in a composite measure (Nandi et al., 2014). Generally in Finland, observed health-behavioural factors (smoking, alcohol consumption, a poor diet, physical activity and high body mass index (BMI)) have been found to account for 45 and 38 per cent of the relative educational disparity in mortality among men and women, respectively (Laaksonen et al., 2008). Even though there is little evidence of an effect of health behaviour on the income-mortality association in Finland, the patterning of unhealthy behaviour by income quintiles has been reported, particularly in terms of smoking, low vegetable consumption and high BMI (Harald et al., 2008; Laaksonen et al., 2003). It must be noted, however, that accounting for these health behavioural factors may explain a large part of the level of mortality in all socioeconomic groups. Therefore also a larger proportion of the absolute mortality gap between extreme groups can be explained than in terms of relative excess mortality (Kivimäki et al., 2008; Lynch et al., 2006).

Obtaining reliable information on health behaviour on the individual level is challenging, particularly among the most economically deprived groups. This applies specifically to health-damaging behaviours such as smoking and harmful alcohol consumption. These are strong risk factors for specific causes of death including liver disease and lung cancer, which are in turn patterned by socioeconomic position (Mackenbach et al., 2015a; Mackenbach et al., 2015c). Therefore, assessing the contribution of these causes of death to the total disparity in mortality allows some inferences regarding the relevance of behavioural explanations. For example, mortality from alcohol related diseases and accidental alcohol poisoning accounted for 13 per cent of the gap in life expectancy between upper white-collar and blue-collar worker men in Finland in 2001-05 (Valkonen et al., 2009). However, smoking and

excessive alcohol consumption also affect mortality attributable to causes other than lung cancer and alcohol-attributable diseases, and concentrating on these specific causes would underestimate the burden of such behaviour on population health and disparities in mortality. For example, information on the death certificate regarding the contributory role of alcohol intoxication or alcohol-related diseases can be used to assess the burden of alcohol on mortality (e.g. Herttua et al., 2007). Furthermore, methods estimating health damage caused by smoking indirectly on the basis of lung-cancer mortality in Western industrialized countries have been developed to tackle this problem (Peto et al., 1992; Preston et al., 2010). It has been reported in a Finnish study based on these methods that of the absolute educational disparity in mortality among 50-69-year-olds in 2006-10, roughly 30 per cent was attributable to smoking. In older age groups the contributions were close to 50 per cent among men and less than 10 per cent among women (Martikainen et al., 2013). However, the contribution of smoking to disparities in mortality is likely to vary in countries at different stages of the smoking epidemic. It is also evident in the Finnish case that smoking is an increasingly relevant driver of disparity among women, whereas among men the contribution among those under 70 is decreasing.

2.2.2 DIRECT AND INDIRECT SELECTION

The observed association between socioeconomic position and mortality is probably somewhat attributable to unobserved, pre-existing confounding factors that increase the propensity to belong to low socioeconomic strata, and also increase the risk of ill health or mortality. This is often referred to as the indirect selection process. The personality characteristics and intelligence introduced in the previous section, for example, are associated not only with health behaviour but also with achieving an advantageous social position. This perspective emphasizes the selective process underlying the socioeconomic gradient in health. Adjusting for these personality characteristics attenuated relative all-cause disparities in mortality by 20 per cent when a composite measure of socioeconomic position was used (Chapman et al., 2010), and by 28 and 11 per cent among men and women, respectively, when measured by income (Nabi et al., 2008). In the case of mortality attributable to cardiovascular diseases (CVD) the attenuation of the association with income was 44 per cent among men but negligible among women (Nabi et al., 2008). Personal characteristics related to intelligence (measured by IQ-tests) have also been linked to adult mortality, although childhood IQ, for example, does not explain the educational disparities in adult mortality. The IQ level in adulthood is also associated with mortality, but the causal process is unclear in that socioeconomic position and education confound and mediate the effect of general intelligence (Calvin et al., 2011; Lager et al., 2009).

Selection is considered to be direct rather than indirect if a person's socioeconomic position has decreased due to deteriorating health, or if poor health has hindered socioeconomic advancement. Direct selection is also known as "reverse-causality" (Kawachi et al., 2010). This covers also cases, for example, in which socioeconomic position decreases due to excessive consumption of alcohol and severe alcohol-related health problems occur afterwards. Reverse causality is likely to be more relevant to income than to other socioeconomic indicators in that the onset of poor health occurring after attaining educational level and occupational position seldom decreases their level. However, it seems that direct selection does not completely explain the association between income and both health and mortality because the disparities, albeit somewhat more modest, are observed in studies including only a healthy population at baseline or accounting for health at baseline (Martikainen et al., 2003; Rehkopf et al., 2008; Skalická et al., 2009). It was also found that the income-mortality disparity did not decrease substantially within 10 years of the income observation, which should occur if people selected into low income due to very poor health were to die during the ten-year period (Hofoss et al., 2013). It has also been shown in a Norwegian study among the middle-aged that although the income from work decreases drastically a few years before death, there is not a substantial drop in total income including all income sources. However, this is likely to depend on the generosity of social benefits in the welfare system in question (Elstad and Dahl, 2014).

Generally there is empirical support for both the selection and the causation hypotheses. Causation seems to play a bigger role in determining status-related disparities in health in terms of education, occupation and household income, whereas both explanations are equally relevant for measures that are closely related to the labour market, such as wages and employment (Kröger et al., 2015). The causality of the association between income and both health and mortality is thus bi-directional, and the roles of causation and selection may differ by health outcome as well as by the definition of income.

2.2.3 THE ASSOCIATION BETWEEN INCOME AND MORTALITY OVER THE LIFE COURSE: AN EXPLANATORY FRAMEWORK

The causal and selective processes introduced above are not mutually exclusive, but operate in interaction with each other at different stages of a person's life. These mechanisms and other processes, both social and biological, are integrated into the life-course perspective, a framework that is commonly used in explaining socioeconomic disparities in mortality (Kuh et al., 2003). It is central to this perspective that health in adulthood can be considered as the result from paths and accumulated events and exposures over the life course, starting from prenatal and childhood conditions (Cohen

et al., 2010; Rahkonen et al., 1997). The evidence suggests that a low parental socioeconomic position is associated with increased mortality in adulthood attributable to several causes, cardiovascular disease in particular but also other causes that are closely related to behavioural risk factors (Galobardes et al., 2004, 2008; Lawlor et al., 2006).

Low socioeconomic resources in the childhood family, and therefore exposure to adverse psychosocial and physical conditions are hypothesized to affect health status and disparities in health and mortality at older ages. Adverse environmental factors are linked to a higher prevalence of psychological problems (e.g. language impairment and hyperactivity) and poor health behaviour, as well as physiological deficits (e.g. higher exposure to infection) among children in families with a low socioeconomic position (Cohen et al., 2010; Van De Mheen et al., 1998). These disadvantageous factors may have a direct effect not only on health in adulthood but also on developing personality characteristics, and on poor educational achievement leading to a low status in other aspects of socioeconomic position and thereby indirectly affecting the adult health (Van De Mheen et al., 1998). Evidence suggests that this indirect effect accounts for much of the disparity in mortality by childhood socioeconomic background (Elo et al., 2014).

These indirect effects are relevant with regard to income given that attained educational level partially mediates the effect of parental background on income in adulthood. There are a few studies exploring the effect of childhood conditions on the income-mortality association in adulthood (Claussen et al., 2003; Lynch et al., 1994; Martikainen et al., 2009). Of these, only two have quantified the attenuated excess mortality in the lowest income deciles, at less than 10 per cent, when observed childhood factors including parental socioeconomic position or growth rate in utero were accounted for (Fors et al., 2012; Martikainen et al., 2009). However, numerous childhood factors are neither observed nor accounted for in these studies. There have been a few attempts to account for various unobserved factors with regard to educational differences in mortality by comparing siblings with differing educational attainment but shared childhood factors. These studies generally report more moderate disparities in mortality between siblings than in respective cohorts (Elo et al., 2014; Næss et al., 2012; Søndergaard et al., 2012). Studies assessing the effect of these unobserved childhood characteristics shared by siblings on the disparity in mortality by income in adulthood are still lacking. Results concerning the role of childhood characteristics on adult mortality are hampered not only by challenges related to the unobserved factors but also by the long time span. Information on childhood is susceptible to recall bias, which may lead to underestimation of the effect of childhood family characteristics on disparities in mortality in adulthood.

Although the life-course perspective tends to emphasize the role of adverse exposures in childhood, disadvantages also accumulate later in life. The income-mortality association has been found to differ by age range, and

the disparity is generally less pronounced after retirement (Backlund et al., 1996; Duncan et al., 2002; Fors et al., 2012; Martikainen et al., 2009; Martikainen et al., 2001b). This is attributable in part to the differing relevance of causal mechanisms during working age and after retirement, and also to selective mortality in that people with poor health in low socioeconomic groups tend to die before reaching an older age (Fors et al., 2012). Reverse causation is also less of an issue at older ages in that income increasingly derives from pensions and is therefore less dependent on functional capacity.

Income measures may include total income over the life course or during a certain period, such as one year. In this case it is a dynamic indicator, which can differ substantially between periods. Exposure to low income may therefore be brief, periodic or continuous. Short-term changes in income could be considered a product of reverse causality, or disruptive noise around the permanent income measure (Cristia 2009). They could also be indicative of the uncertain economic situation of the individual that may be associated with an increased mortality risk in the long run. The evidence suggests, however, that although changes in income, and decreases in particular, do affect health negatively to some extent, income level and persistent poverty are more relevant (Benzeval and Judge, 2001; Gunasekara et al., 2011; McDonough et al., 2005; Miething and Yngwe, 2014). Defining falls and rises in income from the overall level and separating their effects on health from the level of income is a complex and somewhat problematic process. Bævre and Kravdal (2014), for example, report increasing mortality by increasing income if the level of income is controlled, whereas at the same time the rise in income contributes to income level, which is negatively related to mortality.

The explanatory framework of the study

In the context of this study, the conditions and characteristics that are present in childhood, and personality characteristics originating in part from these conditions underlie the associations that form later in life (Figure 1). Not only do education, occupation and employment precede income temporally and, to some extent, causally, their effect on health and mortality is also intertwined with the same psychosocial and behavioural mechanisms over the life course. Observed income-mortality relationships originate in part from educational and occupational differences in psychosocial and behavioural risk factors. The income-mortality association is thus partially confounded by the health effects of education and occupation, although income also mediates their effects on health to some extent (Lahelma et al., 2004). This is evident in several studies reporting a notable attenuation of the income-mortality association following adjustment for educational level and occupational class (Elo et al., 2006; Martikainen et al., 2001b; Rognerud and Zahl, 2006). Attenuation in the effect of income has also been observed

in the Nordic countries with regard to self-rated health (Fritzell et al., 2004; Huijts et al., 2010). Income partially mediates the effect of education in material terms, but it is also suggested that its effect on health is modified by education in that high levels of educational resources might compensate the adverse effects of a low income (Schnittker, 2004).

Income originates from various sources including employment, welfare benefits, pensions and capital income. Individual income is determined not only by education and occupation, but also by employment status. Unemployment and retirement are major determinants of a low income in that unemployment benefits and pensions do not generally compensate fully for the loss of labour income. Given that both benefits are generally earnings-related, the absolute levels tend to be higher among those with a high long-term income. Employment status is somewhat dependent on functional ability, and therefore poor health, illness and disability lead to a higher probability of becoming unemployed and make re-employment more difficult (e.g. Böckerman and Ilmakunnas, 2009). In this sense labour-force participation could be considered a proxy for a poor health status, thus controlling for it in the analyses may underestimate the effect of income (Blakely et al., 2004), particularly if the propensity of exiting the labour force due to poor health is related to the causal mechanisms of low socioeconomic position influencing health. This is plausible given that the risk of disability retirement has been shown to be roughly 30-per-cent higher in the lowest than in the highest income quintile, and even more elevated among those with a low educational level and manual workers after controlling for other socio-demographic factors (Leinonen et al., 2012).

Regardless of health-based selection into unemployment and early retirement, it is also possible that unemployment has an independent negative effect on mortality risk (Clemens et al., 2015; Lundin et al., 2010; Martikainen et al., 2007b; Roelfs et al., 2011). The results of meta-regression analyses suggest a 63-per-cent higher risk of death among those experiencing unemployment following adjustment for additional covariates. Studies controlling for health behaviours have reported only a 24-per-cent lower excess mortality among the unemployed than those not doing so. Furthermore, the effect of unemployment appears to be less pronounced among women (Roelfs et al., 2011). Given that these studies may not fully control for health-based selection the direct effect of unemployment may not be substantial (e.g. Martikainen et al., 2007b). However, it is plausible to suppose that unemployment may exacerbate existing health problems. Hence, employment status may also act as a confounder by affecting both mortality risk and income.

This complex association of economic activity with income and mortality is evident on the empirical level in that adjusting for economic activity or employment status attenuates the income-mortality association substantially (Backlund et al., 1996; Martikainen et al., 2009; Martikainen et al., 2001b). In the case of New Zealand no association was observed when employment

status was controlled for, and when only the employed were included in the analyses excess mortality among those with a low income was observed only during late 1990s (Blakely et al., 2004).

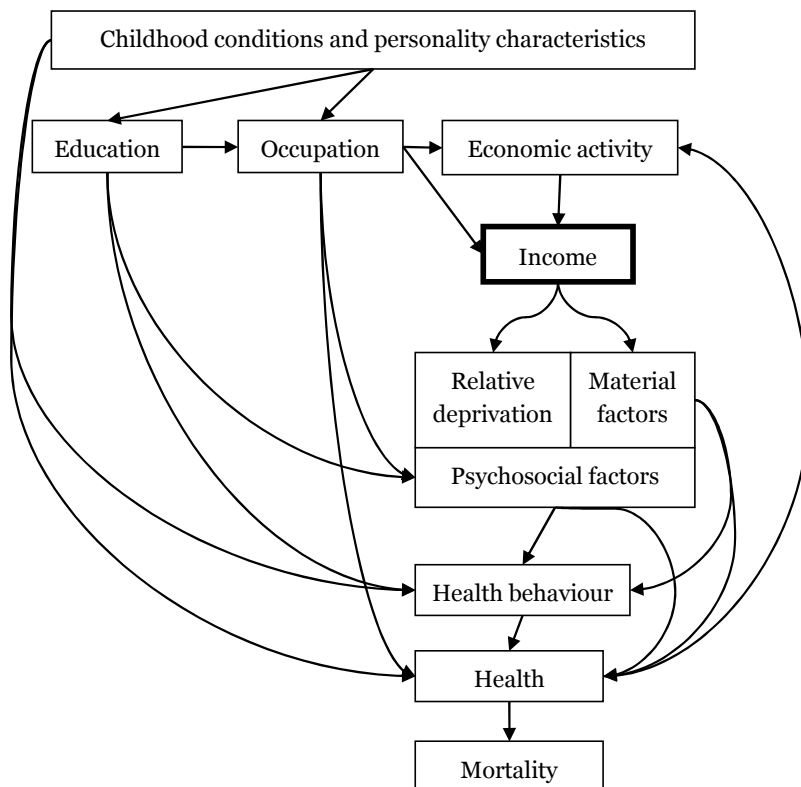


Figure 1 A simplified theoretical framework of the association between income and mortality

2.3 THE TEMPORAL PERSPECTIVE

Changes in the association between income and mortality

Most of the few studies focusing on general mortality trends in income groups report increasing disparities. The increase can be absolute in terms of widening gap in life expectancy or mortality rate between income groups. Relative disparity increases when the mortality rate of the lowest income group is proportionally higher than before compared to the rate of highest income group. As the general level of mortality declines the relative disparity can increase even if the absolute gap between mortality rates remains the same. In the case of New Zealand, the absolute disparity between income tertiles remained at the same level despite a decreasing mortality level among people aged between one and 74 years between 1980-84 and 2001-04. This led to an increase in relative disparity over time, although there were signs of decreasing absolute disparity among the over-45s. On the other hand, there was an increase in absolute disparity among men and women aged 25-44 due to stagnating mortality in the lowest income group (Blakely et al., 2008; Wamala et al., 2006). Similarly stagnating mortality since the mid-1990s has been reported among Swedish men aged 30-64 in the lowest individual-income quintile, whereas the mortality rates among women rose in 1990-2007. In terms of household income life expectancy has also stagnated among women on low incomes in Sweden, which together with the mortality decline in other quintiles has resulted in widening disparity in both absolute and relative terms (Hederos Eriksson et al., 2014; Kondo et al., 2014; Östergren, 2015).

Relative mortality differentials by income also increased in the United States between the 1960s and the 2000s (Cristia, 2009; Pappas et al., 1993). This occurred in all age groups, but more so among the under-65s. There was an increase in absolute disparity in 1983-2003 due to stagnating life expectancy in the lowest quintile, and an increase in other quintiles among men, whereas among women life expectancy declined in the two lowest and increased in the two highest quintiles (Cristia, 2009). In the US the association between absolute income and mortality has proved to be highly curvilinear, and grew stronger at the lower end of the income-distribution scale in 1970-1999. The proportion of the population exposed to a steep income-related mortality risk increased from nine to 32 per cent (Dowd et al., 2011).

Studies exploring both income and educational trends related to disparity in mortality report differing developments when education is used as a socioeconomic indicator (Rognerud and Zahl, 2006; Wamala et al., 2006). Some of the differences between these indicators are attributable to the differing emphasis on causal mechanisms and selection by each indicator. There are two major advantages in using income rank rather than education or occupation as a socioeconomic indicator in studies focusing on how

disparity in mortality changes over time. First, the proportions of educational and occupational groups vary substantially over time due to educational expansion and structural changes in the economy, whereas indicators of income rank remain proportionally equal. Second, income allows the identification of concentrated groups experiencing material disadvantage, whereas the proportion of people with a low educational or occupational status is likely to be up to 40 per cent in most European societies.

Possible explanations of changes in the income-mortality association

Within the theoretical framework presented above the strengthening of the income-mortality association observed in these previous studies may be attributable, first, to the strengthening causal effect of income on mortality, second, to escalating selection into income groups by poor health or personal characteristics that are detrimental to health or third, to the increasing relevance of other factors associated with both income and health, such as other dimensions of socioeconomic position.

The causal effect of income may strengthen from the absolute material perspective if the purchasing power of goods and services relevant to health at the lower end of the income-distribution scale decreases or diverges a lot from other income groups. This occurs if wages in low-paid jobs or the level of social benefits lag behind the general developments in income. The latter condition is relevant in welfare states in that a substantial proportion of income in the lowest deciles originates from income transfers. Further in the context of welfare states, the decline in the provision or reach of public health and social services may weaken the material conditions of those who cannot afford to acquire market-priced services (e.g. healthcare and affordable housing). If psychosocial factors are to explain the widening mortality, exposure to adverse psychosocial effects should have become more unequal in terms of income (Mackenbach, 2012). Although psychosocial stress due to material hardship is not likely to have increased among those on a low income, it is possible that coping strategies become more detrimental to health. Increasing affordability of health damaging goods like alcohol and tobacco may also contribute to these harmful coping strategies particularly among those with a low income.

In the case of increasing selection the probability of ending up in a low-income group would rise among those with poor health or personal characteristics that are detrimental to health (Elo, 2009). This occurs if losing a job or having to change to a lower paid job for health reasons becomes more common or, on the other hand, re-employment after a short unemployment spell is difficult due to health problems. There are several reasons for this. First, when the unemployment rate rises due to economic cycle and competition for jobs on the labour market gets tougher. Second, it may be that working life in general has become more intense and demanding in terms of health. Norwegian evidence indicates an increase in health-

related exclusion from the labour market, which occurs to some extent irrespective of economic cycles (Wel et al., 2010). On the other hand, increasing selection also occurs if sickness benefits and pensions are cut or do not follow general developments in income. Third, it is possible that widening disparities in mortality are attributable to increasing intergenerational social mobility. As parental background decreasingly determines the socioeconomic position of offspring, those with beneficial personality characteristics with regard to education and health are more likely to move to a higher socioeconomic position. Hence, those without further education are increasingly selected by personal characteristics that not only hinder educational attainment but are also detrimental to health (Mackenbach, 2012). Fourth, selection strengthens if morbidity of diseases that severely hinder employment increases in the population irrespective of the income level. For example, evidence suggests that alcohol consumption and alcohol-related health problems tend to be more common during economic boom, partially because people have more money to spend on alcohol (Mäkelä, 1999; Ruhm and Black, 2002). Consumption and harms can increase also among those, whose real income is not increasing during the economic boom if the real price of alcohol decreases.

Finally, the income-mortality association is affected if the distribution of other socioeconomic characteristics associated with both income and health, changes between income groups, or their independent effect on mortality strengthens over time (Elo, 2009). In other words, being unemployed or having a low educational or occupational status may be more hazardous to health than previously, or the extent of the aforementioned characteristics may increase in the lowest income groups (Chen et al., 2013). The latter explanation is plausible in that the proportions of these characteristics tend to change in line with economic cycles and structural changes in the economy and education. The effect of these factors on health may also become stronger if there is further accumulation of adversities among people with these characteristics.

Studies providing evidence of increasing disparity in mortality by income, in relative or absolute sense, do not generally consider whether this occurs because of the increasing prevalence of other individual characteristics that are detrimental to health among those on low incomes. The few studies addressing this aspect give conflicting evidence of the extent to which changes in the composition of the lowest income groups explain the increasing disparity. In the case of Norway, the absolute mortality rates among middle-aged men and women remained stable in the lowest quartile from the 1970s to the 1990s but dropped in the other quartiles in the 1990s. The resulting increase in the relative disparity in mortality remained even following adjustment for education, household size and the urbanity of the area (Rognerud and Zahl, 2006). However, the strengthening relative income-mortality disparity observed in New Zealand in 1981-1999 was generally attenuated when labour-force status was controlled for, but there

were signs of increasing excess mortality among the lowest income groups in the 1990s when the analysis only covered the employed population (Blakely et al., 2004).

Furthermore, given that age is also related to income and to mortality risk, population aging may have an effect on the observed disparity in mortality by income. According to Swedish evidence, increasing disparity in health by income is attributable in part to the decreasing income in an increasing proportion of the population due to retirement and deteriorating health related to old age (Islam et al., 2010). On the other hand, it is unlikely that population ageing has a profound effect on the disparity in ages before retirement.

Causes of death contributing to changes in the income-mortality association

There are also a few studies exploring the cause-of-death structure of the increasing disparity by income in the context of New Zealand and Sweden. The general decline in CVD mortality is narrowing the absolute gap between extreme income tertiles at ages 1-74 in New Zealand, whereas the decrease in mortality attributable to circulatory diseases in Sweden has been greater in the highest income group compared to the lowest. The positive development in New Zealand was offset by an increasing gap in cancers other than lung cancer among both men and women, and in lung cancer among women, in 1980-1999, but there were signs of a decreasing gap in these causes in the early 2000s. Mortality attributable to lung cancer and respiratory diseases increased among women and stagnated among men with low incomes in Sweden: this markedly widened the gap between the extreme quintiles as the respective mortality in the highest income group decreased, with the exception of lung cancer among women (Blakely et al., 2008; Fawcett and Blakely, 2007; Hederos Eriksson et al., 2014).

No other studies give information on the cause-of-death composition of trends in the income-mortality disparity. On the other hand, broadly similar results have been obtained when education was used as a socioeconomic indicator. Absolute disparities in CVD mortality by educational group decreased among men and women in North and West Europe between the 1990s and the 2000s, although this development was partially offset by increasing absolute disparities related to cancer, particularly among women. Mortality attributable to lung cancer has increased among those with a low educational level, with a slower decline in other cancers compared to those with a high education (Mackenbach et al., 2015b).

These results are somewhat in line with the hypothesis stating that increasing disparities in mortality occur because improvements in population health are increasingly dependent on behavioural change, the implication being that immaterial factors such as personality characteristics and social resources are increasingly related to health status (Mackenbach, 2012).

3 THE FINNISH CONTEXT

This study is set in post-1980s Finland. A steady and continuing decline in mortality over several decades and an ageing population serve as the backdrop to the changes in the structure of Finnish society that have occurred since the late 1980s. The distributions of the socio-demographic determinants of mortality, including education, occupation, income and employment status, have not remained static. The unemployment rate increased sharply during the recession of the early 1990s, from roughly three per cent in the late 1980s to 16-18 per cent in 1993-1996, decreased to seven per cent by 2008 and then increased slightly (Statistics Finland, 2015a). The recession partially precipitated the structural changes in the economy from manufacturing towards services. These changes have been reflected in the increase in the gini-index describing inequality in terms of disposable income: there was a rise from 20 to 28 per cent in 1988-2007, and a slight decrease to 26 per cent in 2012 (Statistics Finland, 2014a).

There has been some research on the disparity in mortality between income groups in the Finnish context. The age-adjusted relative rate of disease mortality between the extreme household-income deciles was roughly 2.7 among men and close to 2.5 among women aged 30-64 in 1991-95. The respective relative rates in accidental and violent causes were roughly four among men and three among women (Martikainen et al., 2001b). A later study focusing on the same age range reported age-adjusted all-cause hazard ratios between the extreme deciles of over three-fold among men and over two-fold among women in 1998-2004 (Martikainen et al., 2009). It is difficult to determine from these two studies whether the association has changed over time, thus a significant research gap exists in terms of understanding income differences in mortality over time both in Finland and internationally. Only one study has reported that there were no changes in the self-rated health gradient by household disposable income in 1986-1994 among people aged 25-64 (Rahkonen et al., 2002), and educational disparities in self-rated health also remained at roughly the same level in 1980-2004 (Rahkonen et al., 2009).

These observations regarding self-rated health using survey data are at odds with register linkage studies on trends in socioeconomic mortality based on education and occupational social class, which have shown increasing disparity in mortality between the socioeconomic groups since the 1970s. The gap in life expectancy between upper-white-collar and blue-collar workers widened from 1983-85 to 2003-05 by roughly one year in both sexes, ending up at six years among men and 3.4 years among women (Valkonen et al., 2009; Valkonen and Martikainen, 2006). This widening was largely attributable to a slightly slower increase in life expectancy among blue-collar workers compared to the other groups. The life-expectancy gap

between those with a high and a basic education developed in a roughly similar manner as that between the top and bottom occupational classes in 1981-2000, but widened slightly more between educational groups among men and between occupational classes among women (Valkonen and Martikainen, 2006).

In general, the total effect of both education and occupation on mortality has increased over time. However, the educational effect also seems to be decreasingly independent of occupation among the middle-aged, due in part to the more rapid strengthening of the independent effect of occupational class on mortality. Had there been no change in the distribution of education and occupational class in the total population, the disparity in mortality would have been even greater among those aged 30-49, particularly in the case of educational disparity (Martikainen et al., 2007a).

The overall gain in life expectancy originated mainly in the decreased mortality attributable to ischaemic heart disease (IHD) in all socioeconomic groups (Valkonen et al., 2009; Valkonen and Martikainen, 2006). Decreasing mortality attributable to other cardiovascular diseases and respiratory diseases also had a positive impact on life expectancy in all occupational classes in 1998-2005 (Valkonen et al., 2009). The increase in mortality differences between educational groups and occupational social classes before the 1990s stemmed largely from mortality attributable to cardiovascular disease and alcohol-related causes of death (Martikainen et al., 2001a). However, previous studies have reported a minimal contribution of IHD to the increasing disparity after the 1990s (Valkonen et al., 2009; Valkonen and Martikainen, 2006). On the other hand, trends in alcohol-related mortality by educational groups show no signs of convergence as mortality has increased particularly among the individuals with low education since the 1980s (Herttua et al., 2007). Alcohol-related mortality has grown also in the general population between 1980 and 2005 (Kraus et al., 2015). Furthermore, the gap in life expectancy by education at age 50 is increasingly attributable to smoking related deaths among women whereas among men their contribution is decreasing (Martikainen et al., 2013). These developments suggest that alcohol-related causes of death among both sexes and smoking-related deaths among women are increasingly relevant also to the disparity in mortality by income.

4 THE AIMS OF THE STUDY

The general aim of this study was to enhance understanding of the relationship between income and mortality in the context of Finland, earlier studies not having covered possible changes in this association. The objective in this thesis was to describe and quantify mortality trends among income groups, as well as the contribution of age and cause-of-death groups to changes in reported disparity. One of the aims was to explore the role of other individual socioeconomic factors such as education, occupation and economic activity, which are closely related to income, in explaining the changing disparity in mortality. These socioeconomic factors appear to precede the association between income and mortality, and there is little evidence on the international scale of the extent to which changes in their distribution in the lowest income groups explain the increasing disparity observed in various countries. This lack of evidence regarding the change in the role of other socioeconomic factors also holds for disparity in mortality attributable to alcohol-related causes. It was therefore considered relevant also to assess whether these factors explain the disparity in mortality among income groups to a similar extent with regard to alcohol-related and other causes of death, and whether their explanatory relevance had changed over time. Although income is a relevant indicator of socioeconomic position in adulthood, it is partially dependent on processes originating from childhood. Therefore a further aim of this study was to narrow the gap in research evidence assessing to what extent disparity in mortality by income observed in adulthood is attributable to childhood-family characteristics. Previous studies have included only observed childhood characteristics whereas the present study also assesses unobserved factors shared by siblings, and their relevance among specific cause-of-death groups.

The specific aims of the study were:

1. to explore the trends in life expectancy at the age of 35 by income quintiles and to assess the contribution of cause-of-death and age groups to changes in life expectancy between 1988 and 2007 (sub-study I).
2. to determine how the relative disparity in all-cause mortality by income changed in 1988-2007 among 35-64-year-olds while accounting for socio-demographic factors such as non-employment, occupational social class, education and living alone, which are related to both income and mortality (sub-study II).
3. to assess whether changes in the mortality level of income quintiles are attributable to changes in the distribution of the aforementioned socio-demographic characteristics within the quintiles (sub-study II).

4. to investigate the extent to which observed and unobserved childhood family characteristics shared by siblings explain the disparity among income quintiles in later cause-specific mortality in adulthood (sub-study III).
5. to examine changes in mortality attributable to alcohol-related and other causes among income quintiles in 1988-2012, and to find out whether the explanatory roles of education, occupational social class, and economic activity in the disparity changed over time (sub-study IV).

5 MATERIALS AND METHODS

5.1 DATA SOURCES AND STUDY DESIGNS

Sub-studies I, II and IV were based on longitudinal register data containing information from various administrative registers. The data were compiled at Statistics Finland by combining information from longitudinal population and employment registers and the cause-of-death register, using personal identification codes (permission TK-53-1783-96). The data set included a representative 11-per-cent sample of the whole population residing in Finland during at least one year between 1987 and 2007. In compliance with data-protection regulations, Statistics Finland provides only crude data on the total population. Therefore, to maintain statistical power in the mortality analyses the data set was complemented with a random over-sample of the population that died during the study period, meaning that 80 per cent of all deaths in 1988-2007 were covered. Appropriate weights for individuals from the original and the additional samples were used in the analyses to account for the unequal sampling probability. Sub-study IV also included a further update of the mortality records of individuals in the 11-per-cent random sample covering the years 2008-2012 (permission TK-53-339-13).

In sub-study I individuals aged 35 and over were followed for mortality separately for each year in 1988-2007. Those who emigrated or were institutionalized were censored at the end of the year in question. Individuals were included in the follow-up in sub-study II if they were within the age range of 35-64 at the beginning of any year during the three follow-up periods of 1988-91, 1996-99 and 2004-07. They were censored when they turned 65, emigrated, or were institutionalized. Four baselines were set in sub-study IV, at the beginning of the years 1988, 1994, 2001 and 2007, and individuals aged 35-64 were followed for mortality in the six subsequent years. They were censored when they turned 65 or emigrated. Institutionalized persons were excluded from the analysis at the baseline. The last period after the baseline year of 2007 only included individuals from the 11-per-cent random sample without the oversample of deaths, unlike all the other follow-ups in sub-studies I, II and IV.

Sub-study III was based on a data set comprising a 10-per-cent sample of households drawn from the Finnish 1950 census and including 411,626 individuals in 132,862 families (14% of all families interviewed in the census) (Statistics Finland, 1997). The data included codes for each household and each family in the household, and therefore it was possible to identify all members of the same family at the time of the 1950 census, and to obtain socio-demographic information about the family conditions. Statistics Finland linked all household members in this sample to subsequent census

records from 1970, 1975, 1980, 1985, 1990 and 1995, and to death records for the years 1971-2007 (permission TK-53-835-08).

Children (0-14 years of age) who belonged to a family in the 1950 census were followed for mortality from the month of their 35th birthday until death or censoring at the end of 2007 when they were 57-72 years old. Those who were not present in the census closest to their 35th birthday were excluded from the analyses: these roughly 19,000 individuals (16% of the cohort) had died or emigrated before the beginning of the mortality follow-up in 1971. Sensitivity analyses conducted by Elo and colleagues (2014) suggest that excluding these cases did not bias the main findings. Principal analyses were conducted using data on people with at least one sibling of the same sex born in 1936-50 and alive at the beginning of the mortality follow-up. In total, 27,551 men with 4,878 deaths, and 24,148 women with 1,920 deaths contributed to these analyses. A total of 116,622 children aged 0-14 were included in the census sample used for the sensitivity analyses, in which results including only siblings were compared to the general child population. Number of deaths in other sub-studies are presented in table 1.

5.2 VARIABLES

5.2.1 MEASURES OF INCOME

The main measure used in this study was household income, which provides more accurate information on the actual material resources of the study subject than individual income and also limits the problems of reverse causality and confounding (Benzeval et al., 2001; Martikainen et al., 2001b). Statistics Finland obtained the income information from the registers of the Finnish Tax Administration and Social Insurance Institution. The main income measure used in sub-studies I, II, and IV was household taxable income, consisting of the wages, capital income and taxable income transfers of all household members. Taxable income excludes some non-taxable transfers such as child benefit and certain housing allowances. Disposable household income includes these benefits and takes paid taxes into account. It is available in the data only for the period 1995-2007, and therefore was used for the sensitivity analyses. The household-income measures were adjusted for household composition in accordance with the OECD equivalence scale (OECD, 2013). Household income was divided by the sum of consumption units in the household so that the first member over the age of 17 years corresponded to one unit, all others over that age to 0.7 units, and children under the age of 18 to 0.5 units. Income was operationalized in relative terms in all the sub-studies: income quintiles were used to identify the position of an individual in the distribution. It was measured annually in sub-study I, using information from the preceding year of the mortality

follow-up. The quintile cut-off points were calculated from the population aged over 35, separately for men and women. In sub-study II income was measured annually within the three study periods from the year preceding the mortality information, and the cut-off points were determined from the combined population of men and women aged 35-64. This was unproblematic in this age-group as each sex-specific quintile had at most only one percentage-point deviation from 20 per cent. In sub-study IV income was measured at each baseline year and cut-off points were determined as in sub-study II.

Personal taxable income was used in sub-study III, being the only income variable available in the data. The information originated from the census closest to the 35th birthday and was converted into euros at the 2011 value using the monetary value table of Statistics Finland (Statistics Finland, 2015b). The quintile cut-off points were calculated separately for men and women. There was no information on income for one per cent of the men and three per cent of the women.

5.2.2 SOCIO-DEMOGRAPHIC CHARACTERISTICS

The socio-demographic attributes associated with household income were education, occupational social class, economic activity and living alone. Sub-studies II and IV included education categorized as basic (International Standard Classification of Education ISCED-1997 codes: 0-2), intermediate (ISCED: 3-4) or high (ISCED: 5-6), whereas in sub-study III it comprised four categories: basic (9 years), lower secondary (10–11 years), upper secondary (12 years) and higher education (13+ years). Economic activity at the end of the year was classified in sub-study II into six groups: employed, unemployed, retired, on a disability pension, student and other. Living alone was indicated by a dichotomous variable. In sub-study III economic activity was categorized as employed, unemployed, retired, doing household work, other (students and institutionalized persons) and unknown. Finally, in sub-study IV the main economic activity of the year was classified in four groups: employed, unemployed or granted an unemployment pension, retired and other. The five occupational social classes in sub-studies II and IV were upper-white-collar employees, lower-white-collar employees, manual workers, the self-employed and other. If there was no information on occupational social class for some year the information from previous years was used, and if no occupational social class was found then the person was classified according to the head of the household. Additional socio-demographic information was used in sub-study III: the three categories married, never married and widowed/divorced reflected marital status; household composition was categorized as a single household, a household with two or more persons and unknown; and the housing-tenure categories were home owners, renters and those in employer-provided housing.

All the aforementioned variables were measured at the baseline year in sub-study IV and in sub-study II they were measured annually except for occupational social class, which was measured at five-year intervals. Adulthood socio-demographic characteristics were measured in the same way as income in sub-study III, from the census information closest to the person's 35th birthday.

The variables measuring childhood socioeconomic status and living conditions in sub-study III were based on the 1950 Finnish Census and included parental educational level and occupational social class, housing tenure, overcrowding and region of residence. Both maternal and paternal education was assigned to one of three categories: no schooling or unknown, primary school and past primary school. Socioeconomic status for each parent was classified as professional/administrative workers, manual/agricultural workers, farmers, employers/self-employed and other/unknown. Three regions of residence were identified: the capital region, the rest of southern and western Finland, and eastern and northern Finland. Housing crowdedness was assessed in four categories in terms of the number of individuals per heated room: <2, 2–3, 3–4, 4+ and unknown. Housing tenure in childhood was categorized similarly as in adulthood.

5.2.3 CAUSE OF DEATH

Information on the date of death was obtained from the death register of Statistics Finland. Sub-studies I, III and IV included analyses of specific cause-of-death groups based on the underlying cause given in the death certificate. The classification used in the death certificates was the International Classification of Diseases (ICD) 8th revision for the years 1971–1986, the 9th revision for 1987–1995 and the 10th revision for 1996–2012. The cause-of-death groups used in the studies were constructed from Statistics Finland's 54-category cause-of-death classification (Statistics Finland, 2015c), which has been harmonized in line with changes in the ICD classification and is therefore suitable for analysis over time.

The cause of death analysis in sub-study I is based on the following 11 groups, which incorporate the most common causes and those that are strongly related to behaviour, and also cover all deaths: lung cancer (ICD-10 codes: C32–C34), breast cancer only among women (C50), other cancers (C00–C31, C37–C49, C51–C97), ischaemic heart diseases (I20–I25), cerebrovascular diseases (I60–I69), other circulatory diseases (I00–I15, I26–I28, I30–I52, I70–I99), respiratory diseases (J00–J64, J66–J99), alcohol-related diseases and accidental alcohol poisoning (F10, G312, G4051, G621, G721, I426, K292, K70, K860, K8600, O354, P043, X45), accidents and violence (V01–X44, X46–X59, X85–Y89), suicides (X60–X84, Y870) and other diseases.

The three categories used in sub-study III were cardiovascular diseases (ICD-10 codes: I00-I425, I427-I99), alcohol-related diseases, accidents and violence (F10, G312, G4051, G621, G721, I426, K292, K70, K860, K860, O354, P043, X45, V01-X44, X46-Y89), and all other causes of death.

Two mutually exclusive categories were used in sub-study IV: deaths in which alcohol was an underlying or contributory cause of death, and all other deaths. Death was defined as alcohol-related if the underlying cause was alcohol-related disease or accidental alcohol poisoning (ICD-10 codes: F10, G312, G4051, G621, G721, I426, K292, K70, K860, K8600, O354, P043, X45) or, if the underlying cause was not alcohol, at least one of the three contributory causes on the death certificate was alcohol-attributable disease or alcohol intoxication (ICD-10: F10.0).

Including alcohol as a contributory cause allowed for a more comprehensive analysis of the burden of alcohol on the mortality. This was particularly relevant in the age group under study comprising 35-64-year-olds, in which the proportion of deaths with alcohol as a contributory cause can be over half of the total alcohol-related mortality (Durkin et al., 2010; Herttua et al., 2007).

5.3 STATISTICAL METHODS

Life expectancy at the age of 35 was used for the description and age- and cause-specific analysis of mortality trends among the income quintiles in sub-study I. Age- and cause-of-death-specific mortality rates for the five-year age groups during each year in 1988-2007 were calculated using probability weights in order to account for the 80-per-cent oversample of deaths. The analysis was conducted in STATA 10.1 software. Once the death rates had been extracted the life expectancies at the age of 35 were calculated by income quintile and each year in 1988-2007 using five-year age groups in the abridged life tables (Shryock and Siegel, 1976). The changes in life expectancy in the highest and lowest income quintiles between the two five-year periods 1988-92 and 2003-07 were decomposed by age group and cause of death in accordance with the method presented by the United Nations Secretariat (Ponnapalli, 2005).

The absolute mortality trends in the income quintiles were described in terms of directly age-standardized mortality rates for three periods in sub-study II, and for four periods in sub-study IV. The total population of 35-64-year-olds during all the study periods was used as the standard population in both studies, and all the analyses were calculated using probability weights to account for the over-sample of deaths described earlier.

The relative effect of the income quintile on mortality in sub-study II was assessed using Poisson regression models for ungrouped data (Loomis et al., 2005). The models were estimated for the three study periods 1988-91, 1996-99 and 2004-07, with income as a time-varying covariate within them. The

socio-demographic covariates of education, occupation, economic activity and living alone were added to the model in this order. Changes in the association over time with regard to the declining level of mortality were studied by including interaction term of time period and the income quintile. For this analysis the data were pooled to account for the changing socio-demographic composition of the income quintiles across the periods. The interaction term was applied separately to models including only age and those also including other socio-demographic characteristics. In both cases the rate ratios were plotted using the highest income quintile during the first period as a reference category. All the analyses were conducted separately for men and women using STATA 10.1 software.

The analyses in sub-study III exploring the effect of childhood family background were based on Cox proportional hazards regression (e.g. Armitage et al., 2002). The relative disparity in mortality by income quintiles was assessed among the 35-72-year-olds with at least one same-sex sibling alive at the beginning of the follow-up. Age was used as the underlying time from baseline to censoring or death to estimate the age-adjusted hazard ratios (HR) for the income quintiles relative to the highest quintile. Then, in order to assess the association following adjustment for observed childhood and adulthood characteristics, separate models including age with observed childhood characteristics shared by the siblings and age with observed individual adulthood characteristics were estimated. Finally all the observed childhood and adulthood factors were included in the same model.

Analyses estimating the HRs for income quintiles accounting for the unobserved characteristics shared by siblings were conducted with fixed effects Cox models using the stratification technique suggested by Allison (2009). This corresponds to a situation in which each group of siblings is allowed to have a different baseline hazard function. Therefore only within-family variation was used in estimating the HRs for income, effectively controlling for all unobserved characteristics shared by the siblings. Consequently, only groups of siblings in which at least one sibling died during the follow-up period were included. The models were first estimated including only age, and were then adjusted for observed adulthood characteristics. Robust 95-per-cent confidence intervals were calculated to account for the clustering of the sibling data. Generally the models were estimated separately for men and women. Additionally among the men, however, all the models were estimated for the three cause-of-death groups, deaths attributable to causes other than the one under scrutiny being treated as censored observations at the date of death.

Discrete time survival analysis was used in sub-study IV to estimate the odds ratios (OR) of alcohol-related deaths and deaths attributable to other causes by income quintile. The models were fitted among the population aged 35-64 at baseline. Separate models were estimated for alcohol-related and other-cause mortality, for men and women, and for four six-year periods starting from the baseline years 1988, 1994, 2001 and 2007. Income quintile

was the main independent variable and all the models included age as a covariate with further adjustments for education, occupational class and economic activity. In order to obtain the proportion of how much of the excess mortality in each quintile was attenuated by each socioeconomic factor, the models were fitted within the decomposition framework proposed by Karlson, Holm and Breen (KHB), thereby allowing the simultaneous decomposition of the contribution of each control variable on the income-mortality association (Karlson et al., 2012). This is achieved by including the control variables in the model as residualized variables. These residualized variables are obtained from auxiliary regressions that regress each control variable on income, and the residuals from these models are used as independent variables in the eventual model regressing the odds of death on the income quintile. Furthermore, this approach avoids problems related to comparing nested non-linear models by scaling the coefficients similarly in the age-adjusted and full models (Allison, 1999). All the analyses in sub-study IV were conducted using STATA 12.0 software.

Table 1. *The characteristics of sub-studies I-IV*

	Sub-study I	Sub-study II	Sub-study III	Sub-study IV
<i>Type of data</i>	Register	Register	Register, census	Register
<i>Target population</i>	General population	General population	General population with siblings	General population
<i>Age range</i>	35+	35-64	35-72	35-64
<i>Follow-up periods</i>	Yearly in 1988-2007, and 1988-92, 2003-2007	1988-91, 1996-99, 2004-07	1971-2007	1988-93, 1994-99, 2001-06, 2007-12
<i>Deaths per period</i>	37,704 (yearly average)	33,375, 29,431, 29,962	6798	47,849, 43,587, 43,526, 5908
<i>Mortality outcome</i>	All causes, 11 cause-of-death groups	All causes	All-cause, cardiovascular, alcohol/violent/accident, other causes	Alcohol-related, other causes
<i>Main income variable</i>	Household taxable income	Household taxable income	Individual taxable income	Household taxable income
<i>Covariates</i>	-	Education, occupational class, economic activity, living alone	Education, marital status, economic activity, childhood family characteristics	Education, occupational class, economic activity
<i>Method</i>	Life table, life expectancy decomposition	Poisson regression, Age-adjusted mortality rate	Cox regression analysis with fixed effects estimation	Discrete time survival regression (logit) with KHB-decomposition

6 RESULTS

6.1 TRENDS IN LIFE EXPECTANCY BY INCOME FROM 1988 TO 2007: DECOMPOSITION BY AGE AND CAUSE OF DEATH (SUB-STUDY I)

There was a clear income gradient in life expectancy at the age of 35 among both men and women at the beginning of the study period (Figure 2). The gap between the highest and lowest quintiles in 1988 was 7.4 and 3.9 years for men and women, respectively. Life expectancy increased substantially in the four highest quintiles but there was only a minimal increase in the lowest one. As a result of this developmental stagnation the gap between the highest and the lowest quintiles widened by 5.1 years among men and 2.9 years among women over the study period: in 2007 it stood at 12.5 and 6.8 years among men and women, respectively. The mortality trend in the lowest and second-lowest quintiles also differed, the gap between them widening from 3.2 to 6.2 years among men, and from 1.4 to 3.9 years among women.

The decomposition analyses assessed the change in life expectancy among the highest and lowest income quintiles between the periods 1988–1992 and 2003–2007. Figure 3 depicts the contribution of the 10-year age groups to the change in life expectancy and the change in the gap between the extreme quintiles. Among men the gain in life expectancy was 1.24 years in the lowest and 4.51 in the highest income quintiles. The decreasing mortality among men aged over 65 increased life expectancy in the lowest and highest quintiles by 1.12 and 2.64 years, respectively. Among the under-65s the increase was 1.87 years in the highest quintile, but only 0.12 years in the lowest, partly because of an increase in mortality among the 45–54-year-olds. The increase in the gap between the lowest and the highest income quintiles was 3.27 years, 54 per cent of which was among those aged 35–64.

Life expectancy among women aged 35 increased by 1.12 and 3.26 years in the lowest and highest quintiles, respectively (Figure 4). The increase originated largely from the over-65s in both income groups, 1.73 years in the lowest and 2.47 years in the highest. Among those aged 35–64, on the other hand, mortality increased in the lowest quintile thereby decreasing life expectancy by 0.62 years: these age groups accounted for 66 per cent of the 2.14 years by which the gap between the income quintiles widened.

The increase in life expectancy in both the highest and the lowest income groups and among both men and women was driven by the decrease in mortality attributable to ischaemic heart disease (Figure 4, note the different scales). This positive contribution originated largely from those aged 65+, with the exception of men in the lowest quintile among whom the positive contribution was rather similar in both age groups. Furthermore, there was an identical decrease in IHD mortality in the highest and the lowest quintiles

among men aged 35-64. Increasing alcohol-related mortality in both sexes in the lowest income group decreased life expectancy by 1.04 years among men and 0.56 years among women: almost all of this decrease was attributable to the age group comprising 35-64-year-olds. Increasing mortality attributable to lung cancer and other cancers in the younger age group further reduced life expectancy by 0.17 years among women in the lowest income quintile.

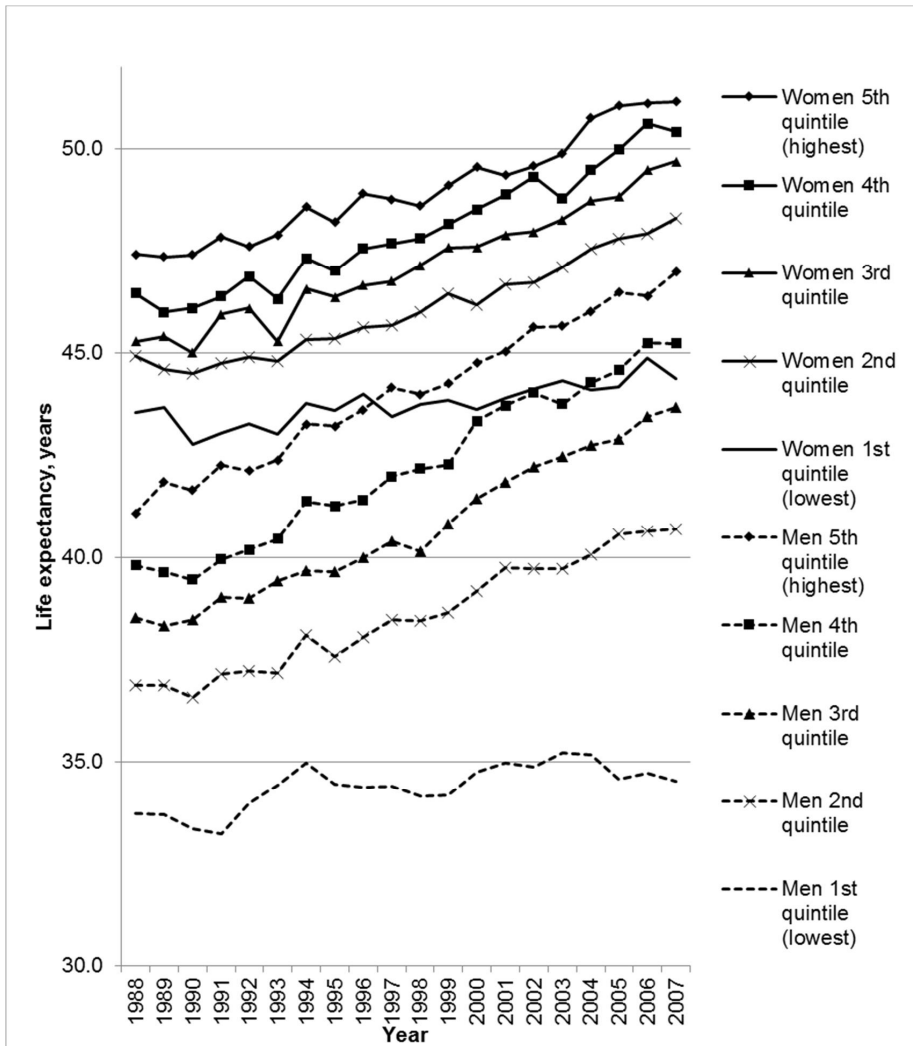


Figure 2 Life expectancy among men and women aged 35 by income quintile in 1988-2007

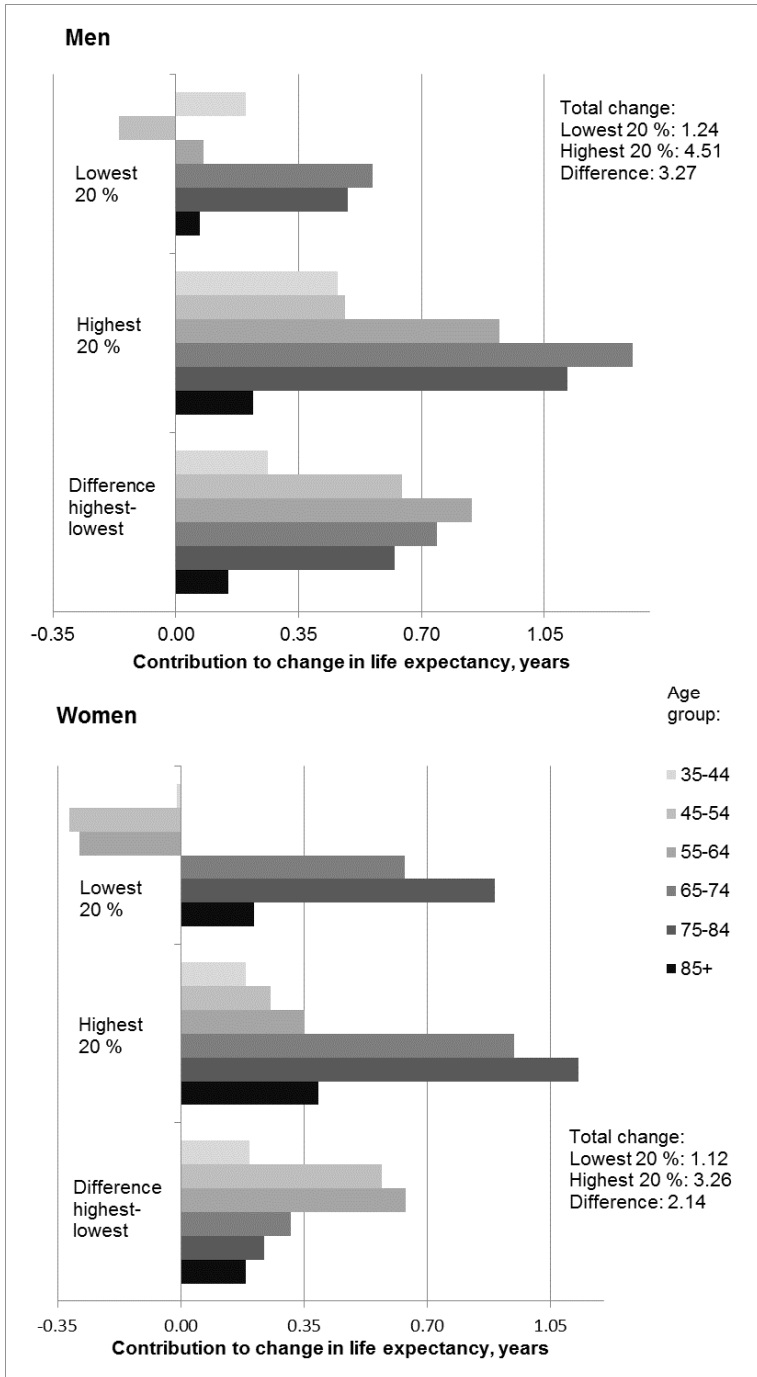


Figure 3 The contributions of 10-year age groups to changes in life expectancy at the age of 35 from 1988-92 to 2003-07 by income quintile, men and women

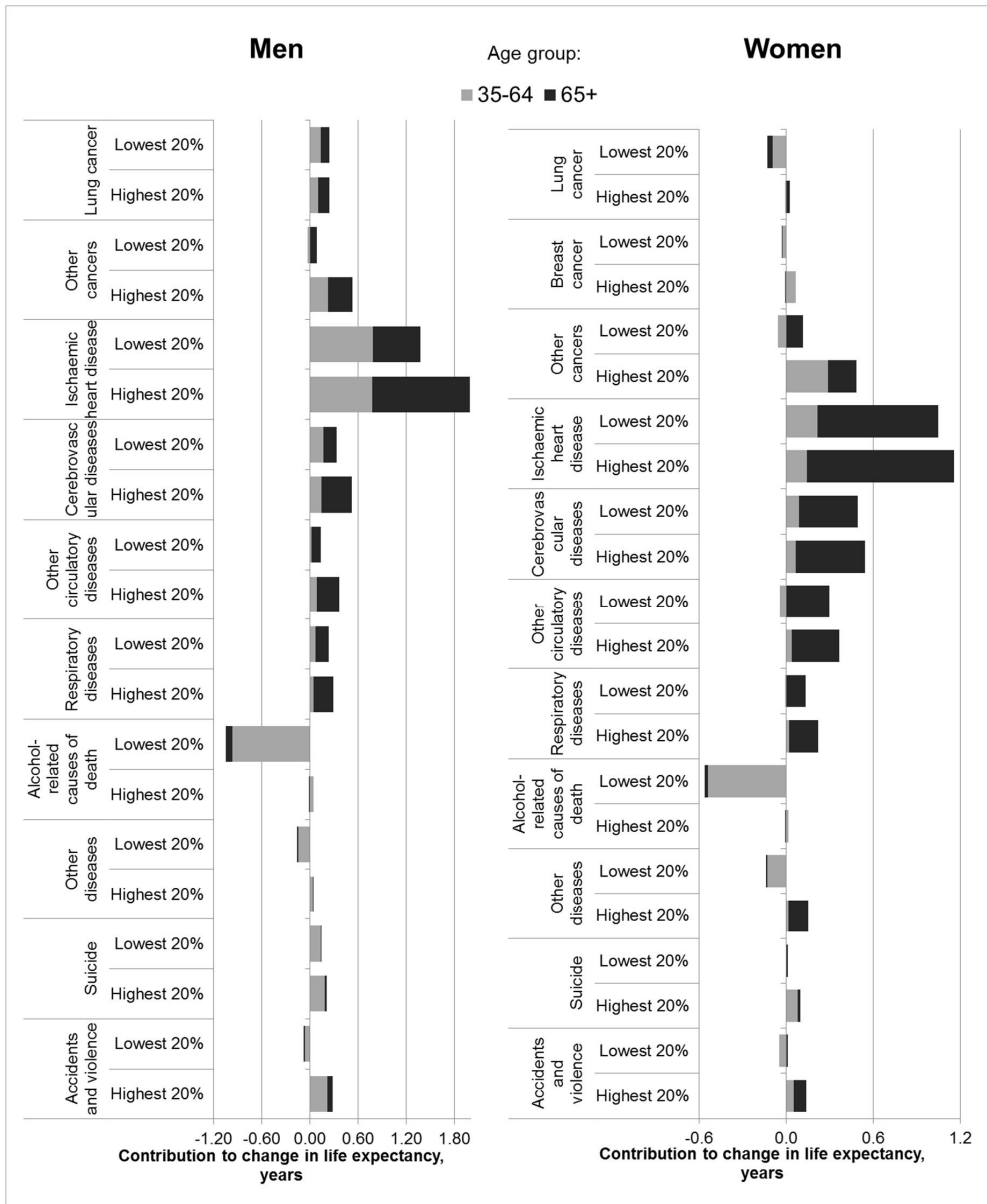


Figure 4 The contributions of selected causes of death and age groups to the change in life expectancy of 35-year-olds between 1988-92 and 2003-07 in the lowest and highest income quintiles, men and women

6.2 THE CHANGING RELATIONSHIP BETWEEN INCOME AND MORTALITY IN FINLAND, 1988-2007 (SUB-STUDY II)

The composition of the income quintiles in terms of other socio-demographic characteristics changed between 1988 and 2007. The proportion of those with a basic education decreased steadily in every quintile whereas the percentage of manual workers decreased slightly in all except the lowest fifth, in which it remained on roughly the same level. The proportion of unemployed people increased sharply in the bottom quintiles between 1988-91 and 1996-1999 during the severe recession of the early 1990s, and then lowered slightly towards 2004-07. The percentage of people outside the labour force was initially high in the lowest quintile, at 40 and 52 per cent among men and women, respectively but decreased in 1996-99 and then rose again among men. The proportions remained rather stable or decreased towards 2007 in the other income groups. There was a general increase in living alone across all income groups, but this was particularly strong among men in the lowest quintile.

Table 2. *Proportions of key demographic characteristics by income quintile, 35-64-year-old men and women in 1988-2007*

Period	Income quintile	Men					Women				
		Basic edu.	Manual workers	Un-empl.	Out LF	Living alone	Basic edu.	Manual workers	Un-empl.	Out LF	Living alone
1988-1991	Highest	31	26	1	6	15	35	15	1	9	14
	4th	47	50	2	11	10	49	30	2	12	14
	3rd	53	57	3	17	7	54	37	3	19	12
	2nd	59	59	5	27	7	58	42	4	32	9
	Lowest	66	50	9	40	18	67	44	5	52	19
1996-1999	Highest	22	25	3	9	18	23	12	4	10	15
	4th	35	46	6	14	13	33	24	7	13	17
	3rd	39	53	10	21	9	37	30	10	20	14
	2nd	44	55	17	27	11	41	35	15	29	11
	Lowest	50	50	31	32	28	46	36	24	39	22
2004-2007	Highest	15	22	2	7	21	13	10	3	10	18
	4th	24	46	4	10	18	20	21	4	11	18
	3rd	28	52	6	15	13	23	27	6	15	13
	2nd	32	55	11	23	12	27	33	10	25	22
	Lowest	40	51	24	37	36	35	37	20	40	26

Abbreviations: Edu: Education; Unempl: Unemployed; Out LF: Outside the labour force

Mortality among both men and women aged 35-64 decreased steadily in the four highest income quintiles, whereas in the lowest it decreased slightly between the first and second periods but then increased towards the last period (Tables 3 & 4). This led to an increasing disparity in age-adjusted mortality across the study periods in all quintiles relative to the highest one, but specifically in the lowest in which the RR increased from 2.80 to 5.16 and 2.17 to 4.23 among men and women, respectively. The excess mortality attenuated substantially following adjustment for education, occupation, economic activity (which caused most of the attenuation), and living alone. However, despite the adjustments the relative disparity in the lowest income fifth increased from 1.32 to 1.73 and 1.13 to 1.66 among men and women, respectively. Statistically significant excess mortality following these adjustments also appeared in quintiles 2-4 during 2004-07.

Table 3. *Mortality rates and rate ratios of all-cause mortality for income quintiles adjusted for age, education, socioeconomic status, economic activity and living alone: Finland in 1988-1991, 1996-1999 and 2004-2007, men aged 35-64*

Men		Income quintile	Mortality rate ^a	Model 1 (M 1):		M 2:	M 3:	M 4:	95% CI
				Age +	95% CI	M1+Edu	M2+	M3+	
Period				Income		+ Ses	Eco	Alone	
1988-	Highest	49.9	1.00			1.00	1.00	1.00	
1991	4th	63.4	1.28	1.22-1.35		1.15	1.00	1.04	0.99-1.10
	3rd	74.3	1.51	1.43-1.58		1.32	0.99	1.05	0.99-1.10
	2nd	92.2	1.88	1.79-1.97		1.64	1.06	1.11	1.05-1.17
	Lowest	139.4	2.80	2.68-2.93		2.48	1.40	1.32	1.26-1.40
1996-	Highest	35.3	1.00			1.00	1.00	1.00	
1999	4th	46.3	1.34	1.26-1.41		1.15	0.97	1.02	0.97-1.08
	3rd	58.0	1.68	1.59-1.77		1.39	0.99	1.05	0.99-1.12
	2nd	74.7	2.17	2.06-2.28		1.77	1.12	1.15	1.09-1.22
	Lowest	126.6	3.73	3.55-3.91		3.15	1.70	1.51	1.43-1.60
2004-	Highest	26.0	1.00			1.00	1.00	1.00	
2007	4th	33.7	1.32	1.24-1.40		1.16	1.03	1.07	1.01-1.14
	3rd	46.5	1.83	1.73-1.94		1.56	1.15	1.22	1.15-1.29
	2nd	62.9	2.47	2.34-2.61		2.08	1.26	1.29	1.22-1.37
	Lowest	131.6	5.16	4.91-5.41		4.36	2.02	1.73	1.63-1.83

^a Mortality rates per 10,000 person years adjusted for age using the population in 1988-2007 as the standard

Abbreviations - Edu: Education, Ses: Occupational social class, Eco: Economic activity, Alone: Living alone, CI: Confidence interval

Table 4. *Mortality rates and rate ratios of all-cause mortality for income quintiles adjusted for age, education, socioeconomic status, economic activity and living alone: Finland in 1988-1991, 1996-1999 and 2004-2007, women aged 35-64*

		Women						
Period	Income quintile	Mortality rate ^a	Model 1 (M 1):		M 2:	M 3:	M 4:	95% CI
			Age +	Income	M1+Edu + Ses	M2+ Eco	M3+ Alone	
1988-1991	Highest	21.6	1.00		1.00	1.00	1.00	
	4th	24.3	1.12	1.03-1.21	1.09	0.97	0.96	0.89-1.04
	3rd	28.9	1.35	1.25-1.46	1.30	1.02	1.01	0.93-1.09
	2nd	35.0	1.62	1.51-1.75	1.54	1.04	1.02	0.94-1.11
	Lowest	48.1	2.17	2.02-2.32	2.03	1.21	1.13	1.05-1.23
1996-1999	Highest	17.5	1.00		1.00	1.00	1.00	
	4th	19.4	1.12	1.03-1.21	1.06	0.96	0.95	0.87-1.03
	3rd	22.4	1.32	1.22-1.43	1.22	0.95	0.94	0.86-1.02
	2nd	29.2	1.71	1.59-1.85	1.57	1.04	1.02	0.94-1.10
	Lowest	47.2	2.75	2.56-2.95	2.52	1.41	1.29	1.18-1.40
2004-2007	Highest	12.8	1.00		1.00	1.00	1.00	
	4th	15.8	1.23	1.13-1.34	1.18	1.10	1.08	0.99-1.18
	3rd	19.9	1.58	1.46-1.72	1.48	1.21	1.18	1.08-1.28
	2nd	28.0	2.22	2.06-2.40	2.04	1.34	1.29	1.19-1.41
	Lowest	53.8	4.23	3.94-4.55	3.81	1.86	1.66	1.52-1.81

^a Mortality rates per 10,000 person years adjusted for age using the population in 1988-2007 as the standard

Abbreviations - Edu: Education, Ses: Occupational social class, Eco: Economic activity, Alone: Living alone, CI: Confidence interval

Figure 5 plots the interaction between income and the study period ($p < 0.05$), and shows the changes in the level of mortality in relation to the mortality of the highest quintile in 1988-91. The solid lines depicting age-adjusted mortality indicate increasing curvilinearity, as the mortality in lowest quintile stagnates among men and increases among women. Following adjustment for the socio-demographic characteristics, mortality stagnated among men and increased among women in the lowest quintile between the last two periods. Hence, the development in mortality is similar to that in the age-adjusted models, although most of the disparity is attenuated. Furthermore, there was a decrease in the middle quintiles between 1988-91 and 1996-99 but not towards the last period, unlike in the age-adjusted models. In fact, mortality would have increased among women in second and third quintiles had the socio-demographic composition remained the same between the last two periods.

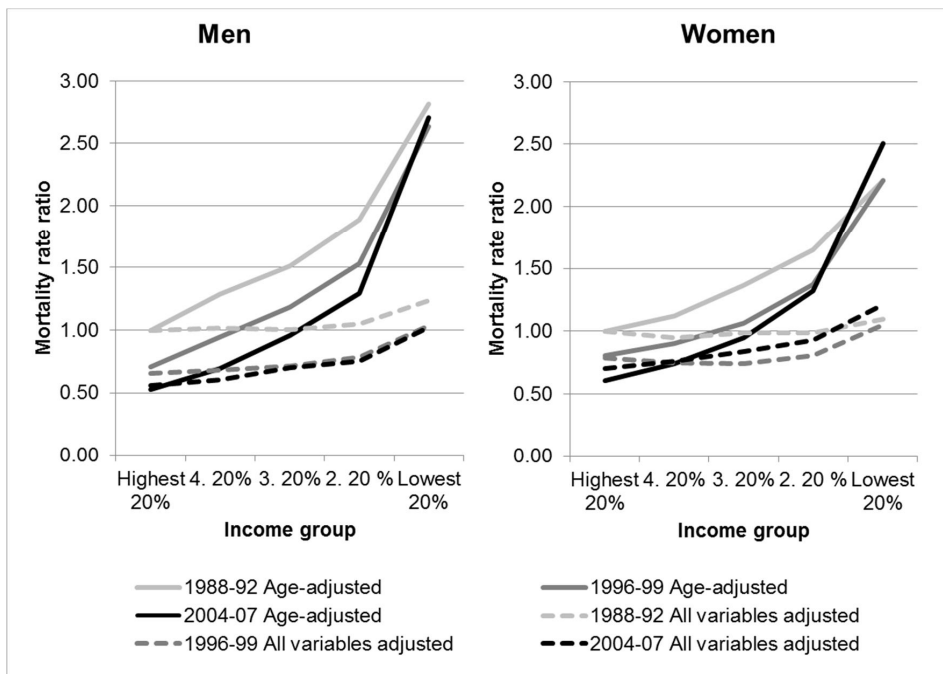


Figure 5 Relative mortality in the income quintiles by time periods, adjusted for age and all explanatory variables (highest quintile in 1988-91 as the reference category), men and women aged 35-64

6.3 CHILDHOOD FAMILY BACKGROUND AND MORTALITY DIFFERENCES BY INCOME IN ADULTHOOD (SUB-STUDY III)

A clear gradient in mortality in 1971-2007 by individual income quintile at the age 35 was observed among persons who had at least one sibling of the same sex alive at the age 35. The disparity was more pronounced among men in that the absolute age-adjusted mortality rate varied from 113 (per 10,000 person years) to 40 between the lowest and highest quintiles, whereas among women the respective rates were 35 and 21. When Cox proportional hazards regression models were fitted the relative disparity in terms of age-adjusted hazard ratios was 2.88 and 1.55 among men and women, respectively (Table 5). The association remained unchanged when observed childhood characteristics including parental education and social class, home-ownership status and crowdedness, and region of residence were accounted for. Adjusting for observed adulthood characteristics marital status, economic activity, education, household composition and home ownership substantially attenuated the excess mortality in the lowest quintiles. Despite the adjustments a statistically significant excess mortality of 57 and 36 per

cent among men women, respectively remained, and further controlling for observed childhood characteristics did not notably change this disparity.

Table 5. Hazard ratios for all-cause mortality in 1971-2007: men and women aged 35-72 with at least one brother or sister alive during the follow-up

Income quintile	Cox regression					Fixed effects Cox regression				
	Model 1 (M1) HR	95% CI	M 2 HR	M 3 HR	Model 4 HR	95% CI	Model 5 HR	95% CI	Model 6 HR	95% CI
Men										
Highest	1.00		1.00	1.00	1.00		1.00		1.00	
4th	1.21	1.09-1.35	1.17	1.01	1.00	0.90-1.13	1.11	0.94-1.31	1.03	0.87-1.22
3rd	1.37	1.23-1.52	1.30	1.03	1.03	0.92-1.16	1.28	1.09-1.51	1.10	0.92-1.31
2nd	1.70	1.54-1.88	1.62	1.18	1.19	1.06-1.33	1.49	1.26-1.76	1.21	1.01-1.44
Lowest	2.88	2.62-3.17	2.80	1.57	1.58	1.41-1.78	2.64	2.24-3.11	1.66	1.38-2.00
Women										
Highest	1.00		1.00	1.00	1.00		1.00		1.00	
4th	1.13	0.96-1.34	1.13	1.09	1.09	0.92-1.30	1.07	0.84-1.37	1.11	0.85-1.44
3rd	1.20	1.02-1.41	1.20	1.10	1.12	0.94-1.34	1.08	0.85-1.38	1.13	0.87-1.48
2nd	1.25	1.06-1.46	1.26	1.13	1.16	0.97-1.38	1.28	1.01-1.63	1.29	0.99-1.69
Lowest	1.55	1.33-1.81	1.58	1.36	1.41	1.16-1.70	1.62	1.27-2.06	1.42	1.06-1.91

Abbreviations: CI, confidence interval; HR, hazard ratio

Model 1: Income, age

Model 2: Model 1 + childhood characteristics: parental education and social class, crowdedness, home ownership, region

Model 3: Model 1 + adulthood characteristics: marital status, economic activity, education, household composition, home ownership

Model 4: Model 1 + all observed childhood and adulthood characteristics

Model 5: Same variables as in model 1. Fixed effects model

Model 6: Same variables as in model 3. Fixed effects model

Fixed-effects Cox models were fitted allowing families to have their own baseline hazard. This approach adjusts for all unobserved characteristics shared by siblings in effectively comparing only siblings with differing income quintiles within families. These analyses also revealed a clear age-adjusted mortality gradient among men, the lowest quintile having a HR of 2.64 compared to highest quintile. Among women the HR was 1.62. Adjusting for characteristics observed in adulthood attenuated the disparity particularly among men, but the excess mortality of the lowest quintile remained at 1.66 and 1.42 among men and women, respectively.

The cause-of-death-specific analysis was conducted only for men due to the low number of deaths among women. It indicates the presence of the age-adjusted mortality gradient in each cause-of-death group, the HR of the lowest quintile ranging from 2.45 for other causes to 3.31 for cardiovascular diseases. Controlling for observed childhood characteristics attenuated the association in each cause-of-death group very little, whereas adding the adulthood characteristics to the model attenuated the excess mortality by

roughly 70 per cent in the lowest quintile. The excess mortality remained in the case of CVD and other causes, and ranged between 24 and 71 per cent in the two lowest quintiles. With regard to mortality attributable to alcohol, violence and accidental causes the excess of 56 per cent remained in the lowest quintile.

Table 6. Hazard ratios for cause-specific mortality in 1971-2007, men aged 35-72 with at least one brother alive during the follow-up

Income quintile	Cox regression						Fixed effects Cox regression			
	Model 1 (M 1) HR	M 2 95% CI	M 3 HR	M 3 HR	Model 4 HR	Model 4 95% CI	Model 5 HR	Model 5 95% CI	Model 6 HR	Model 6 95% CI
Cardiovascular diseases (1694 deaths)										
Highest	1.00		1.00	1.00	1.00		1.00		1.00	
4th	1.37	1.12-1.67	1.30	1.06	1.05	0.86-1.30	1.09	0.81-1.46	0.98	0.73-1.32
3rd	1.65	1.37-1.98	1.53	1.13	1.12	0.91-1.38	1.27	0.95-1.69	1.08	0.80-1.46
2nd	2.07	1.73-2.48	1.93	1.31	1.31	1.07-1.60	1.54	1.14-2.07	1.24	0.91-1.69
Lowest	3.31	2.79-3.93	3.10	1.71	1.71	1.39-2.10	2.27	1.71-3.03	1.38	1.00-1.90
Alcohol related, violent and accidental causes (1511 deaths)										
Highest	1.00		1.00	1.00	1.00		1.00		1.00	
4th	1.12	0.92-1.36	1.07	0.92	0.92	0.74-1.13	1.10	0.83-1.45	1.03	0.77-1.38
3rd	1.26	1.04-1.53	1.19	0.95	0.94	0.76-1.16	1.29	0.97-1.71	1.09	0.81-1.46
2nd	1.52	1.27-1.82	1.44	1.04	1.04	0.85-1.27	1.36	1.03-1.80	1.08	0.80-1.47
Lowest	3.02	2.56-3.57	2.92	1.55	1.56	1.27-1.92	2.77	2.12-3.63	1.73	1.27-2.34
All other causes (1658 deaths)										
Highest	1.00		1.00	1.00	1.00		1.00		1.00	
4th	1.18	0.98-1.41	1.16	1.04	1.05	0.87-1.27	1.14	0.85-1.52	1.09	0.81-1.47
3rd	1.26	1.06-1.51	1.24	1.04	1.05	0.87-1.28	1.30	0.98-1.73	1.17	0.86-1.59
2nd	1.58	1.34-1.87	1.55	1.22	1.24	1.02-1.50	1.56	1.17-2.07	1.32	0.97-1.80
Lowest	2.45	2.09-2.87	2.46	1.47	1.51	1.24-1.83	2.91	2.18-3.89	1.92	1.37-2.69

Abbreviations: CI, confidence interval; HR, hazard ratio

Model 1: Income, age

Model 2: Model 1 + childhood characteristics: parental education and social class, crowdedness, home ownership, region

Model 3: Model 1 + adulthood characteristics: marital status, economic activity, education, household composition, home ownership

Model 4: Model 1 + all observed childhood and adulthood characteristics

Model 5: Same variables as in model 1. Fixed effects model

Model 6: Same variables as in model 3. Fixed effects model

In the fixed-effects setting, the age-adjusted mortality gradient was clear in all cause-of-death groups. Following adjustment for unobserved shared childhood characteristics and observed socio-demographic factors in adulthood in model 6, the excess mortality in the lowest quintile remained statistically significant with HRs of 1.73 for alcohol, violence & accidental causes and 1.92 for other causes, whereas in the case of CVD the HR of 1.38 was bordering on being significant at the 95-per-cent level.

6.4 THE CONTRIBUTION OF EDUCATION, SOCIAL CLASS AND ECONOMIC ACTIVITY TO THE ASSOCIATION BETWEEN INCOME AND ALCOHOL-RELATED MORTALITY (SUB-STUDY IV)

The alcohol-related mortality of men aged 35-64 decreased slightly between 1988-93 and 2007-12 in the highest quintiles, and remained at roughly the same level in the middle quintiles. There was a drastic increase in mortality in the lowest income fifth, from 37 (per 10,000 person years) to 62 (Figure 6, note the different scales for men and women). The increase in alcohol-related mortality among women with a low income was almost threefold when comparing the first and the last study period, the rate rising from five to 14. At the same time, there were signs of a small increase in the middle quintiles and of a decline in the highest. The age-adjusted mortality to other than alcohol-related causes declined steadily in 1988-2012 in all quintiles among men, and among women in all except the lowest, in which it declined between 1988-93 and 1994-99 but then stagnated.

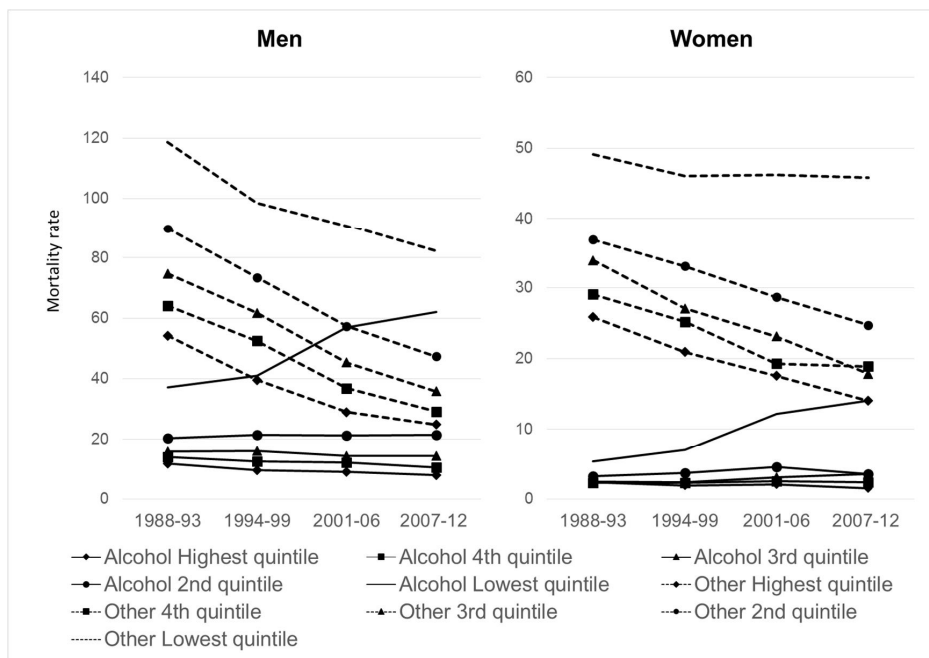


Figure 6 Age-adjusted mortality attributable to alcohol-related and other causes (per 10,000 person years) by income quintile in 1988-2012, men and women aged 35-64

This development led to an increase in the proportion of alcohol-related mortality of total mortality in every quintile, and the absolute gap relative to the highest quintile also consisted increasingly of alcohol-related mortality. Both of these aspects were especially evident in the lowest quintile, in which the proportion of the gap originating from alcohol-related causes increased from 28 to 49 per cent among men and from 11 to 28 per cent among women. The absolute mortality gap in other than alcohol-related causes decreased in all quintiles among men, whereas among women it decreased minimally or remained the same in quintiles other than the lowest, in which it increased substantially.

Table 7. *Odds ratios of age-adjusted alcohol-related mortality and attenuation percentages by income quintile among 35-64 year olds in 1988-93, 1994-99, 2001-06, 2007-12; with the highest income quintile as the reference group, men and women.*

Men					Women					
Period	OR (95% CI)	Attenuation % ^a				OR (95% CI)	Attenuation % ^a			
		Edu	Occ	Eco	Tot		Edu	Occ	Eco	Tot
4th quintile					4th quintile					
1988	1.18 (1.08-1.29)	21	100	29	151	0.97 (0.80-1.19)				
1994	1.22 (1.12-1.34)	28	58	65	151	1.13 (0.93-1.39)				
2001	1.28 (1.18-1.40)	13	47	34	93	1.23 (1.01-1.49)	29	22	23	75
2007 ^b	1.27 (0.99-1.62)	12	78	26	117	1.65 (0.95-2.87)				
3rd quintile					3rd quintile					
1988	1.32 (1.21-1.44)	17	74	39	131	1.06 (0.87-1.30)				
1994	1.51 (1.38-1.65)	19	36	66	121	1.17 (0.96-1.43)				
2001	1.37 (1.25-1.50)	14	46	65	124	1.45 (1.20-1.75)	24	14	40	77
2007 ^b	1.60 (1.26-2.03)	8	47	35	90	2.21 (1.30-3.75)	12	-4	13	21
2nd quintile					2nd quintile					
1988	1.63 (1.50-1.77)	12	42	39	93	1.31 (1.08-1.60)	55	13	78	146
1994	1.99 (1.83-2.17)	13	22	62	97	1.68 (1.39-2.03)	28	4	77	108
2001	1.91 (1.75-2.07)	8	23	58	89	2.04 (1.71-2.44)	15	6	48	69
2007 ^b	2.26 (1.81-2.82)	6	30	38	75	2.15 (1.26-3.68)	16	-7	32	40
1st quintile (lowest)					1st quintile (lowest)					
1988	2.78 (2.57-3.00)	6	13	31	51	2.13 (1.77-2.55)	23	-4	50	69
1994	3.84 (3.55-4.15)	8	8	46	61	3.22 (2.70-3.83)	15	-2	56	68
2001	5.20 (4.82-5.60)	4	7	51	62	5.42 (4.61-6.36)	9	-1	45	53
2007 ^b	6.47 (5.30-7.90)	4	13	41	57	7.98 (4.96-12.84)	8	-6	31	32

^a The figures show the proportions by which the coefficient is attenuated when explanatory variables are included in the model. Percentages are reported only for coefficients with 95% confidence intervals not overlapping 1.00 in the age-adjusted model, and the models in bold type have significant excess mortality ($p < 0.05$) after adjustment. (Coefficients not shown.)

^b The period 2007-2012 includes only an 11% sample of the population without the 80% oversample of deaths

Abbreviations: Edu: education, Occ: occupational class, Eco: economic activity, Tot: total

There were signs of a decrease in the relevance of education, occupation and economic activity as characteristics explaining the excess alcohol-related mortality towards the last period in the second and third quintiles among men, although the excess mortality did not remain statistically significant after these adjustments during any of the periods. Accounting for these factors attenuated the excess mortality in the lowest quintile by roughly 50-60 per cent during each period. Economic activity was the main factor explaining the excess mortality in general, and particularly in the lowest quintile in which education and occupation had minor explanatory roles.

Table 8. *Odds ratios of age-adjusted mortality attributable to other than alcohol-related causes, and attenuation percentages by income quintile among 35-64 year olds in 1988-93, 1994-99, 2001-06, 2007-12; with the highest income quintile as the reference group, men and women.*

Men						Women						
Period	OR (95% CI)	Attenuation % ^a				Tot	OR (95% CI)	Attenuation % ^a				Tot
		Edu	Occ	Eco				Edu	Occ	Eco		
4th quintile						4th quintile						
1988	1.09 (1.04-1.15)	46	42	57	144	1.04 (0.97-1.11)						
1994	1.22 (1.16-1.29)	18	34	39	91	1.15 (1.08-1.23)	16	6	26	48		
2001	1.18 (1.12-1.25)	23	30	34	88	1.09 (1.02-1.17)	10	22	37	68		
2007 ^b	1.15 (1.00-1.33)	32	36	30	98	1.25 (1.03-1.51)	11	-8	11	14		
3rd quintile						3rd quintile						
1988	1.20 (1.14-1.26)	31	28	62	122	1.16 (1.09-1.24)	25	0	61	86		
1994	1.37 (1.30-1.44)	16	29	48	92	1.20 (1.12-1.28)	17	6	55	78		
2001	1.35 (1.28-1.43)	18	21	43	81	1.24 (1.16-1.33)	5	12	40	57		
2007 ^b	1.31 (1.14-1.51)	21	23	40	84	1.18 (0.97-1.42)	22	-14	45	53		
2nd quintile						2nd quintile						
1988	1.41 (1.34-1.48)	20	17	55	92	1.20 (1.13-1.28)	24	3	95	122		
1994	1.66 (1.58-1.74)	11	20	44	75	1.38 (1.29-1.48)	11	3	54	67		
2001	1.66 (1.57-1.75)	13	13	44	70	1.43 (1.33-1.53)	4	7	53	65		
2007 ^b	1.63 (1.42-1.87)	15	15	41	71	1.51 (1.26-1.82)	11	-6	39	44		
1st quintile (lowest)						1st quintile (lowest)						
1988	1.91 (1.82-1.99)	12	9	43	64	1.59 (1.50-1.69)	11	3	62	76		
1994	2.33 (2.22-2.45)	8	10	36	55	1.91 (1.79-2.03)	7	0	42	48		
2001	2.78 (2.64-2.92)	8	5	42	56	2.27 (2.12-2.42)	3	3	45	51		
2007 ^b	2.88 (2.54-3.26)	9	7	45	61	2.58 (2.18-3.06)	7	-2	43	47		

^a The figures show the proportion by which the coefficient is attenuated when explanatory variables are included in the model. Percentages are reported only for coefficients with 95% confidence intervals not overlapping 1.00 in the age-adjusted model, and models in bold type have significant excess mortality ($p < 0.05$) after adjustment. (Coefficients not shown.)

^b The period 2007-2012 includes only an 11% sample of the population without the 80% oversample of deaths

Abbreviations: Edu: education, Occ: occupational class, Eco: economic activity, Tot: total

Education and occupational class attenuated the association in the higher quintiles, but education and economic activity had generally decreasing relevance across periods in the middle quintiles. The findings were rather similar among women, but occupational class had little relevance in explaining the excess mortality in any quintile, and the attenuation after controlling for education and economic activity also declined in the lowest quintile.

In the case of other than alcohol-related causes the adjusted socio-economic factors explained income disparity to a decreasing degree in the second and third quintiles. The adjusted factors attenuated the excess mortality rather similarly during each period in the lowest quintile, the percentages varying between 55 and 64 among men. With regard to women, 76 per cent of the excess mortality was attenuated by these factors during 1988-93, but the proportion remained at roughly 50 per cent during the subsequent periods.

7 DISCUSSION

7.1 A SUMMARY OF THE MAIN FINDINGS

Life expectancy among the four highest income quintiles increased substantially over the study period of 1988-2007. However, the stagnation of mortality among men in the lowest quintile and a very slow and minor increase among women caused the disparity with other quintiles to increase markedly. In 2007 the gap in life expectancy between the extreme quintiles stood at 12.5 and 6.8 years among men and women, respectively. This widening disparity originated slightly more from the 35-64-year-olds than from older groups, mainly on account of the increasing mortality among women and the stagnating mortality among men in this age group in the lowest quintile. In ages 35-64 mortality relative to the highest quintile increased between 1988-91 and 2004-07 in all the other quintiles even following adjustment for the individual socio-demographic characteristics of education, occupational class, economic activity and living alone. Likewise, accounting for the changes in the composition of the lowest income quintile by these socio-demographic measures did not explain the increasing mortality level towards 2004-07 among men or women.

The disparity in mortality between individual income quintiles among those aged 35-72 also persisted following adjustment for observed and unobserved factors of childhood family conditions shared by siblings. The adulthood socio-demographic characteristics were considerably more relevant explanatory factors than childhood characteristics, but the disparity remained even after controlling for both. This observation was consistent over three cause-of-death groups: cardiovascular diseases, alcohol/violent/accidental causes, and other causes.

Alcohol-related causes of death (alcohol-related diseases and accidental alcohol poisoning) were the main drivers of the adverse mortality development in the lowest quintile. Disparities in cancer mortality among women and in ischaemic heart disease among men over the age of 65 also increased the gap in life expectancy between the extreme income quintiles in 1988-2007. The increasing significance of alcohol-related mortality in the disparity was evident during the period from 1988 to 2012 when deaths with alcohol as a contributory cause were also included. This occurred because of minimal changes in alcohol-related mortality in quintiles other than the lowest one, in which it increased substantially. Education, occupation and, in the main, economic activity explained 50-60 per cent of the excess alcohol-related mortality in the lowest quintile among men despite the increasing mortality level. Among women the proportion explained by these factors declined over the study period, from roughly 70 to 30 per cent.

7.2 MORTALITY TRENDS IN INCOME GROUPS

The association between income rank and mortality has generally strengthened in Finland over the previous decades, in both absolute and relative terms, which is in line with observations from other Western industrialized countries including Sweden, Norway, New Zealand and the US (Blakely et al., 2008; Dowd et al., 2011; Hederos Eriksson et al., 2014; Rognerud and Zahl, 2006). The increasing disparity has been observed not only in relative but also in absolute terms in Norway and Sweden. This phenomenon has also been characterized elsewhere by a slower decline in mortality, or even stagnation, in the lowest income groups, an adverse development that has been particularly prominent in the working-aged population (Blakely et al., 2008; Cristia, 2009). However, the results of this study show that gains in life expectancy above retirement age are also greater in the highest than in the lowest income quintile, despite the weaker association between income and mortality after retirement (Martikainen et al., 2001b). On the other hand, given that the mortality level of the lowest income quintile increased despite accounting for the changing age structure of the population aged 35-64 between 1988 and 2007, it could be assumed that the strengthening association between income and mortality is not attributable to population aging.

The disparity in mortality between income groups tends to be more pronounced than educational and occupational disparities (Duncan et al., 2002; Geyer et al., 2006). It also seems that analyses of the trends in life expectancy among income quintiles give a significantly different picture of increasing socioeconomic disparities than among educational or occupational groups. The life expectancy of manual workers and those with a basic education in Finland shows an increasing trend, thus the gap from the higher categories has widened only moderately by these measures (Valkonen et al., 2009).

7.2.1 SOCIO-DEMOGRAPHIC FACTORS EXPLAINING THE DISPARITY IN MORTALITY BY INCOME

A substantial proportion of the observed association between income quintile and mortality was attributable to the other dimensions of socioeconomic position, and particularly employment status in the working-aged population. The attenuation due to controlling for these individual characteristics in this study is in line with that in numerous previous studies (e.g. Backlund et al., 1996; Martikainen et al., 2009; Martikainen et al., 2001b).

Despite the attenuation however, the measured individual socio-demographic characteristics did not fully explain the increase in relative disparity by income. Moreover, the increasing level or stagnation of mortality

among those with a low income persisted after accounting for these characteristics despite non-employment becoming more prevalent in the lowest quintile. However, the decrease in the level of mortality in the middle and second-lowest quintiles was largely attributable to socio-demographic characteristics between 1996-99 and 2003-07. In other words, mortality in the middle quintiles would have stagnated (or increased among women) had the composition of the other socio-demographic factors remained constant over time.

In terms of explaining the changes in disparity by income over time, it seems from the few existing studies that the role of these characteristics has varied by country. In Norway, for example, the strengthening income-mortality association in 1970-97 persisted following adjustment for education, household size and urbanity level in the area of residence (Rognerud and Zahl, 2006). This Norwegian study did not account for employment status, whereas controlling for it explained the increasing relative disparities in mortality by income in New Zealand from the late 1980s until the late 1990s. However, some indications of a strengthening association were observed when the analysis was restricted to the employed population while adjusting for marital status and other aspects of socioeconomic status (Blakely et al., 2004).

The generally improved educational level was reflected in the declining proportion of those with basic educational attainment in all income quintiles. It has been suggested that educational expansion may affect the time trends of health inequalities (e.g. Chen et al., 2013). However, attenuation following adjustment for both education and occupational class did not increase, whereas economic activity accounted for a substantial proportion of the excess mortality. The increasing disparity was also evident in the pooled analysis accounting for distributional changes. Therefore the results of the current study do not support this hypothesis in the Finnish context. Despite the somewhat minor role of education in explaining the disparity in mortality by income, the previous evidence from the US suggests that income increasingly mediates the effect of education on health (Lynch, 2006). This study did not focus on the possible changes in the mediating role of income but future research should assess this topic.

Causal explanations of changes in the income-mortality association

The observations reported in this study provide some evidence that factors related to income independent of other socio-demographic characteristics are of increasing relevance to mortality. Therefore, being on a low income may have increasingly harmful effects on health. The concentration of the excess mortality in the lowest quintile in particular lends support for the increasing relevance of the absolute income hypothesis. If the causal explanation is plausible with regard to the stagnating mortality in the lowest income quintile, the income development of those at the lower end of the

income distribution should be adverse or modest. The median disposable household income per consumption unit in the lowest deciles has increased very little in Finland compared to general developments in income, and the slight increase since 2000 almost disappears when housing expenses are taken into account (Statistics Finland, 2016a, 2016b).

A large proportion of those in the lowest income quintile are dependent on income transfers. The Nordic welfare model aims to provide an adequate level of economic resources via largely state-funded universal social benefits. It has been found in international comparisons that this model effectively reduces long- and short-term poverty rates (Fouarge and Layte, 2005). However, Finnish welfare-state structures have changed since the late 1980s. The minimum level of social benefits has not followed general developments in income: real disposable income after housing costs among households dependent on social support (excluding those on pensions) decreased or remained the same between 1990 and 2010. The minimum benefit level is not considered to provide minimum needed economic resources, and in 2010 it was estimated to cover roughly two thirds of the adequate minimum level in single-person households (Moisio, 2011). Over time this development may have amplified the harmful effects of being on a low income in terms of material deprivation, and also from the perspective of relative deprivation.

The role of selection and confounding in explaining changes in the income-mortality association

Income is generally more prone to health-based selection than education and occupation. Given that this study concentrated on the over-35s, many of the selection processes during the early part of the life course have already occurred in that education and occupation are usually settled. It may be that these selection processes, whether direct or indirect, strengthened during the study period. Employment status, as noted earlier, is somewhat of a proxy for poor health. Controlling for it adjusts for selection to some extent, but may also be an over adjustment if non-employment occurred due to poor health caused by having a low income. It is evident that a large part of the increase in mortality in the lowest quintile originated from the non-employed population. Whether this was attributable to the causal effect of non-employment, selection or confounding is unclear. Norwegian evidence indicates that health-based exclusion from the labour market has increased in general (Wel et al., 2010). It is uncertain whether this has also occurred in Finland.

The proportion of the non-employed increased in the lowest quintile after the late 1980s, mainly due to increasing unemployment but also because of a peak in the incidence of disability retirement in the early 1990s (Leinonen et al., 2011). Pre-existing poor health is an obvious factor with regard to disability retirement, but in terms of unemployment the process is less clear. Unemployment is a risk factor for mortality, but the excess mortality among

the unemployed is partly due to selection and confounding (Clemens et al., 2015). Although becoming unemployed during the severe recession in Finland was likely to be less selective by poor health, re-employment was probably selective by health particularly when the unemployment level decreased after the recession (Martikainen and Valkonen, 1996). Despite the declining number of long-term unemployed after 1993, however, the effects of the unemployment peak of the early 1990s were long-lasting, and long-term unemployment never returned to the low pre-recession level (Ministry of Employment and the Economy, 2015). It was found in a follow-up study extending to 2008 that over half of the roughly 500,000 people who were unemployed at the end of 1993 never returned to employment. The employment rate among such people reached 48 per cent in 2000, and remained at that level while the rest remained unemployed or on an unemployment pension (14%), retired (26%), emigrated or died (10%) (Myrskylä, 2010). The duration of unemployment was strongly associated with mortality among the unemployed in 2001-07 in Finland, which was 2.5 times higher among those who had been unemployed for two years or more than among those experiencing unemployment lasting less than a year (Pensola et al., 2012). Although part of this effect was attributable to health-selective re-employment, Swedish and Danish studies accounting for some of the health selection into unemployment report a rising mortality risk by prolonged unemployment (Garcy and Vågerö, 2012; Osler et al., 2003). It is plausible to suggest that the emergence of long-term unemployment, which was virtually non-existent before the recession, laid the foundation for the diverging mortality trends in the income quintiles.

Furthermore, the increasing proportion of non-employed individuals in the lowest quintile may be related to the increasing proportion of single households. The percentage of the population living in single-person households increased from 13 to 20, and of single households among all households from 31 to 42, in 1989-2013. The increase is especially evident among men under 70 years of age (Kauppinen et al., 2014). Given the increasing proportion of people living alone, non-employment is more likely to lead to low household income than before because the income of other household members does not buffer the loss of labour income. If non-employment occurs due to poor health, this development strengthens the direct selection process behind income-mortality association. However, the fact that adjusting for economic activity and living alone did not fully account for the increasing relative disparity in mortality or the stagnation of the mortality level in the lowest quintile in this study, is an indication that direct selection is not the only factor leading to an increase in excess mortality in the lowest quintile. In other words, the mortality of those in the lowest quintile who are healthy enough to be employed has not declined to the same extent as in other quintiles.

Strengthening indirect selection in terms of personality characteristics has also been introduced as a probable explanation for the widening disparity

in mortality by income. Characteristics such as external locus of control, neuroticism and low conscientiousness that increase the ill-health risk may have become more concentrated in the lowest socioeconomic strata. This has possibly resulted from the increased opportunities for upward intergenerational social mobility among those with personality characteristics that are favourable to educational attainment (Mackenbach, 2012). In the case of Finland, parental income has decreasingly determined the income of offspring, particularly after the Second World War, due to educational expansion and structural change in the economy. The intergenerationality of income level clearly decreased among cohorts born between 1930 and 1950. However, among cohorts born in 1950-1970 intergenerationality of income has remained stable or even increased (Pekkala and Lucas, 2007). It is therefore unclear whether or not the current mortality trends result from the concentration of personality characteristics in the lowest income quintiles due to increasing social mobility. Personality factors were not measured in this study, and were adjusted for in the analyses only to the extent that they would correlate with education, occupation, economic activity and living alone. It cannot be ruled out that the remaining increase in excess mortality in the lowest quintile is attributable to the increasing concentration of these unobserved factors in the lowest income groups. However this is unlikely to be an exhaustive explanation given previous findings that personality characteristics explain less than 30 per cent of the general income-mortality association among men, and roughly 10 per cent among women (Nabi et al., 2008).

7.3 CHILDHOOD FAMILY CONDITIONS AS AN EXPLANATORY FACTOR OF DISPARITY IN MORTALITY BY INCOME

The hazard ratios among those with siblings in 1971-2007 by individual income quintile at the age of 35 showed a gradient, the lowest quintile having an age-adjusted all-cause excess mortality of 188 and 55 per cent among men and women, respectively. Accounting for observed childhood characteristics did not notably attenuate the excess mortality, but adjusting for socio-demographic characteristics observed at the age of 35 did so in the lowest quintiles by roughly 70 and 30-40 per cent among men and women, respectively. The small explanatory role of childhood characteristics shared by siblings is in line with previous studies in the Nordic countries reporting attenuation of less than 10 per cent of the income-mortality association in populations aged 30-60 following adjustment for various observed measures of childhood socioeconomic conditions (Claussen et al., 2003; Fors et al., 2012; Lynch et al., 1994; Martikainen et al., 2009). These studies included only a limited number of characteristics observed in childhood, and it is thus unclear whether or not accounting for characteristics shared by siblings but

left unobserved would change the relevance of childhood characteristics to disparity in mortality at older ages. However, as the analysis in this thesis has shown, accounting for unobserved shared childhood-family characteristics among siblings did not remove the disparity in adulthood. Given the more robust evidence than in previous studies, the implication is that childhood socioeconomic conditions shared by siblings do not explain the disparity in mortality by income in adulthood despite the evidence that exposure to low socioeconomic conditions in childhood predicts higher mortality in adulthood. This conclusion holds not only for all-cause mortality but also among men from causes that have been identified as specifically pronounced among those with a low socioeconomic background in childhood, namely CVD and alcohol-related, violent and accidental causes (Lawlor et al., 2006; Pensola and Martikainen, 2003). However, the observed excess age-adjusted mortality in the lowest income quintiles attributable to CVD within siblings was somewhat more modest than in the general population. Previous studies exploring the role of childhood socioeconomic conditions in adulthood disparity in mortality by income have concentrated on the under-60s among whom chronic causes of death, and specifically CVD, are less dominant. The present analysis shows that, despite including people aged up to 72 and thus substantial contribution of chronic causes of death, shared childhood conditions offer little explanation for the disparity in mortality by income.

The excess mortality in the lowest quintiles remained even following adjustment for adulthood socio-demographic characteristics despite substantial attenuation. Evidence suggests that adulthood characteristics such as education mediate the effect of childhood conditions on mortality in adulthood to some extent (Elo et al., 2014). However, given that the initial adjustment for observed and unobserved shared characteristics had a negligible effect on the association it is more likely that these adulthood characteristics explain both income and mortality independently of shared childhood conditions. In addition, following adjustment for adulthood factors neither the observed nor unobserved shared childhood conditions attenuated the excess mortality significantly. These results suggest that, in general, the health effects of income are mainly associated with events and characteristics occurring in adulthood and personal characteristics not shared by siblings.

The relevance of adulthood characteristics strengthens the possibility of an income-mortality association deriving from selection into low income on account of poor health. However, analyses including only the employed population at the baseline yielded similar results as the initial models. These sensitivity analyses among a population healthy enough to be employed at the age of 35 indicate that the association persists when health-related selection into low income is at least partly accounted for. On the other hand, despite adjustment for unobserved childhood family characteristics shared by siblings, there are still childhood and early-adulthood characteristics they do not share (e.g. peer groups, childhood illnesses and personality

characteristics). It is likely that such characteristics are associated with adulthood socio-demographic factors, hence they were partially accounted for in this analysis, but some of the remaining effect of income on mortality is also attributable to these factors.

Previous studies assessing the explanatory role of unobserved shared childhood conditions in educational disparities in mortality report somewhat more modest disparity by education within siblings than in the general population (Elo et al., 2014; Næss et al., 2012; Søndergaard et al., 2012). Accounting for unobserved shared childhood characteristics has attenuated educational disparities particularly in mortality attributable to causes incorporating major behavioural risk factors such as alcohol-related mortality and lung cancer. The results of this study are broadly consistent with these observations regarding CVD, although the wide confidence intervals in the estimated fixed-effects models hinder inferences concerning the proportion of excess mortality attenuated by adjusting for unobserved characteristics. The minor explanatory relevance of unobserved shared childhood characteristics to the disparity in mortality by income may be attributable in part to the stronger role of health-related selection by income than by education.

The minor effect of shared childhood characteristics on the disparity in adulthood mortality is consistent with the high level of social and income mobility in Finland. Intergenerationality in terms of income level clearly weakened among the cohorts included in this study, born between 1930 and 1950, and therefore exposure to low income in both childhood and adulthood is decreasingly prevalent (Pekkala and Lucas, 2007). Despite the relatively high mobility, however, the odds of ending up in the lowest income quintile at the ages of 29 to 32 in 2003-07 were over fourfold among those whose parents had belonged to the lowest quintile compared to those with parents in the highest quintile (Sirniö et al., 2013). It is possible that the role of childhood conditions in explaining disparity in mortality by income is changing over time, although this could not be assessed in the present study.

7.4 THE CAUSE-OF-DEATH COMPOSITION OF CHANGES IN THE ASSOCIATION BETWEEN INCOME AND MORTALITY

Differences in mortality attributable to cardiovascular diseases have made a major contribution to mortality trends by education, occupation and income in Finland and elsewhere in Western industrialized countries in previous decades (Blakely et al., 2008; Fawcett and Blakely, 2007; Valkonen and Martikainen, 2006). Moreover, not only has the steady decrease in mortality related to cardiovascular causes continued in Finland, it is also occurring more equally across occupational and educational groups during 1990-2005 than earlier (Valkonen et al., 2009; Valkonen and Martikainen, 2006). The

results of this study highlight the fact that a substantial proportion of the increasing mortality gap by income among men aged over 65 still originates from changes in mortality attributable to IHD and other circulatory diseases. It has also been suggested that cancer is overtaking CVD as the main driver of the income-mortality disparity (Fawcett and Blakely, 2007). The results of this study give some support to this claim with regard to women, but not so much among men. Swedish evidence also emphasizes the increasing relevance of lung cancer and respiratory diseases, both largely attributable to smoking, in the stagnation of life expectancy among women in the lowest income quintile (Hederos Eriksson et al., 2014). Lung cancer and respiratory causes contributed only modestly to the increasing disparity among women in the current study, but recent studies emphasize the increasing contribution of smoking-attributable causes to the widening gap in life expectancy by income and education in Finland. This increase derives from the increasing mortality attributable to smoking in the lowest income quintile among women, and the slower decline among men than in higher quintiles (Martikainen et al., 2013, 2014).

7.4.1 ALCOHOL-RELATED CAUSES OF DEATH

The most drastic results of this study concern the role of alcohol-related causes in the disparity in mortality. Such causes have previously been identified as an important factor in the increasing disparity by education and occupation in Finland (Valkonen et al., 2009; Valkonen and Martikainen, 2006). The strengthening relevance of alcohol-related health problems to educational disparity in mortality has also been reported elsewhere, especially in Eastern and Northern European countries (Mackenbach et al., 2015a). However, the sub-study I of this thesis was the first study to report a substantial increase in disparity in mortality by income due to alcohol-related causes in Finland.

The results of the current study could be interpreted in the context of the secular upward trend in alcohol-related mortality in Finland (Kraus et al., 2015). Increasing disparity was observed in mortality with alcohol as an underlying cause as well as a contributory or underlying cause. However, most of the increase in alcohol-related mortality originates from chronic diseases such as liver cirrhosis, which may take up to 20 years of excessive drinking to develop (Skog, 1980). Therefore, drinking patterns established well before the study period affected the mortality trends substantially. The higher prevalence of binge drinking in cohorts born during and after the Second World War compared to earlier cohorts, together with the maturing of these cohorts to an age at which most alcohol-related deaths occur, may explain some of the increase (Härkönen and Mäkelä, 2011; Kraus et al., 2015). This may also be reflected in the rising alcohol-related mortality in the years following retirement among men (Statistics Finland, 2014b). For these

reasons the processes leading to death related to alcohol are having an increasing effect on socioeconomic disparities in mortality in general. This is evident in the results of the current study showing that all-cause mortality in 35-64-year-olds is increasingly attributable to alcohol-related causes as other-cause mortality is decreasing.

The upward trend in alcohol-related mortality is associated with the rising total consumption of alcohol per capita that has occurred over several decades in Finland (Kraus et al., 2015). The changes in total consumption over time, in turn, are related to affordability and availability. The improved affordability originated mainly from the increase in real incomes until 2004, and the decrease in incomes during the recession of the early 1990s was therefore also reflected in the drop in total consumption in 1990-93. The substantial cuts in excise taxes on alcohol and the abolishing of travellers' import quotas in 2004 made alcohol more affordable and increased consumption irrespective of real income development (Karlsson and Österberg, 2009). From short-term perspective the tax cuts resulted in an increase in alcohol-related mortality particularly among the non-employed and those on low incomes, affecting the trends observed in this study as well (Herttua et al., 2008). A later study showed that in longer-term perspective after the tax cuts alcohol-related hospitalizations increased also among men who were employed (Herttua et al., 2015a). The current results reaching year 2012 show that the trend of increasing alcohol-related mortality is continuing in the lowest quintile despite the alcohol tax hikes in 2008-09, and the decline in general alcohol-related mortality among men and its stagnation among women after 2008 (National Institute for Health and Welfare, 2014; Statistics Finland, 2014b).

Wider disparity by income group has been previously noted in mortality attributable to alcohol-related causes than in all-cause mortality. On the other hand, a proportionally roughly equal part of the disparity in both cases is attributed to the explanatory factors education, social class, economic activity and family structure (Martikainen et al., 2001b). Despite the increasing level of alcohol-related mortality among those on low incomes however, no increase in the explanatory role of education, occupation and economic activity was observed in this study, and it was rather the opposite among women. The implication is that processes other than those connected to the general socioeconomic factors measured here also drive the increase in alcohol-related mortality in the lowest income quintile, and that alcohol-related harm is more prevalent than previously throughout the lower levels of income distribution. However, given that controlling for economic activity may be an over-adjustment to some extent, the relevance of income level to alcohol-related mortality may be more pronounced than observed here. Although accounting for economic activity did not completely explain the widening disparity, a large proportion of the increase in alcohol-related mortality originated from the non-employed population. In terms of employment status the selective path from severe drinking problems to non-

employment is plausible. Becoming non-employed prior to death has been shown to be somewhat more common in alcohol-related than in other-cause mortality: of those who died from alcohol-related causes between the ages of 45 and 64, 40 per cent were still employed five years before their death, whereas the figure for other causes was 50 per cent (Paljärvi et al., 2014). On the other hand, it is possible that the increasing mortality attributable to alcohol-related causes among the non-employed is one indication of a developing trend in which non-employment exacerbates existing alcohol abuse: the increasing mortality to alcohol related causes was particularly evident among the long-term unemployed and the pensioned population in 2001-05 (Herttua et al., 2008).

Although the attenuation of relative excess mortality in the lowest quintile remained at 50-60 per cent among men and decreased among women, it is likely that greater proportion of the absolute gap would be explained by these socio-demographic factors (e.g. Kivimäki et al., 2008; Lynch et al., 2006). This occurs mainly because adjustments, economic activity in the main, explain also the level of mortality throughout the income quintiles and therefore the absolute gaps may narrow substantially. However, unreported sensitivity analysis showed increasing absolute mortality rates to alcohol-related causes also among the employed in the lowest quintile. Further research assessing the predicted level of mortality by income while accounting for socio-demographic factors would be needed.

7.4.2 EXPLANATIONS OF THE STRENGTHENING ASSOCIATION BETWEEN INCOME AND ALCOHOL-RELATED MORTALITY

There are several possible reasons why alcohol-related mortality has increased in the lowest relative to the highest income quintile, also to some extent irrespective of education, occupation and economic activity. The shift of the cause-of-death structure in the income-mortality disparity towards alcohol-related causes could be interpreted in terms of the increasing relevance of the behavioural mechanisms behind the income-mortality association. The observed increasing relevance of causes of death with a substantial behavioural component is emphasized in findings on smoking- and alcohol-related mortality. If alcohol- and smoking-attributable deaths had been excluded, the gap in life expectancy between the extreme quintiles would have remained at roughly the same level among women, and would have increased only moderately among men in 1988-2007 (Martikainen et al., 2014). This highlights the possible increasing prevalence of personality characteristics elevating susceptibility to these health behaviours among those with a low income (Mackenbach, 2012). However, as discussed previously with regard to the relatively low proportion of disparity explained by personality characteristics in all-cause mortality, this explanation is not likely to be exhaustive. On the other hand, increasing affordability and

consumption of alcohol in Finland has led to more alcohol-related health problems, both somatic and mental, also in the employed population (Herttua et al., 2015a). As such development is likely to lead to lower income among those affected, the process contributes to increasing relevance of selection in the income-mortality association.

However, as controlling for economic activity did not completely explain the increase in excess mortality in the lowest quintile, it is difficult to determine whether or not individuals in Finland with drinking problems are now more likely to end up with lower incomes before their death, while still remaining employed. One indication of this would be if income trajectories before death have changed given that alcohol-related causes are increasingly contributing to the disparity in mortality among those of working age. It is left for future studies to explore whether this has happened in countries reporting increasing disparities in mortality by income.

Instead of selection, it is also plausible that people at the lower end of the income-distribution are increasingly burdened with adverse life-events that were not measured in this study. Furthermore, such events are likely to be cumulative and in combination with economic difficulties may exacerbate existing susceptibility to mental disorders such as alcohol dependence and abuse, which are deeply intertwined with alcohol-related mortality (Roerecke and Rehm, 2013). The life-course perspective and accumulated adversities are relevant in interpreting these results. However, the current findings regarding the modest explanatory power of observed and unobserved shared childhood-family characteristics in the disparities in alcohol-related, violent and accidental mortality suggest that events in adult life are more closely associated with the income-mortality association.

The increasing relevance of behavioural causes to the disparity in mortality could also be interpreted in terms of the psychosocial effects of a low income - not necessarily in the direct sense given the difficulty in determining whether or not exposure to psychosocial stress among those with a low income has increased in the long run. However, consuming increasing amounts of alcohol for extended periods to cope with psychosocial stress is decreasingly restricted by low income in Finland as alcohol has become more affordable. Therefore increasing affordability of alcohol can also be interpreted as contributing to the causal path from low income to mortality.

Although cohort changes in the prevalence of binge drinking may partially explain the increasing trend in alcohol-related mortality, it does not explain its strengthening association with income unless changes in drinking habits are strongly patterned by income level. This would be in accordance with evidence suggesting that harmful alcohol-consumption patterns are more prevalent among those in the lower socioeconomic strata (Härkönen and Mäkelä, 2011). On the other hand, it has also been suggested that among individuals exhibiting similar drinking behaviour, those with fewer socioeconomic resources are more vulnerable to the harmful effects of

alcohol (Mäkelä and Paljärvi, 2008). The excess alcohol-related harm in the lowest socioeconomic groups may be attributable in part to the accumulation of various chronic health problems and other health-damaging factors not measured in this study, such as overweight and smoking. Why this vulnerability would have increased specifically related to income is nevertheless unclear. For example, BMI level has increased only slightly among those with only basic education in 1997-2012 in Finland (Männistö et al., 2015).

7.5 METHODOLOGICAL CONSIDERATIONS

7.5.1 REGISTER DATA

The register data used in the study provides several advantages with regard to studying disparity in mortality and how it changes. The data does not suffer from non-response and attrition, and includes socially excluded groups that do not participate in surveys. Therefore underestimation of the mortality level of these deprived population segments is avoided, particularly with regard to alcohol-related causes of death where non-response bias may be substantial (Harald et al., 2007; Jousilahti et al., 2005). The income data originated from the Finnish Tax Administration and Social Insurance Institution, hence the measurement is reliable and more accurate than self-reported income measures, which are somewhat prone to misreporting and recall bias.

Information on causes of death originated from the Finnish Cause of Death Register, which is recognised internationally as being of high quality (Lahti and Penttilä, 2001). By including not only the underlying cause of death but also information on the contributory causes of death on the death certificate, the data allows assessing the burden of alcohol related causes to mortality disparity to wider extent than majority of international studies. A new ICD-10 cause-of-death classification was introduced in Finland in 1996, but this does not affect the results, which are based on the Statistics Finland classification harmonized for changes in ICD classifications over time. A minor effect of the new classification, restricted specifically to the year 1996, has been previously shown in terms of underreporting alcohol as a contributory cause of death (Herttua et al., 2007). Furthermore, the cause-of-death analyses of mortality trends do not suffer unduly from the changes in methods of determining cause of death over time, there being no notable changes in the period 1988-2012 among the population aged 35-64: roughly 40 per cent of deaths were coded following a clinical examination by a medical doctor, and 60 per cent by autopsy. Because most of the increasing alcohol-related mortality originated from deaths with alcohol as an underlying cause (usually requiring long periods of excessive alcohol

consumption), the increasing trend does not occur because alcohol would have been increasingly mentioned as one of the three contributory causes in the death certificate.

Study designs involving data from events occurring decades apart are particularly challenging with regard to data reliability, and recall bias is a potentially significant source of error in retrospective data measuring childhood-family characteristics. The combination of census and register data used in sub-study III helped to minimize the effect of these error sources on the results.

There are also downsides in using data from administrative registers. Information on factors related to health behaviour, health status and various measures of personality characteristics are not directly included, for example. As a result it was difficult to identify the effect of various selective processes, both direct and indirect, in this study. On the other hand, register data made it possible to assess the selection mechanisms by using sibling design. Due to register data confidentiality regulations complete information on all deaths could not be obtained for the study period. Including an oversample of 80 per cent of deaths occurring in 1988-2007 made it possible to conduct robust analyses by several causes of death and socioeconomic groups despite the fact that death below retirement age is a relatively rare event. However, as the oversample did not cover the years 2008-2012, the corresponding results should be interpreted with caution because of the greater random variation due to the lower number of cases than in the preceding years.

7.5.2 INCOME MEASUREMENT

How the income measure is defined has repercussions on the results. The relationship between mortality and income is dependent to some extent on the definition of this measure (Benzeval et al., 2001; Martikainen et al., 2009). Household income adjusted for household composition was the main measure used in this study as it reflects the real consumption potential of the individual and is less prone to reverse causation than individual income.

The measure of disposable household income, which includes tax-free benefits and excludes paid taxes, yields a somewhat weaker association with mortality than individual or taxable household income (Martikainen et al., 2009). As expected, sensitivity analyses conducted in sub-studies I, II, and IV using the disposable-income measure showed somewhat weaker associations with mortality, but the results regarding the diverging mortality trends and the explanatory role of the controlled factors were not substantially affected. The difference in the association implies that those receiving tax-free benefits also have higher mortality. The greatest proportion of tax-free benefits available for 35-64-year-old population consists of the child benefits while housing allowances and income support form also substantial part of total

tax-free benefits paid. As the two latter benefits are means tested, their receivers are mostly in the lowest quintile. Receiving income support is unlikely to result in other income quintile than the lowest but regarding housing allowance this is possible. However, as this allowance is directed for those with low income but high housing costs their disposable income after housing costs is unlikely to differ from those in the lowest quintile. Therefore drawing inferences from the difference of these income measures should be careful in the absence of disposable income measure accounting for housing costs.

Individual income as used in sub-study III is likely to be more strongly affected by reverse causation than household income, and does not necessarily reflect the real economic resources available to some specific groups such as women doing household work. Sensitivity analyses including only employed women provided similar results after adjustment, although the age-adjusted disparities were smaller. Furthermore, the chosen measure of income in adulthood may affect the strength of the association between income and mortality, but is unlikely to substantially affect the contribution of shared childhood characteristics to that association.

In this study income was measured in the year preceding the mortality follow-up. Incomes fluctuate over the years, especially among those of working age, and it is therefore often proposed that average income across several years be the preferred measure as it is less riddled with random variation and reflects economic resources more accurately. However, this fluctuation is less of an issue in analyses of mortality trends if the pattern of fluctuation does not change substantially over time. Furthermore, the use of income quintiles in this study restricted the effects of fluctuation to some extent in that changes in income within the income categories did not affect the income measure. Moreover, the initial analyses and the sensitivity analyses conducted in sub-studies I and II using income measures from three years before the mortality follow-up yielded similar results. Additionally, given that the objective of the study was to extend the observation period to cover the earliest mortality information available in the data, namely to 1988, averaging incomes across several years would have meant postponing the beginning of the mortality follow-up. Further, the measurement of income rank used in sub-study III was constructed at the baseline age of 35. This decreased the role of reverse causality in that poor health preceding death did not affect the income of a substantial proportion of the population, and the low income did not generally derive from studying at that age. However, it is likely that income changed several times during the subsequent follow-up of 22-37 years, and did not precisely indicate real exposure to low income during the follow-up - thereby introducing some downward bias into the estimates. It was probably for these reasons that the observed mortality gradient was more moderate in sub-study III despite the use of individual income as the income measure.

Income may not fully reflect access to economic resources in that wealth may buffer the effects of a low income. No adjustments were made for wealth in the analyses given the lack of relevant information covering a sufficient time span. Those with a low taxable income may include some people with substantial wealth, but it is likely that such people have fewer accumulated adversities and therefore also a lower risk of death. However, this is unlikely to affect the findings, particularly concerning the lowest income quintile, and the presence of such an effect would make the current estimates rather conservative. Furthermore, household income cannot be defined for those who do not belong to a household (i.e. institutionalized and homeless persons). Excluding these individuals with a high mortality risk and a low income from the analyses is likely to have only minor repercussions on the results, but also produces more conservative estimates of the disparity in mortality.

The operationalizing of income measures in studies also has repercussions on interpretations of the results. Relative rank in the income distribution stresses the psychosocial aspects of income inequality, whereas absolute income measures consumption potential more directly as well as the material dimension of disparity (Åberg Yngwe et al., 2005). In any case, these measures are highly correlated, and the choice between rank and absolute measures is less problematic in studying mortality trends given that the intention is not to disentangle the absolute and relative effects of income on mortality. Finally, in terms of temporal changes in disparity, income as a socioeconomic indicator may be particularly sensitive to period effects, partly because changes in health-related harm deriving from alcohol consumption, the level of unemployment and the level of social benefits affect the level of income more than educational level and occupational status. Thus, period changes in socioeconomic disparities in mortality may go unnoticed if trend analyses concentrate on education and occupational class.

7.5.3 STATISTICAL METHODS

Life expectancy calculated from life table is a measure of age-adjusted mortality, which is relatively easy to understand intuitively. However, certain assumptions are easily misunderstood. Calculating life expectancy at the age of 35 for each income quintile during a specific year indicates how many years a person aged 35 would live, on average, if he or she were to remain in the same quintile and the mortality in the age groups in that quintile did not change. Given that mortality does not, in fact, remain unchanged, and that people are unlikely to remain in the same quintile throughout life, life expectancy should be seen as describing mortality during a certain year and not as a projection. On the other hand, life expectancy calculated for educational groups does not suffer to same extent from individuals moving between categories, although because of educational inflation the meaning of

having a secondary education, for example, differs between cohorts. When comparing life expectancies and age-adjusted mortality rates, it should also be remembered that deaths at young ages will be emphasized more in life expectancy than in mortality rate.

Study design of sub-study III is based on comparisons of siblings within families, and therefore the population from which inferences are drawn is the population with siblings of the same sex. However, the distributions of the independent variables among all children aged 0-14 in 1950 and those with siblings of the same sex were almost identical. Moreover, the differences in the associations of these variables with all-cause mortality were small when Cox regression models 1-4, including all children, were fitted. Hence, the restriction of the analyses to those with siblings alive at the age 35 is not likely to have affected these results.

Certain other restrictions should be kept in mind when fixed-effects models are used to adjust for unobserved shared childhood characteristics when estimating the income-mortality association. Only siblings discordant in terms of income contribute to these analyses, and those differing in terms of income level may also differ from total population in other respects as well. It has been shown, that the restriction to discordant siblings may bias the estimates of the sibling comparison because the restriction might emphasize the effect of unobserved confounders not shared by the siblings (Frisell et al., 2012). In other words, while this design adjusts for unobserved shared factors it may also introduce other sources of confounding compared to individual-level analysis. Therefore the inferences concerning the magnitude of attenuation should be careful. On the other hand, further analysis showed that the distributions of income and economic activity among these discordant siblings and all siblings were not different, only the proportion of those with a basic education was slightly (3-8 percentage points) higher among the discordant siblings. In addition, regular Cox models were fitted only for siblings who were discordant in terms of income. This sensitivity analysis yielded largely similar results as models 1-4, with only slightly lower HRs in the lowest quintile.

KHB-decomposition was used in the sub-study IV to assess the extent to which adjusted variables attenuate the income-mortality association. Using the KHB method in comparing nested non-linear models the problems related to the rescaling of coefficients between models are avoided (Allison, 1999; Karlson et al., 2012). Some caveats regarding the KHB decomposition should be kept in mind when drawing inferences from the attenuation percentages. It is not currently possible to calculate the confidence intervals of these percentages using bootstrapping or jackknife resampling. However, the main findings concerning the percentages are consistent across periods and are therefore not likely to occur due to randomness. The attenuation percentages were also calculated from the change in coefficients, when the control variables were introduced one by one into the regular discrete time survival model. This sensitivity analysis yielded results largely similar to the

initial KHB analyses. Only occupational class had slightly less explanatory value.

The fact that mortality in the lowest quintile, unlike in the other quintiles, did not decrease may imply that income rank has an increasingly curvilinear association with mortality over time. This could have methodological repercussions on measuring disparity trends in mortality using relative and slope indices of inequality, as their use requires the ranking variable to have a linear association with mortality (Regidor, 2004). Strengthening the non-linearity of the association may therefore cause an underestimation of the disparity when these measures are used without estimators relaxing the linearity assumption.

7.6 IMPLICATIONS FOR POLICY

The goals set for tackling socioeconomic disparities in mortality in the WHO Health21 and Health 2020 programmes and on the national level have not been met in Finland in terms of reducing inequalities. The general decline in mortality is reflected in increasing life expectancy, but not equally. It has been proposed that reducing absolute disparities should be the aim of public health policy given that it is difficult to tackle the relative differences in times of decreasing mortality (Mackenbach, 2015). However, not only the relative but also the absolute gap between extreme income groups has widened in Finland. High mortality is increasingly concentrated in the population segments with low economic resources, and often outside the labour force. Targeting the low end of the income distribution is essential to narrow the gap in life-expectancy differentials. Although the real income of those fully dependent on the minimum level of social benefits has slightly increased since 2011, the proportion of people in this group has increased and stood at 4.3 per cent of the population in 2013. The proportion of those whose income derived mostly (over 50%) from basic benefits was roughly nine per cent. Minimum social benefits still cover only 71 per cent of what is considered the minimum adequate level of consumption for those on unemployment or sickness benefits (National Institute for Health and Welfare, 2015).

The insufficiency of basic social benefits is likely to have negative repercussions on health in many respects. On the other hand, increasing incomes in the low end of the income distribution does not necessarily add consumption beneficial to health. Therefore also the reach of health services should be emphasized. Non-employed persons generally rely on public healthcare services, which are universal and of good quality but not completely free of charge: patient fees constitute a substantially greater proportion of the disposable income of those in the lowest income quintile (Kapiainen and Klavus, 2007). Raising or introducing new patient fees in times of austerity could postpone or hinder the seeking of medical care in less severe cases among those on a low income.

The decline in mortality attributable to circulatory diseases is still the main contributor to the increasing life expectancy throughout the income distribution. However, tackling the general increasing trend in alcohol-related mortality in both sexes and smoking-attributable mortality among women is crucial to narrow the gap in life expectancy between the income groups. The substantial behavioural component in these causes of death is challenging from the policy perspective but can be addressed by regulating price and availability of alcohol and tobacco. Decreasing the affordability of these substances via taxation and minimum unit pricing might direct the preventive measures specifically to those with a low income and susceptible to the most health-related harm. The responsiveness of individuals with drinking problems and alcohol dependence to increased alcohol prices may not be straightforward (e.g. Herttua et al., 2015b) but alcohol-related harm is found to be generally inversely related to the level of alcohol prices and taxes (Wagenaar et al., 2010).

Tackling alcohol-related harm should not be confined to price in that a low income could also be a consequence of extensive alcohol consumption. Both the early detection of alcohol abuse and intervention should be emphasized in the primary-care setting specifically among the non-employed. However, the employment level of those dying from alcohol-related causes is roughly at the same level as that of survivors 16 years before death (Paljärvi et al., 2014). Consequently, interventions aimed at this point in time, when employment has not yet been lost, are particularly crucial given the signs of a strengthening adverse effect of unemployment on alcohol-related mortality. Despite the observation that shared childhood-family characteristics did not comprise a substantial explanatory factor with regard to disparity in mortality by income, cumulative adversity and social exclusion should be addressed in the early ages. It is essential to tackle school dropout levels and to encourage further education so as to reduce the risk of non-employment later in life, given the pronounced and increasing unemployment level of young people with only compulsory education (Kalenius, 2014).

8 CONCLUSIONS

Income is strongly associated with mortality. The association is a result of interrelated processes that do not remain static over time. This study strengthened the existing evidence of a mortality gradient by income among the over-35s. Part of the association could be attributed to the educational and occupational composition of the income quintiles, and the higher proportions of the unemployed and early retirees in the lowest quintiles in particular explain it to a substantial degree. Despite the fact that childhood-family socioeconomic conditions predict mortality in adulthood, childhood characteristics shared by siblings do not offer a substantial explanation of income disparity net of adulthood socio-demographic characteristics.

However, this study has shown that the association between income and mortality has grown stronger in Finland since the late 1980s. The gap between the lowest and the other income quintiles in particular increased markedly in 1988-2007, mainly because mortality declined relatively modestly in the lowest quintile among the over-65s, and increased or stagnated among those aged 35-64. Most of the adverse mortality development in the lowest income quintile originated from the non-employed population, but was not restricted to this segment in that the increasing disparity persisted when economic activity was accounted for.

Although the decline in mortality attributable to cardiovascular diseases is driving the gains in life expectancy, the diverging development among those on a low income originates increasingly from causes of death with a substantial behavioural component. The observation of drastically increasing alcohol-related mortality in the lowest income quintile underlined this finding. Even though the increase in mortality level among those with a low income originates from alcohol-related causes, the disparity in other causes shows very little signs of decreasing. The traditional individual socio-demographic characteristics related to income, and changes in the prevalence of these factors within the income quintiles do not explain the adverse mortality trends in alcohol-related or other causes of death.

This development may reflect the increasingly harmful effects of being on a low income that operate to some extent via material and psychosocial mechanisms leading to the adoption of coping strategies that are harmful to health. The increasing affordability of alcohol has probably contributed to this change but also strengthened the role of selection into low income. Because income is partially affected by health, the growing excess mortality in the lowest quintile may imply that people are now more likely to end up with a low income before death due to poor health while still remaining employed. On the other hand, personal characteristics and behaviours that are harmful to health but were left unobserved in this study may increasingly accumulate among those with a low income. In any case, low economic

resources and high mortality are increasingly connected. The strengthening behavioural component in the widening mortality disparity indicates that people with low incomes are not struggling only in terms of low economic resources but also with problems related to substance abuse prior to early death.

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