Socioeconomic deprivation and cardiovascular disease

Pardeep S. Jhund
BSc(Hons), MBChB, MSc, MRCP

Submitted in fulfilment of the requirements for the degree of PhD

University of Glasgow
Faculty of Medicine - BHF Glasgow Cardiovascular Research Centre and Department of Public Health and Health Policy

Summary

Socioeconomic deprivation (SED) is inversely associated with mortality. The most deprived are at a higher risk of all cause mortality and cardiovascular mortality. However, only limited study of the relationship between SED and non-fatal cardiovascular disease has been previously undertaken. In those studies that have examined the relationship between SED and non-fatal cardiovascular disease, analyses have been limited to one form of cardiovascular disease (CVD), such as myocardial infarction or stroke and often prevalent disease. Furthermore, these studies have often failed to examine the association between SED and CVD whilst adjusting analyses for cardiovascular risk factors which are more prevalent in the most deprived. The aim of this work was to examine the association between SED and a number of cardiovascular outcomes after adjusting for the traditional cardiovascular risk factors of age, sex, smoking, blood pressure, diabetes mellitus and cholesterol. To determine is SED is in fact a risk factor for CVD after adjustment for these other risk factors, the relationship between SED and a number of fatal and non-fatal cardiovascular outcomes was examined. A number of forms of CVD were examined, including all coronary heart disease, myocardial infarction, stroke and heart failure

A cohort of over 15,000 men and women who participated in the Renfrew Paisley cohort study was examined. These individuals were enrolled between 1974 and 1976 and underwent comprehensive screening for cardiorespiratory risk factors. They have since been followed for hospitalisations and deaths for 28 years. SED was measured using the Registrar General's social class system and the Carstairs Morris index of deprivation. Rates of fatal and non-fatal outcomes were calculated, as were a number of composite outcomes. Adjusted analyses using multivariable regression were conducted to account for the risk factors of age, sex, smoking, blood pressure, diabetes and cholesterol. Further adjustment for the risk factors of lung function as measured by forced expiratory volume in 1 second, cardiomegaly on chest x-ray, body mass index, and a history of bronchitis was also made. The association between SED and the risk of recurrent cardiovascular hospitalisations, the burden of cardiovascular disease, as well as mortality and premature mortality was assessed for SED.

I found that SED was associated with higher rates of hospitalisation for CVD disease in men and women irrespective of the measure of SED, either social class or the area based score of the Carstairs Morris index. This association persisted after adjustment for the traditional cardiovascular risk factors of age, sex, smoking, systolic blood pressure and diabetes and cholesterol. Further adjustment for lung function, the presence of bronchitis, body mass index and cardiomegaly on a chest x-ray did not explain the relationship between SED and each outcome. This risk was long lasting and persisted to the end of follow up. The strength of association of SED with coronary heart disease, myocardial infarction and stroke and all cause mortality was similar.

The risk of a recurrent CVD hospitalisation was not higher in the most deprived after adjustment for CVD risk factors. However, I observed that SED was associated with higher mortality following an admission to hospital with CVD, before and after adjustment for cardiovascular risk factors of age, sex, smoking, systolic blood pressure, cholesterol and diabetes and after adjusting for the year of first developing cardiovascular disease.

All cause mortality and cardiovascular mortality was highest in the most deprived. Again this association persisted after adjustment for cardiovascular risk factors. The most deprived also experienced longer hospital stays than the least deprived for a number of cardiovascular diseases including myocardial infarction and stroke. As a result the costs associated with cardiovascular disease admissions to hospital were highest in the most deprived despite their higher risk of dying during follow up. The cost differential was also explained by the finding that the most deprived experienced a higher number of admissions per person. Finally, the population attributable risk associated with SED is comparable to that of other traditional cardiovascular risk factors.

In conclusion, I have found that the risk of CVD in the most deprived is higher even after adjustment for a number of cardiovascular risk factors. The numbers of hospitalisations, costs and mortality are also highest in the most deprived. Efforts are required to redress this imbalance. This can be achieved at the level of the individual through health care interventions to reduce the absolute burden of cardiovascular risk factors and to treat disease. However, societal level interventions are also required to tackle this problem as SED exerts complex effects on health that seem to also be independent of risk factors.

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Abbreviations

95% CI – 95% confidence interval

ASSIGN – ASSessing cardiovascular risk, using SIGN

BMI – body mass index

CHD – coronary heart disease

CVD – cardiovascular disease

ECG – electrocardiogram

EUROASPIRE – European Action on Secondary Prevention through Intervention to Reduce Events

FEV1 – forced expiratory volume in 1 second

HDL – high density lipoprotein

HF – heart failure

HR – Hazard ratio

MONICA – Multinational Monitoring of Trends and Determinants of Cardiovascular Disease

MI – myocardial infarction

NHS – National Health Service

OR – odds ratio

RR – Rate ratio

Statin – HMG CoA reductase inhibitor

SD – standard deviation

SE – standard error

SED – socioeconomic deprivation

SMR – Scottish Morbidity Record

Acknowledgements

Firstly I would like to thank Prof John McMurray. His guidance and support over many years has been unwavering. I will always be grateful for his advice and insights during my career in both academic and clinical Cardiology.

I would also like to thank my co-supervisor Dr Kate MacIntyre for providing me with the training required to complete this thesis. I am especially thankful to her for her enthusiasm and for passing on her expertise on the Scottish Morbidity Record.

Prof David Hole sadly passed away early on in the course of this thesis but his contribution at the start of these studies was invaluable and it was an honour to work with him. He is sorely missed.

I would like to thank Dr James Lewsey for helping me to decipher the literature on competing risks and for his insights into statistics.

In addition to the people who participated in the Renfrew Paisley study, I would like to thank all those involved in the study over the years. In particular I am indebted to Mrs Pauline MacKinnon who maintains the dataset and Dr Carole Hart whose insights into the conduct of the study and the data have been invaluable.

I am grateful to the Chief Scientist Office of Scotland for supporting this work through a Health Services Research Training Fellowship.

Finally, I would like to thank Michelle for her love, support and patience throughout this research and for bringing into this world our son, Talvin, whose arrival gave me the impetus to finish this thesis.

Author’s Declaration

I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Pardeep S Jhund

Introduction

This thesis will examine the relationship between socioeconomic deprivation and cardiovascular disease. It will review the published literature surrounding this topic and will report the results of a number of studies examining the relationship between socioeconomic deprivation (SED) and cardiovascular disease (CVD) occurring in a cohort of men and women in the west of Scotland followed for over 25 years.

In the first section I will review the principles behind the measurement of socioeconomic deprivation before moving on to describe the literature relating SED to health and well-being in Scotland, and the UK. The next section will describe the literature that has examined the association between SED and cardiovascular outcomes, highlighting the deficiencies in the literature that underlie the need for these analyses. Following from this I will state the aims and objectives of this thesis. I will then describe in detail the cohort studied in these analyses and some of the general statistical methods used to analyse the data. The subsequent chapters will present the results of the analyses performed which have examined the association between SED and CVD. I will present the results of analyses that have examined the association with a first non-fatal CVD hospitalisation and a number of composite outcomes, the impact of SED on recurrent hospitalisations and subsequent cardiovascular and all cause mortality and finally the burden of disease, including the numbers of CVD admissions, length of stay and health care costs. In each of the analyses a number of the major forms of CVD will be examined including all coronary heart disease, myocardial infarction, stroke and heart failure.

Socioeconomic Deprivation

Measurement and definition of socioeconomic deprivation

The literature surrounding the concept of socioeconomic status or deprivation is almost immeasurable and many concepts and terms are still open to debate and outside the scope of this thesis.[1] For example, multiple terms are used to describe the concept of social status from “social class”, “social inequality”, “socioeconomic position” and “socioeconomic deprivation” with each having theoretical advantages. For consistency I will refer to socioeconomic deprivation (SED) throughout this thesis. This can be measured by a number of different methods. It is often defined on an individual level using measures such as income, education and occupation. Each measure has its own advantages and disadvantages; however, comparing measures between different countries and cultures is often difficult as levels or scores are country or culturally specific. In addition, individual measures of SED may not account for the other contextual effects that poverty and the environment impart on an individual. As these are much harder to quantify than individual measures such as income, a number of different scoring systems have been developed. I will discuss below the theory and use of two measures of SED that I will utilise in the studies that I have conducted and note some of the other measures commonly encountered in the literature surrounding SED and CVD.

Theoretical background to the measurement of socioeconomic deprivation

Before discussing the methods by which SED can be measured in the literature it is important to assess the broad concepts underlying the measurement of SED. Societies are complex systems and social stratification is an important mechanism by which societal resources and goods are distributed and accumulated over time by different members of a population. Different measures of SED capture different aspects of social stratification. Each measure may be more or less related to different health outcomes and may also be related to health at different stages of life. For example, social class as defined by parental occupation is more likely to reflect social circumstances in childhood than late adulthood. Most indicators are correlated with each other to some degree because they all measure some aspect of a population’s underlying socioeconomic stratification.

The full theoretical and historical background of social theory is too large to summarise here but has been reviewed by other authors.[2] Two social theorists have informed much of the thinking around social stratification and the concepts which have led to different measures of SED.[3] The first is Karl Marx. Marxist theory defines social position as a structural relation between groups in a society based upon the production and ownership of material goods. This is based on how the owning classes exploit the non-owning classes in a society. The theory is underpinned by the inherent conflict in a society between the exploited workers and the exploiting capitalists. Therefore, in this view of SED the relationship is not a feature of the individual per se but of the inherent social system of the few exploiting the many.

Max Weber is credited with the other major theory of SED. Weber suggested that a society is stratified through many dimensions. This creates groups of individuals who share a common position within a society and therefore share the same "life chances". Their life chances are created by a common ability to beneficially use or trade their education, skills and attributes in the marketplace of their society. Thus, Weberian theory leads to the use of education, occupation and income as measures of these aspects. Weber, in contrast to Marx, therefore places more emphasis on the individual's ability to change life circumstances as opposed to the inherent flaws in a society that Marx proposed, over which an individual had little influence.

Occupation based measures

Occupation based indicators of SED are widely used and are perhaps the most commonly understood method of assessing SED.[3,4] Occupation can represent SED by reflecting a person's place in society in relation to their social standing, income and intellect. It can also characterise working relations between employers and employees. Most studies use the current or longest held occupation of a person to assign an individual's SED. Occupational measures based on one individual are often used to define the social position of those around them. For example, the occupation of the ''head of the household'' can be used as an indicator of the SED of dependants (the most common situation is that of the husband's occupation being used to define the social position of his wife and children) or the household as an entirety. A number of general mechanisms may explain the relation between occupation and health outcomes. Occupation is strongly related to income, and therefore, the association with health may be one of a direct relation between material resources and health. Alternatively, occupation may reflect social standing and be related

to outcomes because of the privileges that it brings, for example better access to health care, access to education, and so on. Occupation may also reflect social networks, stress at work, level of control, and autonomy and thereby affect health outcomes through a psychosocial process. Finally, occupation may reflect specific toxic environmental or work related exposures, for example, environmental smoke.

A particular strength of this measure of SED is its availability in routine data sources, such as the census and death certificates. A limitation of occupational indicators is that they cannot be readily assigned to people who are not currently employed such as housewives. As a result, if used as the only source of information on SED, socioeconomic differentials may be underestimated through the exclusion of some of the population.[4]

In the UK, social class was measured according to industry as early as 1851. In 1911 the Registrar's General's annual report differentiated occupation and industry with a summary of occupations representing ''social grades''.[5] This scale is based on the prestige or social standing that a particular occupation has in our society. In 1990 it was revised to take into account more explicitly the skills needed to perform a particular occupation.

In the Registrar General's social class scheme, occupations are divided into six classes (Table 1), ranked from highest, to lowest, on the basis of prestige.[6] The table is also divided into two broad categories, manual and non-manual occupations. The seventh category of all people in the armed forces (irrespective of their rank), is generally excluded in health studies.

Table 1 Registrar General's Social Class scheme

Grade	Example Occupations	
I Professional	Doctor, Lawyer, Executive	Non-Manual
II Intermediate	Sales Manager, Teacher	
III-N Skilled non-manual	Shop Assistant, Clerk	
III-M Skilled manual	Machinist, Brick layer	Manual
IV Partly skilled	Postman,	
V Unskilled	Labourer, Porters	
VI Armed forces		

The strength of this measure is its past official status in the UK and hence its widespread use in central statistics, as well as a number of censuses and surveys. It has been adapted and used in other countries, making comparability between studies easier. However, its subjective basis is a limitation. Furthermore, it does not account for recent changes in the occupational structure of society. There has been an increase in service jobs and a decrease

in unskilled and semi-skilled manual occupations. To redress these difficulties, since 2000, the Office for National Statistics in the UK has used the new UK National Statistics socioeconomic classification as its official occupation classification. Despite these issues the Registrar General's social class system has been, and continues to be, widely used.

Other occupation based measures are available. For example the Erikson and Goldthorpe Class Schema was devised to allow international comparisons to be more easily made. It has been used in some studies.[7] However, it does not have an implicit hierarchical rank and therefore may not capture gradients in risk across its groups. A Marxist view of occupation underlies the classification system of Wright, which has also been adapted.[8] It explains differences in outcomes across groups in terms of exploitation and conflict between the classes (capitalists, petty bourgeoisie and self-employed). This is an underused scheme though has been applied in the UK.[9] Other scores or measures of occupation include the Duncan socioeconomic index, and, the Cambridge social interaction and stratification scale.[4] Again, these scores are relatively underutilised in the health care literature especially with respect to CVD.

Area level measures and indices of socioeconomic deprivation

Area level indicators are also used as measures of SED. These are commonly aggregated from individual level or small area data, usually from census or other data sources.[4] They can be used to define areas as deprived, or affluent, and consequently are used as a marker of SED for the people living in those areas. A number of area level measures of SED, also often referred to as indices of deprivation, have been developed. I will discuss the index utilised in these analyses, but also highlight some of the other commonly used scoring systems.

The Carstairs Morris deprivation index

The Carstairs-Morris deprivation index is an area based risk score.[10] This index, based on official Scottish-wide census data, is used to rank postcodes of residence into seven deprivation categories. The geographical areas are based on postcode sectors – that is areas with identical postcodes except from the last two characters (e.g. 'G84 9_ _' omitting the last two letters of the postcode). There are almost 1,000 postcode sectors in Scotland, with an average population of around 5,000. The index was originally developed in the 1980s

using 1981 census data. It is composed of four indicators which were judged to represent disadvantage in the population. The four indicators are combined to create a composite score. The deprivation score is divided into seven separate categories, ranging from the most deprived (category 7) to the least deprived (category 1). The seven categories were designed so as to retain the discriminatory features of the distribution of the deprivation score, rather than to ensure equality of numbers between each deprivation category.[11] Some very small postcode sectors were excluded and do not have a score. The index was designed with the expectation that it would be mirrored by direct measurement of household income if that were possible.[10]

The four variables measured were:

1. ***The degree of overcrowding***:

   This was defined as the number of persons in private households living at a density of more than one person per room as a proportion of all persons in private households

2. ***Level of Male unemployment***

   This is the proportion of economically active males who are seeking work in that postcode sector.

3. ***Proportion in Social class IV or V***

   This is the proportion of all persons in private households where the head of household was deemed to be in social class IV or V according to the Registrar General's social class scheme outlined previously.

4. ***Ownership of a car***

   The proportion of all persons in private households with no car

All the proportions are calculated using the households in a given postcode sector.

As suggested by the above, area based indicators account for the socioeconomic conditions of an area, and therefore can have an independent influence on health. Recently, the concept that over and above individual characteristics, the place where a person lives can

affect their health, has received more attention. The place where a person lives can be defined as a neighbourhood, a city, region, or country. Studies that have investigated ‘‘area effects’’ tend to find smaller associations relative to the size of individual SED effects. It is unclear if the association between area level measures of socioeconomic circumstances, and health outcomes, are related to the socioeconomic characteristics of where people live independently of the (lifetime) characteristics of the people living in these areas.[4] One difficulty in disentangling this question is that area based measures are often based on individual level data. One disadvantage of area measures is that they are often used as proxies for individual level indicators when these are not available. In such a situation, given the misclassification of individual socioeconomic circumstances when measured by area characteristics, the association with a disease is likely to be underestimated. The larger the areas the greater the misclassification will be. In my analyses I will utilise both the Carstairs Morris index and occupational social class to minimise this misclassification.

Before discussing other measures of SED it is worth noting that the Carstairs Morris index is not the only area based measure available. The Townsend deprivation index[12], Jarman or Underprivileged area score[13] are conceptually similar to the Carstairs score. They are area based scores constructed from census variables that are similar to the Carstairs score. For example, the Townsend index uses four variables, the proportion of unemployment amongst the ages of 16-64, proportion of non-owner occupied households, car ownership and overcrowding. The Breadline Britain Index is slightly different in that it includes variables such as proportion of individuals with long term illness and lone parent households.[14] These other area based measures have been used in the literature surrounding SED and CVD. In particular, the Townsend deprivation index is commonly used in studies based in England. However, despite their differences, all of these area based scores share the same limitations as the Carstairs Morris index with respect to misclassification and potential difficulties in extrapolating results to the level of the individual.

Other measures of socioeconomic deprivation

Other measures of SED are used by researchers, particularly in the field of cardiovascular disease. The most common of these are income and level of education. As these will not be utilised in the analyses conducted during this thesis they are discussed here in brief, however, they are worthy of note due to their widespread use in the cardiovascular literature. They have been used in multiple prior studies of the relationship between SED and cardiovascular disease particularly in North America.

Income enables an individual to purchase goods and services, such as education and health care, which may impact on health. Income also allows individuals to purchase items such as better food and shelter. It may also be beneficial through the purchase of material goods relevant to participation in a society, thus fostering higher self esteem in an individual, an example would be membership of a social group such as a sports club.[4] Income has limitations as a measure. Poor health may lead to an inability to work and lower income which may lead to reverse causality in epidemiological studies. However, the measurement of income is complex as individual or family income can be measured. Income may be adjusted for family size. Income can also come from other sources. For example, income can contribute to wealth over and above the primary wage in the house, through non-monetary income such as benefits, and, an account of tax relief measures enjoyed by an individual may need to be included to fully determine income. One final limitation of income as a measure of SED is the high rates of non-response in relation to income related questions, which is reported at approximately 10%. Income is particularly favoured as a measure of SED in North America as the health care system is not a universal access for all system such as the National Health Service (NHS) in the UK, therefore, the treatment an individual receives may be directly related to their ability to pay for access to health care services.

Education is a widely used measure of SED in epidemiological studies.[4] Questions on educational attainment have very low rates of non-response in comparison to those on income and questions are rarely complex. Education may also reflect future employment and income. As level of education is fixed after young adulthood it is not influenced by poor health in adulthood, as income may be, and therefore, is not likely to lead to reverse causality. However, poor health in childhood may lead to lower educational attainment. This is not the only limitation of education. There are differences between birth cohorts in level of education, so that the resulting social and behavioural correlates of education may vary according to age.

Whilst there are many measures of SED, no one measure can adequately measure or capture the entire multidimensional construct behind the term socioeconomic status. In a recent study of SED in health research Braveman *et al* [15] concluded that socioeconomic deprivation should be measured by as many relevant measures as possible, and, include individual and area based measures. Whilst it is acknowledged that no one measure is perfect, by examining health effects using multiple measures, the unmeasured socioeconomic effects are lessened.

Socioeconomic deprivation and health in the UK

Before moving on to examine the relationship between SED and CVD, it is worth recounting the relationship between SED and general health and well being, and, the political agenda in the UK. This has set the scene for the current interest in health inequalities and government policy is one of the key drivers to reduce such inequities.

The NHS was launched in the UK on 5 July 1948 with a guiding principle that health care should be available to all irrespective of wealth. Thus, one of its aims was to redress health inequalities through the provision of a universal health care system. However, subsequent Government reports noted that the NHS appeared to be failing in its aim of reducing inequalities in health when evidence of widening health inequalities began to emerge.[16]

The current interest in social inequalities is driven by recent reports in the UK. In the 1980s the existence of health inequalities was famously ignored by the then Conservative government who labelled such inequalities 'variations', explained by statistical artefacts or the fault of those who suffered as a result of them. Furthermore, the magnitude and underlying meaning of the difference was ignored. This is best exemplified by the persistent refusal to acknowledge the findings of the 'Black Report'[17], and by attempts to bury it by publishing it on the August bank holiday in 1980 and producing only 260 copies. The report, by Sir Douglas Black, was not received well as noted by the foreword by the then Secretary of State, Patrick Jenkin. In his foreword he noted that:

"*they (Sir Douglas' group) make clear, the influences at work in explaining the relative health experience of different parts of our society are many and interrelated.....It will come as a disappointment to many that over long periods since the inception of the NHS there is generally little sign of health inequalities in Britain actually diminishing and in some cases, they may be increasing. It will be seen that the Group has reached the view that the causes of health inequalities are so deep rooted that only a major and wide-ranging programme of public expenditure is capable of altering the pattern. I must make it clear that additional expenditure on the scale which could result from the report's recommendations - the amount involved could be upwards of £2 billion a year - is quite unrealistic in present or any foreseeable economic circumstances..... I cannot, therefore, endorse the Group's recommendations. I am making the report available for discussion, but without any commitment by the Government to its proposals"*.

The inequalities in death rates according to SED that were described in the Black report were therefore to be left un-tackled. A major issue with the Black report was the inability of the authors to disentangle why these inequalities were present. One explanation was that they were due to artefact and it is on this explanation that the Government of the day seized.

However, the Black report was not the only report that documented the inequalities in health in UK society. Following a change of government in 1997 to that of Labour health inequalities became an important issue. The Independent Inquiry into Inequalities in Health – 'The Acheson Report'[18] chaired by Sir Donald Acheson, reviewed the evidence of the most effective action to reduce health inequalities. This report also reinforced the findings of the Black report that health inequalities were still widening and were evident across all aspects of health. More reports on the health inequalities in the UK have followed [19]and in Scotland similar reports of health inequalities also exist [20-22].

Socioeconomic deprivation and Scotland

On the 6th of May 1999 Scotland underwent devolution from Westminster. Devolved powers included: health, education, local government, social work, housing, planning, the environment, sport, arts, agriculture, forestry, and fishing. Some aspects of law, home affairs and transport were also devolved. Health inequalities in Scotland had been well documented.[20] It has been documented that of the "worst off million" people in the UK in terms of health, 52% of these individuals were living in Scotland. Mortality rates in Scotland's local authority areas with the worst health were twice as high as the UK average. Inequalities in health also existed within Scotland. The rate of coronary heart disease mortality was two and a half times higher in the most deprived versus the least deprived. In 1998, a comprehensive report looked at health and health services in Scotland through from a health inequalities point of view [23]. Using NHS data, it highlighted substantial inequalities both in the distribution and access to health care for all the major health issues (mental health, coronary heart disease, stroke, and cancer). As expected the most deprived communities experienced the worst health and least access to care, re-affirming the inverse care law of Tudor-Hart, that the availability of good medical care tends to vary inversely with the need of the population served.[24]

Summary

Socioeconomic deprivation is a complex construct which not only refers to poverty. The theoretical basis of SED is founded on two philosophical schools of thought that have guided the development of measures of SED. The Registrar General's social class scheme, an individual measure of SED, and the Carstairs Morris index, an area based measure of SED will be used in this thesis. The relationship between SED and health has been the subject of much interest in the last few decades and differences in health, between the most deprived and least deprived members of society, have been documented in Scotland and throughout the UK.

The relationship between cardiovascular disease in particular and socioeconomic deprivation has also been studied. Prior studies have reported that in those with cardiovascular disease, the prevalence of socioeconomic deprivation is higher.[25] The distribution of SED in relation to prevalent disease is perhaps the best studied aspect of the association between SED and cardiovascular disease. Survival and case fatality in those with cardiovascular disease has also been studied widely. However, much less is known about the association between SED and incident cardiovascular disease. In the next chapter I will review the literature surrounding the relationship between SED and cardiovascular disease. I will focus on studies of incidence and subsequent mortality as well as cardiovascular mortality. I will review the literature surround the relationship between SED and recurrent cardiovascular events before examining the impact of SED on the burden and cost of cardiovascular disease.

Socioeconomic Deprivation and Cardiovascular Disease

This chapter will examine the literature surrounding the relationship between SED and cardiovascular disease. The literature surrounding the prevalence of cardiovascular disease runs to hundreds of manuscripts and has been extensively reviewed in a seminal American Heart Association (AHA) Medical/Scientific Statement by Kaplan and Keil in 1998.[26] Rather than replicate that study of the literature I will instead concentrate on the areas of the relationship between SED and CVD that are less well studied. It is these understudied areas that the present thesis aims to address. I will also focus on more recent studies, published after 1998 and where possible cite studies from Scotland or the UK.

MEDLINE, CINAHL and EMBASE were searched for articles published between January 1998 and January 2009. A generic search strategy (Appendix 1) was written in MEDLINE with appropriate synonyms used to search CINHAL and EMBASE. The grey literature was searched using the terms 'Socioeconomic Deprivation' or 'Health Inequalities' and 'cardiovascular disease'. Reference lists of selected articles were reviewed and citation checks carried out to identify further potentially relevant studies. A number of exclusions were applied. Studies employing a life course approach were not examined as the aim of the present studies was not to examine the relationship between CVD and SED over a lifetime but rather adult SED and CVD. Some studies also included "softer" event types such as coronary artery spasm in their composite outcomes and were therefore excluded.[27] Finally, studies that examined the relationship between SED and cardiovascular disease in developing countries or countries currently undergoing the epidemiologic transition were excluded. In these countries a positive association between SED and CVD is observed i.e. the most socioeconomically deprived exhibit the lowest risk of disease.[28] In the UK, this association was present until the middle of the last century for CVD.[29] However, the association has now reversed and the most deprived are at higher risk. In light of this, the findings of studies in developing countries are unlikely to be generalisable to the UK population.

Socioeconomic deprivation and coronary heart disease

Coronary heart disease mortality

All cause mortality has been related to SED since the 19th century [30] and these inequalities persist.[31] Cardiovascular mortality is also inversely related to SED.[32] Higher mortality rates are consistently found in the most deprived individuals.[33,34] Importantly coronary heart disease is one of the main contributors to the excess mortality in the most socioeconomically deprived groups.[35]

Coronary heart disease mortality is consistently higher in the most deprived, an observation that was reported in the middle of the last century.[29,36] Studies from Sweden[35,37], Finland[38],Denamrk[39], Norway[40], UK[25] and Scotland[41] and a number of other European countries (Belgium, Italy, Spain, Switzerland, [32]) have all reported this association. Studies from other developed countries around the world such as the USA[42-44], Japan[45], Australia[46] and New Zealand[47] also exist and confirm the association. These studies are broadly similar in that the most deprived are at higher risk of CHD death over follow up regardless of the measure of SED used. However, such studies have been based on population level data, thus, are unable to fully correct for cardiovascular risk factors,[40,43,44] or, have been limited to men[44] or women[43].

A few studies are however, worthy of more scrutiny. No review of the literature on the relationship between SED and coronary mortality could be complete without referring to the seminal Whitehall study. In this study 17,530 civil servants, between the age of 40 and 64, were screened for the prevalence of coronary heart disease. The prevalence of angina was nearly 53% higher in the most deprived individuals (those on the lowest employment grade) as compared to the least deprived (the highest employment grade). After follow up for 10 years the mortality rate from coronary heart disease was 3.6 times higher in the most versus least deprived.[48] Since this study multiple studies (outlined above) have reported similar findings and a repeat sample of civil servants, the Whitehall II study[25], reported that these inequalities persist. The finding has also been replicated in women. The gradient of risk seen in women may be weaker than that in men.[49] Some authors suggest that up to a quarter of coronary deaths in the UK are attributable to higher levels of socioeconomic deprivation.[50] Recently in a large study of European coronary death rates, Avendano and colleagues [32] demonstrated a clear excess of coronary deaths amongst the most deprived members of each society. In contrast to lung cancer where the gradient followed smoking

trends, the trends in coronary mortality did not. In keeping with other studies the strongest trends were seen in women. Interestingly, they observed that socioeconomic disparities in coronary mortality were higher in northern European countries as compared to southern countries.

A number of studies have examined the relationship between SED and CHD mortality in Scotland.[41,51,52] However, as with studies from other countries they are all limited by the inability of the authors to adjust for cardiovascular risk factors as the studies have all used administrative data sources, which do not hold information on patient risk factor profiles. Finally, and perhaps most worryingly, data from Sweden suggests that difference in CHD mortality by SED, as measured by neighbourhood, is in fact widening.[53] This finding has now been observed in Scotland.[41]

Coronary heart disease incidence

Whilst much has been written on the relationship between SED and CHD mortality, very little has been published in relation to non-fatal CHD. Studies are consistent in that they all report that the most deprived individuals display higher rates of coronary heart disease, though exceptions in the literature do exist[37]. Whether SED is measured by individual measures such as education or social class or whether area based measures are examined, consistent results are obtained (Table 2).

Studies have tended to included non-fatal CHD as part of a composite outcome with fatal events. This makes disentangling the relationship between SED and non-fatal CHD difficult. However, as can be seen from Table 2, fairly consistent results are obtained regardless of the measure of SED utilised. Adjustment for cardiovascular risk factors is not comparable between studies, though it is consistently reported that adjustment attenuates, but does not remove, the association between SED and CHD.

The study by Sundquist *et al*[54] merits further exploration. It has a number of strengths. Firstly the size of the sample is large, the entire Swedish population between the ages of 40 -64 years amounting to 2.6 million people. They were followed using an administrative hospital discharge database which is highly accurate. It included both men and women and it used two measures of SED, and individual one, income, and, an area based measure. They reported that after accounting for individual income, the odds of developing CHD was 1.87 (95% CI 1.72 - 2.03) in women and 1.42 (95%CI 1.35 - 1.49) in men. However, as this was an administrative database only age and sex were adjusted for in the analyses.

Two other studies[55,56] have overcome this limitation and adjusted for the risk factors that are classically associated with cardiovascular risk, age, sex, smoking, diabetes, blood pressure and cholesterol. They both reported that education was not associated with a higher risk of fatal or non-fatal CHD, especially after adjustment, however, Thurston *et al*[55] found that income was associated with a higher risk after adjustment for the traditional cardiovascular risk factors in both men and women.

Table 2 Summary of the literature on socioeconomic deprivation and the association with fatal and non-fatal coronary heart disease

Study	*Design*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Winkleby[57] Sweden	Prospective cohort	Fatal / non-fatal CHD	Neighbourhood	Men 1.7(1.53-1.88) Women 1.56(1.23-1.74)	1.36 (1.22-1.52) 1.33 (1.08-1.65)	Age, marital status, family income, education, immigration status, mobility, urban/rural area
Sundquist[58] Sweden	Prospective cohort	Fatal / non- fatal CHD	Neighbourhood education		1.38 (1.13-1.69)	Age, sex
			Neighbourhood income		1.36 (1.11-1.66)	
Rosengren[37] Sweden	Prospective cohort (Men)	Fatal/ non-fatal CHD	Social Class	P=not significant		
Emberson[50] UK	Prospective cohort (Men)	Fatal CHD/ non fatal MI	Social Class	1.41 (1.21-1.64)	1.23 (1.05-1.44)	Smoking, systolic blood pressure, cholesterol, BMI, physical activity, alcohol, FEV1
Picciotto[59] Italy	Prospective cohort	Incidence of fatal/ non-fatal CHD	Neighbourhood		Men 1.4 (1.3-1.5) Women 1.78 (1.60-1.98)	Age
Sundquist[54] Sweden	Administrative database	Non- fatal CHD	Income	1.75 (1.65-1.85)	1.70 (1.60-1.79)	Age, income and neighbourhood deprivation.
			Neighbourhood	2.02 (1.86-2.20)	1.87 (1.72-2.03)	
Thurston[55] USA	Prospective cohort	Fatal/ non-fatal CHD	Education	Men 1.58 (1.18-2.12) Women 2.15 (1.46-3.17)	Men 1.29 (0.90-1.74) Women 1.61 (1.08-2.39)	Systolic and diastolic blood pressure, hypertension, cholesterol, BMI, diabetes, smoking, alcohol, activity, marital status, ethnicity
			Income	Men 1.40 (1.11-1.76) Women 1.64 (1.31-2.05)	Men 1.35 (1.06-1.71) Women 1.40 (1.10-1.79)	
Yarnell[56] Ireland and France	Prospective cohort	Fatal/ non-fatal CHD	Education (most vs. least)	0.72 (0.73-0.98)	0.9 (0.65-1.24)	Age, smoking, diastolic blood pressure, diabetes, BMI, cholesterol,

Morris[60] UK	Prospective cohort (Men)	Fatal/non-fatal CHD	Neighbourhood	1.55(1.19-2.00)	1.22(0.93-1.59)	fibrinogen, study site Marital status, Housing, car ownership, social networks, social class

Socioeconomic deprivation and myocardial infarction

Myocardial infarction incidence

It is perhaps unsurprising that most research on the relationship between SED and cardiovascular disease has focussed on myocardial infarction (MI). Socioeconomic deprivation is associated with an increased risk of myocardial infarction (Table 3). This association again has been demonstrated in a number of countries through a number of years (see Table 3). The association was examined in a number of the MONICA (Multinational Monitoring of Trends and Determinants of Cardiovascular Disease) cohorts. For example, in Glasgow, Scotland, the age adjusted relative rate of myocardial infarction was 1.74 (95%CI 1.58-1.91) in the most versus least deprived men with the least deprived being less likely to survive to reach hospital alive (age adjusted odds most versus least deprived 0.93 (0.87-0.99)).[61] As noted above the same pattern was seen in women but the gradient was steeper (age adjusted relative rate most versus least deprived 2.34(1.98-2.76)), and again the most deprived were less likely to reach hospital alive (age adjusted odds 0.94(0.85-1.05)). In the Finnish MONICA study similar patterns were observed when education and income were used as measures of SED in contrast to the area-based measure of SED used in the Scottish study.[62,63] However, both studies, being registry based, failed to adjust for the traditional cardiovascular risk factors such as smoking, blood pressure, diabetes and cholesterol, a major limitation of these otherwise informative studies. As can be seen from Table 3 many studies have failed to adequately adjust for all cardiovascular risk factors or have examined the incidence of MI in conjunction with all cause mortality or in other composite outcomes.

A number of studies, including that of Morrison *et al*[61] have been conducted in Scotland. Each study has utilised a hospital discharge database (the Scottish Morbidity Record Scheme [SMR]) which records all discharges from NHS hospitals in Scotland. Each have employed slightly different methods, and examined different outcomes. In one study the likelihood of reaching hospital alive was lower in the most deprived versus the least deprived as measured by Carstairs Morris index (16% less in deprived men and 3% in deprived women).[64] In another study of all fatal MIs occurring in Scotland between 1986-1995 the risk was highest in the deprived and the gradient appears steeper in younger women.[65] A recent study examining all discharges where MI appeared in any of the diagnoses at discharge and all coronary heart disease deaths, confirmed this finding,

however, the use of such broad inclusion criteria make extrapolation of these results difficult.[66]

More recently, the INTERHEART study [67] confirmed that a number of risk factors, psychosocial factors (stress, stressful life events, perceived locus of control and depression), apolipoprotein B/apolipoprotein A1 ratio, hypertension, diabetes, smoking, exercise, vegetables and fruits, alcohol consumption and abdominal obesity) were responsible for the majority of cases of myocardial infarction. In a study that added education into the collection of explanatory variables, SED as measured by education was a significant risk factor.[68]

Table 3 Summary of the literature on socioeconomic deprivation and incidence of MI (including studies where MI was part of a composite outcome)

Study	*Design*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Stjarne[69] Sweden	Prospective cohort	Non-fatal MI	Social class index of area	Age Men 1.50 (1.12-2.00) Women 1.94 (1.22-3.09)	Men 1.19 (0.88-1.62) Women 1.60 (0.96-2.66)	Age, individual level socioeconomic status, education, employment status, marital status, ethnicity
Hallqvist[70] Sweden	Prospective cohort	Fatal / non-fatal MI	Social class		Men 1.99 (1.58-2.53) Women 2.34 (1.52-3.61)	Age
Emberson[50] UK	Prospective cohort (Men)	Fatal CHD/ non fatal MI	Social Class	1.41 (1.21-1.64)	1.23 (1.05-1.44)	Smoking, systolic blood pressure, cholesterol, BMI, physical activity, alcohol, FEV1
Albert[71] USA	Prospective cohort (Women)	Cardiovascular death or Non-fatal MI/stroke or revascularisation	Education (most vs. least) Income (most vs. least)	Age and race 0.5 (0.3-0.7) 0.4 (0.3-0.7)	0.8 (0.5-1.2) 0.8 (0.5-1.2)	Age, race, BMI, smoking, hypertension, diabetes, LDL and HDL cholesterol, triglycerides, hormone use, family history of CHD, alcohol, activity, CRP, ICAM, fibrinogen, homocysteine
Diex-Roux[72] USA	Prospective cohort	Fatal CHD/ non-fatal MI	Neighbourhood	Age and study site White 2.1 (1.6-2.8) Black 1.7 (1.2-2.3)	White 1.6 (1.1-2.2) Black 1.5 (1.0-2.3)	Smoking, activity, hypertension, diabetes, LDL and HDL cholesterol, BMI
Morrison[11] Scotland	Registry	Fatal/ non-fatal MI	Neighbourhood (Carstairs)	Men 1.74 (1.58-1.91) Women 1.28 (1.22-1.24)		
Salomaa[63]† Finland	Registry	Incident MI	Income Education		Men 1.67 (1.57-1.78) Women 1.52 (1.38-1.68) Men 1.48 (1.40-1.55) Women 1.65 (1.48-1.83)	Study area, urban/rural residence
Rose[73]	Prospective cohort	Non fatal MI	Neighbourhood	Black men		

USA				1.63(1.20-2.06) Black women 2.14(1.69-2.58) White men 1.24(1.07-1.41) White women 1.79(1.58-2.00)		
Davies[66] Scotland	Administrative database	Fatal CHD/Non fatal MI	Neighbourhood	1990-92 2000-02	1.74(1.58-1.92) 1.94(1.76-2.15)	
Rosengren[68] Multinational*	Multiple case control cohorts	Non fatal MI	Education		1.95(1.71-2.21)	Age, sex , psychosocial factors (stress, stressful life events, perceived locus of control and depression), apolipoprotein B/apolipoprotein A1 ratio, hypertension, diabetes, smoking, exercise, vegetables and fruits, alcohol consumption, abdominal obesity, and region
Macintyre [65] Scotland	Administrative database	Fatal MI	Neighbourhood (Carstairs)	Men‡ <65 years RR 1.93 65-74 RR 1.39 >75 RR 1.08 Women‡ <65 years RR 2.58 65-74 RR 1.50 >75 RR 1.12		

† Duplicate study [62] not included, * Results from high income countries only included, ‡Estimated from figures given

Myocardial infarction and case fatality

Similarly survival following a myocardial infarction varied according to SED in the MONICA studies.[61-63] In the Glasgow MONICA cohort the rate of CHD death in hospital was not different according to SED, though CHD mortality following discharge was.[61] It is in the setting of post infarction survival that most studies are concentrated (Table 4). As noted previously, the most deprived have higher rates of adverse risk factors.[74] Most of these studies have used well characterised members of registries and therefore are able to adjust for cardiovascular risk factors. However, despite this many studies have found that after adjustment the relationship is attenuated to such and extent that it becomes non-significant.[75-77] Multiple studies have tried to explain this association. Some studies would suggest that the most deprived receive the least aggressive pharmacotherapy[78], the least follow up[79,80] and lower rates of revascularisation.[62,79]

Table 4 Summary of the literature on socioeconomic deprivation and case fatality following a myocardial infarction

Study	*Design*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Gerber [81] Israel	Prospective cohort	Mortality following MI	Income	2.64 (1.92-3.63)	1.58 (1.13-2.21)	Age, sex, smoking, hypertension, diabetes, physical activity, MI severity, ejection fraction, killip class, anterior MI, admission to intensive care, comorbidity index, coronary angiography, angioplasty, thrombolysis, aspirin, beta blockers, race, employment status
		IHD mortality following MI		2.68 (1.79-4.01)	1.52 (1.02-2.31)	
Gerward[82] Sweden	Registry	28 day survival following MI	Neighbourhood		1.25 (1.03-1.52)	Age and sex
Engstrom[83] Sweden	Prospective cohort	3 year survival following MI	Neighbourhood	*Men R=0.6, p<0.01 *Women R=0.37, p=0.35		
Pilote[76] Canada	Administrative database	MI mortality	Neighbourhood		Quebec, Ontario, 30 day – NS, 1 year - NS British Columbia 30 day – NS, 1 year 1.18(1.09-1.28)	Age, sex, comorbidities, hospital
			Income or employment rate or education or population size, average rent		All areas, 30 day and 1 year – NS	
Stjarne[69] Sweden	Case Control	Case fatality at 28 days	Neighbourhood (Carstairs)	Age adjusted Men 0.98 (0.90-1.07) Women 1.01 (0.89-		

				1.16)		
Alter[84] USA	Prospective cohort	2 year post MI mortality	Income (high vs. low)	0.45 (0.35-0.57)	0.62 (0.48-0.74) 0.77 (0.54-1.10)	Age, sex, ethnicity, psychosocial factors and pre-existing cardiovascular diseases
Alter[85] USA	Registry	1 year MI mortality	Neighbourhood income (high vs. low)		0.90 (0.86-0.94)	Age, sex, specialty of admitting physician, hospital
Gerber[75] USA	Prospective cohort	Post MI mortality	Neighbourhood income	2.10 (1.42-3.12)	1.62 (1.08-2.45)	Age, sex, race, comorbidities, ejection fraction, hypertension, hypercholesterolaemia, smoking, BMI, beta blocker, aspirin, statin, angioplasty, bypass surgery, ST elevation
			Education	2.21 (1.47-3.32)	1.01 (0.65-1.58)	
Rao USA	Retrospective cohort	30 day case fatality following MI 1 year mortality following MI	Income of area		Low vs. middle 1.09 (1.04-1.13) High vs. middle 0.89 (0.85-0.94) Low vs. middle 1.05 (1.0-1.10) High vs. middle 0.92(0.88-0.97)	Age, sex, ethnicity, smoker, diabetes, mobility, past history of MI or CABG, hypertension, stroke, COPD, dementia, hospital, treatment and revascularisation.
Rosvall[86] Sweden	Registry	5 year mortality post MI	Income		Men 1.63 (1.51-1.77) Women 1.44 (1.27-1.63)	Age
Chang[87] Canada	Retrospective cohort	1 year mortality post MI	Neighbourhood median income (per $10,000 increase)	0.87 (0.83-0.90)	0.94(0.91-0.98)	Age, sex, diabetes, hypertension, hypercholesterolaemia, cancer, peripheral vascular disease, past MI.
Cesana[88] Italy	Registry	28 day post MI mortality	Social Class	2.46 (1.52-3.99)		
Rasmussen[89] Denmark	Registry	30 day case fatality	Income Education		1.54 (1.36-1.79) 1.24 (1.03-1.50)	Age, sex, year, civil status, comorbidity, education or income.

		>31 days	Income Education		1.65 (1.45-1.85) 1.33 (1.11-1.59)	
Bernheim[77] USA	Cohort	1 year mortality	Income	2.80 (1.37-5.72)	1.19 (0.54-2.62)	Age, sex, ethnicity, health insurance, smoking, diabetes, hypertension, hypercholesterolemia, COAD, HF, ejection fraction <40%
Picciotto[59] Italy	Prospective cohort	28 day case fatality post MI	Neighbourhood		Men 0.91 (0.69-1.19) Women 1.35 (0.94-1.94)	Age
		1 year case fatality post MI			Men 1.23 (0.86-1.75) Women 1.36 (0.85-2.17)	Age, co morbidities, angioplasty
		28 day case fatality post MI	Education		Men 1.22 (0.95-1.56) Women 1.31 (0.91-1.88)	
		1 year case fatality post MI			Men 1.02 (0.75-1.38) Women 1.02 (0.64-1.62)	
Salomaa[63]† Finland	Registry	28 day case fatality following MI	Income		Men 3.18 (2.82-3.58) Women 2.17 (1.76-2.68)	Study area, urban/rural residence
			Education		Men 1.92 (1.74-2.11) Women 2.43 (1.91-3.09)	
		1 year case fatality following MI	Income		Men 3.18 (2.84-3.55) Women 2.15 (1.77-2.62)	
			Education		Men 1.87 (1.71-2.05) Women 2.34 (1.88-	

					2.92)	
Morrison[11] Scotland	Registry	28 day CHD case fatality	Neighbourhood (Carstairs)		Men 0.98 (0.90-1.07) Women 1.01 (0.89-1.16)	Age
MacIntyre [65] Scotland	Administrative database	30 day case fatality	Neighbourhood (Carstairs)	Men‡ <65 years RR 1.96 65-74 RR 1.29 >75 RR 1.02 Women‡ <65 years RR 2.62 65-74 RR 1.40 >75 RR 1.23		
Chaix[53] Sweden	Prospective cohort	Post MI IHD case fatality	Neighbourhood	1.40 (0.71-2.85)		
Tonne[90] USA	Prospective cohort	MI case fatality	Neighbourhood	Age and sex 1.55 (1.24-1.93)	1.38 (1.14-1.67)	Age, sex, hospital, AF, heart failure, shock, angina, Q-waves, hypertension, diabetes, stroke, past MI and age-sex interaction
Manderbacka[91] Finland	Administrative database	Post MI 2 year CHD case fatality	Income	Age Men 1.39(1.18-1.63) Women 1.26(1.02-1.55)	Men 1.35(1.15-1.59) Women 1.17(0.95-1.43)	Age, heart failure, arrhythmia, hypertension, diabetes, asthma and chronic obstructive pulmonary disease, severe mental disorders, thyroid insufficiency, multiple sclerosis, Parkinson's disease, epilepsy, malignant tumours, sarcoidosis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, and gouty arthritis
		28 day case fatality		Men 1.94(1.81-2.08) Women 1.49(1.34-1.67)	Men 1.93(1.80-2.07) Women 1.44(1.29-1.61)	

** Correlation coefficient ‡Estimated from figures given

Recurrence of myocardial infarction

Following from this, despite there being a large body of literature on the epidemiology of recurrent myocardial infarction, there are very little data on the association between SED and recurrent infarction (Table 5). One study did examine recurrent ischaemic events (Death, MI or unstable angina) following a non-fatal MI according to SED.[92] Interestingly the authors reported that after adjustment for age, sex, diabetes, race, treatment with aspirin and thrombolysis and left ventricular failure the adjusted risk of an event in the most versus the least deprived was 1.59 (95% CI 1.03-2.44). After further adjustment for the use of secondary prevention (aspirin and beta-blockers) at discharge the association became non-significant 1.78 (0.80 -3.99). This would support the hypothesis of others that the differential survival post MI by SED is explained by differential treatment following the event.[79,93] However, as noted above not all authors have found this in relation to case fatality.[81]

In another study by Scheffler *et al*[94] of the Kaiser Permanente Health Insurance Database in California USA, the rate of recurrent fatal or non-fatal MI was lower with increasing income (HR 0.94 95%CI 0.91-0.97) after adjustment for sex, race, age, measures of income inequality of an area, societal capital and race mix of an area. After further adjustment for past medical history and pharmacotherapy including revascularisation therapy the association persisted (HR 0.97 95%CI 0.95-1.00).

As can bee seen from Table 5, inconsistent results have been reported when the risk of recurrent coronary events associated with SED has been examined. This may be related to the different populations, different outcomes (many of which are composite outcomes) and different methods of adjustment in the multivariable models.

Table 5 Summary of the literature on socioeconomic deprivation and recurrent myocardial infarction and coronary heart disease

Study	*Design*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Pilote[76] Canada	Administrative database	Readmission for MI/HF/Angina	Neighbourhood or income or employment rate or education or population size, average rent		All areas, 30 day and 1 year - NS	Age, sex, comorbidities, hospital
Scheffler[94] USA	Administrative database	Recurrent acute coronary syndrome	Income	0.94(0.91-0.97)	0.97(0.95-1.00)	Age, sex, race, social capital indices, medical therapy, hypertension, diabetes, depression, stroke, heart failure, peripheral vascular disease, revascularisation
Barakat[92] UK	Prospective cohort	Readmission Angina/MI/Death	Neighbourhood (Carstairs)			
		30 days		1.54(1.02-2.32)	1.56(1.01-2.39)	Age, sex, race
		31 days to 1 year		1.02(0.66-1.60)	1.05(0.66-1.67)	
		30 days			1.60(1.04-2.48)	Age, sex, race diabetes, aspirin and
		31 days to 1 year			1.08(0.68-1.71)	thrombolysis use
		30 days			1.59(1.03-2.44)	Age, sex, race LVF
		31 days to 1 year			1.07(0.68-1.70)	
		30 days			1.78(0.80-3.99)	Age, sex, race discharge aspirin and
		31 days to 1 year			1.00(0.63-1.59)	betablockers
Rao[95] USA	Trial registry	Death or recurrent MI	Income		30 days 1.3(0.8-2.1) 6 month 1.4 (0.9-2.1)	Age, weight, height, smoking, systolic blood pressure, heart rate, presence of rales, time to treatment

Bernheim[77] USA	Prospective cohort	Post MI all cause rehospitalisation at 1 year	Income	1.55 (1.17-2.05)	1.36 (1.01-1.89)	Age, sex, ethnicity, health insurance, smoking, diabetes, hypertension, hypercholesterolaemia, COAD, CHF, ejection fraction <40%
Picciotto[59] Italy	Prospective cohort	1 year MI rehospitalisation	Neighbourhood		Men 1.06 (0.63-1.78) Women 0.94 (0.44-1.98)	Age, comorbidities, angioplasty
		1 year other CVD rehospitalisation			Men 0.93 (0.74-1.17) Women 0.99 (0.68-1.42)	
		1 year MI rehospitalisation	Education		Men 0.83 (0.56-1.25) Women 1.39 (0.61-3.18)	
		1 year other CVD rehospitalisation			Men 0.98 (0.81-1.19) Women 1.03 (0.73-1.47)	

Socioeconomic deprivation and stroke

The relationship between stroke and SED has been well studied in relation to mortality and case fatality or survival. The incidence of stroke and its relation to SED has also been studied. As with coronary heart disease, the relationship between SED and stroke is inverse i.e. the most deprived suffer from higher rates of stroke, higher case fatality and higher stroke mortality.

Stroke mortality

Stroke mortality is higher in the most deprived members of a number of societies including Europe[96], USA[33] and Japan[45]. In a study of 22 European countries the mortality rates from stroke was consistently higher in the most versus the least deprived members (as measured by social class and education) of each society.[31] In another international comparison by Avendano and colleagues[97], the association between SED (measured by educational level and occupational class) and stroke mortality, appeared to be stronger than that for SED and coronary mortality in six European societies. More worryingly, in their study, they also examined trends over time (comparing the period 1981-1985 to 1991-1995), and found that not only had inequalities persisted, but may have in fact widened in some societies. Finally, Kunst *et al*[7] reported in a further study on behalf of the European Union Working Group on Socioeconomic Inequalities in Health, that the rate of stroke mortality was consistently higher in the most deprived versus the least deprived in 12 European countries.

Stroke incidence

The association between SED and stroke incidence has been examined in a number of studies (Table 6). Irrespective of the measure of SED the most deprived are at higher risk of experiencing an incident stroke. Many studies have examined both fatal and non-fatal first strokes together. [98-104] Most have used income as a measure of SED a large proportion have incompletely adjusted for known risk factors for stroke.

Stroke case fatality

It is not only the relationship between socioeconomic status and the development of stroke that is understudied and thus unclear. The relationship between stroke case fatality and socioeconomic status has only been examined in the short term, at 30 days, or, 1 year at most, though consistent results have been reported (Table 7). As with studies of stroke incidence, whilst results have been consistent irrespective of the measure of SED used, most studies have failed to adjust for the major cardiovascular risk factors.

Table 6 Summary of the literature on socioeconomic deprivation and stroke incidence

Study	*Design (all stroke types unless stated)*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Li[105] Sweden	Prospective cohort	Non fatal incidence	Men: Income Social Class Women: Income Social Class	**1.37(1.06-1.58) 1.62(1.16-2.28) 1.72(1.34-2.20) 3.14(1.61-6.11)	1.29(1.06-1.58) 1.43(1.21-1.68) 1.75(1.36-2.25) 2.84(1.45-5.56)	Age, marital status, country of birth, housing
Avendano[98] USA	Prospective cohort	Fatal/Non-fatal incidence	Age 65-74 Education Income Age >75 Education Income	Age and sex 2.07(1.04-4.13) 2.08(1.01-4.27) 0.42(0.22-0.79) 0.43(0.22-0.86)	 1.10(0.52-2.31) 0.50(0.24-1.08)	Age, sex, race, hypertension, smoking, diabetes, alcohol, BMI, activity, psychosocial factors and functioning level
Thrift[106] Australia	Prospective cohort	Fatal incidence Non-fatal incidence	Index of relative socioeconomic disadvantage (area based)	†1.56 †1.91		
Kuper[104] Sweden	Prospective cohort	Fatal/Non-fatal incidence	Education	Age adjusted All stroke 2.1(1.4-2.9) Ischaemic stroke 2.9(1.8-4.7) Haemorrhagic stroke 1.4(0.7-2.7)	 All stroke 1.5(1.0-2.2) Ischaemic stroke 2.2(1.3-3.7) Haemorrhagic stroke 1.1(0.5-2.4)	Age, smoking, BMI, alcohol, hypertension, diabetes, exercise
Kleindorfer[107] USA	Prospective cohort	 Fatal/Non-fatal incidence Non-fatal incidence	Area based measure All stroke Hospitalised stroke	 †White1.49 Black1.49 White 1.79 Blacks 1.78		Age and sex
Jakovljevic[108] Finland	Prospective cohort (intracerebral haemorrhage)	Fatal/Non-fatal incidence	Income	Age 25-59 †Men 3.22 Women 3.37 Age 60-74 Men1.37		

Jakovljevic[99] Finland	Prospective cohort (ischaemic stroke)	Fatal/Non-fatal incidence	Income‡	Women 0.84 Age 25-59 †Men 2.05 Women 1.96 Age 60-74 Men1.51 Women 1.63		
Jakovljevic[109] Finland	Prospective cohort (subarachnoid haemorrhage)	Fatal/Non-fatal incidence	Income	† Age 25-44 Men3.37 Women3.71 Age45-59 Men 1.92 Women1.36 Age 60-74 Men 1.24 Women1.18		
Wolfe[110] England	Prospective cohort	Fatal/Non-fatal incidence	Social class	1.65(1.21-2.23)		
van Rossum[111] Holland	Prospective cohort	Fatal/Non-fatal incidence	Education (most vs. least)	Age adjusted 0.18(0.02-1.28)	0.19(0.03-1.36)	Age, blood pressure, hypertension, antihypertensive use, smoking, CHD, AF, diabetes BMI, alcohol, fibrinogen, left ventricular hypertrophy
			Social class (High vs. low)	0.60(0.38-0.96)	0.57(0.26-1.24)	
Hart[101] Scotland	Prospective cohort	Non-fatal incidence	Social class	Age adjusted 1.37(1.13-1.66)	1.07(0.87-1.31)	Age, smoking, FEV1, diastolic and systolic blood pressure, height, alcohol, history of CHD
			Carstairs Morris Index	1.17(0.96-1.42)	0.96(0.79-1.18)	
Hart[100] Scotland	Prospective cohort	Fatal/Non-fatal incidence	Social class	Age adjusted Men 1.80(1.05-3.06) Women 1.62(0.90-2.89) Men 2.09(1.24-3.54)	Men 1.31 (0.76-2.26) Women 1.24(0.69-2.24) Men 1.58(0.93-2.69)	Age, smoking, FEV1, diastolic and systolic blood pressure, height, BMI, diabetes, history of CHD
			Carstairs Morris Index	Women 2.27(1.42-3.62)	Women 1.72(1.07-2.77)	
Gillum[102] USA	Prospective cohort	Fatal/Non-fatal incidence	Education (most vs.	Age adjusted White	Age adjusted White	

			least)	Men 0.86(0.61-1.20) Women 0.60(0.42-0.86) Black 0.59(0.42-0.85)	Men 1.03(0.72-1.46) Women 0.72(0.50-1.03)
			Poverty index(most vs. least poor)	White Men 0.64(0.46-0.88) Women 0.65(0.46-0.91) Black 0.62(0.41-0.95)	White Men 0.80(0.57-1.12) Women 0.74(0.52-1.05) Black 0.70(0.46-1.08)
Smits[112] Netherlands	Prospective cohort	Non-fatal incidence	Area based measure	1.27(1.08-1.51)	

*multiple other measures all non significant (antiplatelet agents, thrombolysis, blood glucose measurement, temperature measurement, physiotherapy, occupational therapy and speech therapy)

**Age adjusted

†confidence interval not calculable from data presented

‡only income shown due to wide confidence intervals for education

Table 7 Summary of the literature on socioeconomic deprivation and stroke case fatality

Study	*Design(all stroke types unless stated)*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Saposnik[113] Canada	Retrospective cohort	7 Day in hospital fatality Fatality at discharge	Income and hospital volume		1.26(1.07-1.49) 1.27(1.11-1.45)	Age, sex, hospital of admission, Charleson score, hospital location
Arrich[114] Austria	Retrospective cohort	Case fatality	Education (most vs. least)	0.71(0.44-1.14)	0.77(0.40-1.48)	Age, sex, stroke severity,
			Occupation	2.25(0.84-6.06)	1.17(0.39-3.49)	
			Income	0.96(0.38-2.39)	1.44(0.51-4.08)	
Li[105] Sweden	Prospective cohort	Case fatality 28 day	Men income		3.13(1.35-7.24)	
			Women income		1.68(0.69-4.08)	
		1 year	Men income		2.17(1.18-4.00)	
			Women income		1.29(0.67-2.45)	
Weir[115] Scotland	Prospective cohort	6 month case fatality	Carstairs Morris index	Non-significant		Age, sex, history of CHD, diabetes, stroke type, onset in hospital, function at admission, systolic blood pressure, neuroimaging
		6 month case fatality + institutional care		Non-significant		
		6 month case fatality +dependency		2.43(1.51-3.91)	1.89(1.09-3.30)	
Casper[116] USA	Retrospective cohort	Case fatality	Social class	†White 2.3 †Black 2.8		
Aslanyan[117] Scotland	Retrospective cohort	Case fatality	Womersley score	1.01(0.98-1.04)	1.03(1.00-1.06)	Age, sex, stroke severity, blood pressure, subtype and past medical history
			Murray score	1.03(0.94-1.13)	1.09(0.99-1.19)	
Kapral[118] Canada	Retrospective cohort	30 day case fatality 1 year case fatality	Income		0.91(0.87-0.96) 0.95(0.92-0.99)	Age, sex, comorbidity, physician and hospital of admission
Jakovljevic[108] Finland	Prospective cohort (intracerebral haemorrhage)	28 day case fatality	Income	Age 25-59 Men 2.10(1.00-4.42) Women 2.68(0.88-8.19) Age 60-74 Men 2.29(0.98-5.34) Women 1.40(0.63-3.13)		

Jakovljevic[108] Finland	Prospective cohort (intracerebral haemorrhage)	1 year case fatality	Income	Age 25-59 Men 2.12(1.02-4.40) Women 2.43(0.80-7.40) Age 60-74 Men 2.40(1.04-5.55) Women 1.15(0.52-2.57)		
Jakovljevic[99] Finland	Prospective cohort (ischaemic stroke)	28 day case fatality	Income ‡	Age 25-59 Men 2.61(1.46-4.68) Women 1.53 (0.65-3.60) Age 60-74 Men1.62(1.03-2.54) Women 1.53(0.89-2.63)		
Jakovljevic[99] Finland	Prospective cohort (ischaemic stroke)	1 year case fatality	Income ‡	Age 25-59 Men 2.41(1.48-3.93) Women 1.81 (0.86-3.80) Age 60-74 Men1.48(1.06-2.07) Women 1.58(1.03-2.44)		
Jakovljevic[109] Finland	Prospective cohort (subarachnoid haemorrhage)	28 day case fatality	Income		Age 25-44 Men 3.88(1.87-8.05) Women 1.09(0.41-2.89) Age 45-74 Men 1.05(0.67-1.64) Women 1.68(1.00-2.81)	Age, study area, urban/ rural residence
Jakovljevic[109] Finland	Prospective cohort (subarachnoid haemorrhage)	1 year case fatality	Income		Age 25-44 Men 4.25(2.05-8.78) Women 1.14(0.43-3.01) Age 45-74 Men 1.07(0.67-1.70)	Age, study area, urban/ rural residence

		Women 1.86(1.12-3.10)

*multiple other measures all non significant (antiplatelet agents, thrombolysis, blood glucose measurement, temperature measurement, physiotherapy, occupational therapy and speech therapy)
**Age adjusted
†confidence not calculable from data presented
‡only income shown due to wide confidence intervals for education

Recurrent stroke

The burden of recurrent stroke according to SED has not been well studied (Table 8). The risk of readmission following a stroke according to SED has only been examined in a small number of studies. In a study by Li *et al* [105],of men and women in Malmo, Sweden, despite finding a relationship between SED and incident stroke and case fatality, after adjustment for covariates (age, marital status, country of birth, and housing condition) they only found that low income in women was associated with higher rates of readmission for stroke. Some, but not all authors, have reported that stroke severity varies by SED, as does access to therapies such as physiotherapy, occupational therapy and carotid surgery[118,119]. However, length of stay does not seem to be related to SED. Functional recovery may be related to SED following a stroke[115] and therefore, the burden of stroke is likely to be higher in the most deprived.

Table 8 Summary of the literature on socioeconomic deprivation and stroke recurrence

Study	*Design*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Aslanyan[117] Scotland	Retrospective cohort	Readmission any CVD	Womersley score Murray score	1.05(1.01-1.09) 1.21(1.08-1.35)	1.06(1.02-1.10) 1.23(1.10-1.38)	Age, sex, stroke severity, blood pressure, subtype and past medical history
Li [105] Sweden	Prospective cohort	Recurrent stroke	Men: Income Social Class Women: Income Social Class		1.15(0.72-1.82) 1.00(0.46-2.20) 2.04(1.03-4.01) 2.78(0.70-10.98)	

Socioeconomic deprivation and heart failure

The relationship between SED and heart failure is similarly understudied (Table 9). Given that coronary heart disease is a major risk factor for developing heart failure and the multiple studies outlined above relating SED to coronary heart disease it is surprising that few studies have examined the relationship between heart failure and SED. A systematic review by Blair *et al*[120] published in 2001 identified only 8 relevant studies (two of which were published only in abstract form). Since that report only a handful of other studies have addressed this relationship (Table 9).

The prevalence of heart failure clearly varies with socioeconomic status. In cross sectional study from Scotland the prevalence of heart failure in primary care practices was higher in the most deprived.[121] In the most affluent the rate was 6.4 per 1000 population rising to 7.2 in the most deprived, a 13% increase.

The incidence of heart failure is consistently higher in the most socioeconomically deprived. In the same study of primary care practices in Scotland the incidence of heart failure was 44% higher in the most deprived versus the least deprived intervals.[121] A study from Goteborg, Sweden reported that in 6999 men followed for 28 years a hospitalisation for heart failure were 72% more likely in the most as compared to the least deprived men as measured by social class after adjustment for age, height, BMI, smoking, activity levels, systolic BP, diabetes, alcohol problems and cholesterol.[122] In a further study of 2841 men from Uppsala, Sweden, after follow up for a median of 29.6 years the rate of incident heart failure hospitalisation was twice as high in those with only an elementary education versus a college education.[123] Furthermore, when occupational class was examined as a marker of SED the risk was approximately 50% higher in those with a low occupational as opposed to high occupational class. I have reported that in Scotland rates of first hospitalisation for heart failure in Scotland were 56% higher in the most deprived compared to the least deprived.[124] Finally, we have reported in an analysis of 15703 participants in the Renfrew Paisley cohort, that the risk of heart failure as measured by a hospitalisation for heart failure was 40% higher in the most deprived versus the least deprived.[125] This association was evident after adjustment for age, sex, history of angina, stroke, blood pressure, FEV1, smoking status, atrial fibrillation, abnormal ECG, cardiomegaly on a chest x-ray and BMI.

Survival in those with heart failure is poorer amongst the most deprived. In a study of all hospitalisations for heart failure in Scotland we reported that the risk of death at 30 days was 18% higher in the most deprived versus the least deprived men after adjustment for

age, year of admission and previous admissions for multiple causes.[124] In women the excess risk was 3% and not significant. At 1 year the excess risk was 11% and 14% at 5 years in men. In women the respective figures were 3% (non-significant) at 1year and 4% at 5 years which was a significant difference.

It is not only first hospitalisation rates for heart failure that very by SED, the burden of heart failure is highest in the most deprived. Readmission rates for heart failure are inversely related to SED. In a study of admissions in New York, USA, after adjustment for a risk score (comprising of ethnicity, comorbidities, type of discharging facility and procedures performed and finally health insurance type) the risk of readmission for heart failure was 18% higher in those in the lowest income group compared to the highest income group.[126] Similar results were reported from a study of hospitalisations amongst the elderly in Rome, Italy, where rates of hospitalisations for heart failure were inversely related to deciles of income.[127] Hospital admissions for cardiac causes in those with heart failure are also inversely related to SED. Using the Carstairs Morris Index, Struthers *et al* [128] reported that the rate of cardiac hospitalisations was 26% in the least deprived versus 40% in the most deprived, irrespective of disease severity, diuretic dose and adherence and age and sex. One explanation for this finding may be that the most deprived individuals with heart failure are in contact with their primary care physician less than their affluent counterparts.

Table 9 Summary of the literature on socioeconomic deprivation and heart failure

Study	*Design*	*Outcome*	*Measure of SED*	*Unadjusted*	*Adjusted*	*Adjustment*
Antonelli Incalzi[127] Italy	Retrospective cohort	Readmission rates	Income Men Women	 2.32(2.04-2.63) 3.28(2.95-3.65)		
Auerbach[129]USA	Prospective cohort	Care by cardiologist	Income (low vs. high) Education (College vs. high school)		0.65(0.45-0.93) 1.89(1.02-3.51)	Acute Physiology Score, site of enrolment, history of dementia admitted to an intensive care unit
Coughlin[130] USA	Case control	Cardiac transplantation listing	Income (low) No private health insurance	P<0.05		
Compos Lopes[131] Brazil	Prospective cohort	Cardiac death	Public vs. private health care		OR 3.46(1.91-6.27)	Aetiology of HF, Digoxin use, No of past MI, history of hypertension
Gottinder[132] USA	Retrospective cohort	Incidence	Income	P=0.0002 (women) P<0.0001(men)		
Jhund[124] Scotland	Retrospective cohort	Case fatality 30 day (men) (women) 1 year 5 years	Carstairs Morris Index Most vs. least deprived		 1.18 (1.10–1.28) 1.03 (0.96–1.10) 1.11 (1.07–1.16) 1.03 (0.99–1.07) 1.14 (1.11–1.18) 1.04 (1.01–1.08)	Age, prior admissions (MI, Stroke, AF, CHD, renal failure, diabetes, hypertension, peripheral arterial disease, respiratory disease, cancer)
Ingelsson[123] Sweden	Prospective cohort	Incidence	Social Class Education Marital status	1.82(1.20-2.74) 2.47(1.34-4.55) 0.90(0.50-1.61)	1.46(0.97-2.21) 1.94(1.04-3.59) 0.83(0.46-1.48)	Hypertension, diabetes, Left ventricular hypertrophy, smoking, BMI, cholesterol
Latour Perez[133] Spain	Retrospective cohort	HF on admission with MI	Social Class		2.4(1.1-5.2)	Age, diabetes, marital status, sex
McAlister[121] Scotland	Retrospective cohort	Incidence Prevalence Health care usage Prescribing of ACE inhibitors Survival	Carstairs Morris Index Most vs. least deprived		1.44 1.13 0.84 NS* 0.88	Age, sex

Philbin[126] USA	Prospective cohort	Readmissions with HF	Income (High vs. low)		1.18(1.10-1.26)	Risk score comprising of race, insurance, aetiology of HF diabetes, renal disease, chronic lung disease, history of prior cardiac surgery, referral to home health services upon hospital discharge, telemetry monitoring during the index admission, admission to rural hospital, discharge to a nursing facility echocardiography, cardiac catheterisation.
Rathore[134] USA	Retrospective cohort	**Case fatality 30 day 1 year Readmission at 1 year	Area based score	 0.90(0.75-1.08) 0.93(0.86-0.99) 1.11(1.07-1.15)	 1.13(0.92-1.38) 1.10(1.02-1.19) 1.08(1.03-1.12	Age, race, Left ventricular function, medical history and mortality prediction score
Romm[135] USA	Prospective cohort	Activity score Symptoms	Social class	R= -0.181 R= -0.185		
Schaufelberger [122] Sweden	Retrospective cohort	Incidence	Social Class	2.00(1.42-2.82) (age adjusted)	1.72(1.34-2.20)	Age, height, BMI, smoking, activity, systolic blood pressure, diabetes, alcohol, cholesterol
Stewart[125] Scotland	Prospective cohort	Incidence	Carstairs Morris Index	1.39 (1.04 to 2.01)		Age (per year),Sex, History of angina, Stroke, smoking, atrial fibrillation, LBBB and ischaemia Systolic and diastolic blood pressure FEV1, Cardiomegaly Blood sugar Body mass index
Struthers [128] Scotland	Prospective cohort	Readmission: Cardiac All	Carstairs Morris Index	 1.11(1.004-1.225) 1.007(0.933-1.008)	 1.11(1.002-1.224) 1.013(0.937-1.096)	Age, sex

*measure of effect not stated

**also multiple measures of quality of care

Socioeconomic deprivation and the health care costs of cardiovascular disease

The health care costs associated with various cardiovascular diseases have been documented in multiple health care systems.[136,137] However, in a search of the literature only one study directly examined the costs of cardiovascular health care according to socioeconomic status. In a report from the Women's Ischaemia Symptoms Evaluation study, the cost associated with a 5 year follow up of 819 women referred for clinically indicated coronary angiography was higher in the most versus the least deprived as measured by household income.[138] The total hospital costs over five years in the most deprived was $40,477 compared to $23,132 in the least deprived ($p<0.001$). Of course this study did not include men limiting its utility. More importantly, the costs in this study were determined over a five year period only. As SED confers a higher risk of all cause and cardiovascular mortality, would this translate in less opportunity to accrue health care costs over time given that the most deprived die earlier? This question remains unanswered as does the precise calculation of the costs of cardiovascular hospitalisations according to SED.

Socioeconomic deprivation and the health care burden of cardiovascular disease

The literature surrounding SED and CVD may be abundant with studies on the association with mortality and case fatality (albeit with great deficiencies). However, with regards to the burden of CVD the only information in the literature stems from studies of the cross sectional prevalence of disease in various communities according to levels of SED. However, a greater burden of prevalent disease according to SED does not necessarily equate to greater health care usage. No studies have explicitly examined the relationship between SED and the health care system burden of CVD. A few studies of some forms of CVD, such as heart failure have presented data on the primary care burden of disease by SED [121].

In a study of the primary care burden of angina in Scotland, the most deprived individuals in 55 general practices, attended their general practitioner less than the least deprived individuals (Odds ratio (OR) most versus least deprived 0.67 95% CI 0.57-0.79).[139] In the

same setting another report from the same authors found that the most deprived individuals with heart failure were also less likely to visit their general practitioner than the least deprived individuals with heart failure (OR 0.77, 95% CI not stated, p<0.001). From this it can be inferred that the most deprived individuals utilise the health services less than the least deprived members of society, however, extrapolating these trends outside of the setting of primary care is difficult. A study of patients with heart failure demonstrated that the most deprived were less likely to receive specialist care OR 0.65(0.45-0.93). It is not known if these trends translate into fewer hospitalisations for CVD in the most deprived for certain conditions such as heart failure. The observations above in the primary care setting may simply relate to a different health behaviour and health seeking behaviour on the part of the most deprived.

Relationship between socioeconomic deprivation and cardiovascular risk factors

Numerous risk factors for cardiovascular disease have been proposed. What is consistent is the finding that some risk factors are undoubtedly the most important. This has been demonstrated in multiple studies throughout the 20th and 21st centuries.[67,140] Moreover, the importance of these modifiable risk factors has been underlined by the finding that reducing exposure to these risk factors through avoidance or drug therapy reduces the rates of cardiovascular disease. The main modifiable risk factors for cardiovascular disease are smoking, the presence of diabetes mellitus, hypertension, hypercholesterolaemia.[140] Inevitably as interest in SED and CVD has grown it has been hypothesised that differences in the distribution of these risk factors explains the gradient in CVD rates by SED.[38,40,71,98,100,141-143] SED has been associated with higher levels of all of these risk factors.[25,142,144-148], including in those with and without cardiovascular disease.[149] In the following section I will present the literature surrounding the association between SED and these risk factors. In the Renfrew Paisley cohort a number of other variables were measured that are also associated with cardiovascular risk. These are body mass index (BMI), adjusted forced expiratory volume in 1 second (FEV1), bronchitis measured by the Medical Research Council questionnaire and cardiomegaly on chest x-ray. In further analyses, these variables were examined in a multivariable model to determine if they explained any of the potential gradients in disease risk according to SED. Therefore, the association between SED and these additional risk factors will also be discussed here.

Smoking

Smoking is undeniably an important cardiovascular risk factor.[67] A large number of studies have examined the relationship between smoking and SED. Smoking is consistently related to SED[25,147,150,151] and this is seen in a number of countries[152], but is related to cultural and other factors also.[152,153] Whilst in this thesis it would be impossible to summarise all the literature surrounding smoking and the relationship with SED there are a number of important aspects to the relationship that are worthy of highlighting here. The most obvious perhaps is that the deprived consistently display higher rates of smoking at around 20%.[145] This association is seen in all ages and in both sexes.[146] The relationship is found irrespective of the method of measuring SED whether an individual[25] or area based measure[154]. The relationship is seen in all developed countries.[147,155] Overall, whilst smoking rates are falling, in the most deprived the rate of smoking is falling more slowly than in the least deprived in the UK.[146] This is not an isolated finding, and has been reported in the USA[151] and Denmark[74]. Consequently, as a major risk factor for cardiovascular disease, this gives rise to the concern that this trend could increase inequalities in CVD in the future.

Hypertension

Hypertension is another of the major cardiovascular risk factors that is modifiable through lifestyle and pharmacological interventions. An inverse relationship with SED has been described widely in the developed world and has been comprehensively reviewed elsewhere.[156,157] Again, irrespective of the measure of SED used, and whether examining systolic or diastolic blood pressure, the most deprived display higher rates of elevated blood pressure.[144,147,151,158,159] The relationship persists after adjustment for factors such as salt intake and obesity.[160] Furthermore, treatment rates do not affect this relationship.[155] Whilst overall blood pressure has been falling in the community as a result of primary prevention, SED gradients remain.[146,151]

The relationship between blood pressure and SED is one where progress has been made in elucidating the determinants of the association. Awareness of the risks of hypertension may be lower in the most deprived.[161] The foetal programming hypothesis of Barker has been applied to this area in an attempt to explain this association.[162] Factors related to foetal under nutrition were associated with the development of hypertension, indicating that more deprived life circumstances in-utero, predispose to greater deprivation in later life and the development of hypertension. Genetic influences on the relationship between

SED and hypertension have been reported. A polymorphism of the alpha 2 beta-adrenergic receptor has been shown to interact with job strain (jobs with high demands and low decision making responsibility i.e. manual class jobs) to lead to raised blood pressure.[163] Therefore, while the association between SED and hypertension is clear, it is in this area where some of the greatest strides are being made to disentangle the pathways by which SED leads to higher blood pressure.

Cholesterol

Whilst hypercholesterolaemia is a major cardiovascular risk factor the relationship with SED is less clear. Many studies have reported that cholesterol increases as the level of SED increases.[25,144,147,150,151,164] In a study of over 37,000 women and 33,000 men undergoing risk factor screening serum cholesterol was significantly higher in the most deprived as compared to the least deprived (as measured by Townsend score).[150] However, the magnitude of the difference was reported to be only 0.02mmol/l though this was statistically significant (95%CI 0.01 - 0.03). Similar differences in serum total cholesterol and HDL cholesterol were recorded in the EUROASPIRE II study.[155] The magnitude of difference being similar to the study by Layratzopoulos *et al* at 0.07mmol/l. However, despite these differences the rates of prescribing of appropriate lipid lowering therapy is lower in the most deprived.[155,165] Finally, it is not only total cholesterol that is related to SED, subclasses of lipids are also related to SED. The most deprived have higher levels of triglycerides and low density lipoprotein cholesterol and lower levels of HDL cholesterol.[71,166,167]

Diabetes

As with cholesterol and blood pressure the presence of non-insulin dependant (Type II) diabetes varies according to SED.[147,148,151,155,167] The relationship between the presence of diabetes and SED is independent of body habitus. In addition to this the most deprived in one study displayed higher levels of insulin, greater blood glucose, greater insulin resistance and higher levels of glycosolated haemoglobin A1c[168]. These associations persisted after correction for body habitus as measured by BMI.[168] In the Whitehall studies, the fasting glucose levels of individuals did not seem to differ according to SED.[169] However, one large epidemiological study reported that there was no relationship between SED and diabetes in men.[164] These conflicting studies used only one measure of SED highlighting the sentiments of Braveman *et al*[170] that multiple measures of SED should be

used to explore relationships with health outcomes. However, as with smoking, there are reports that the disparities in diabetes prevalence by SED may be increasing.[151]

Obesity

Obesity is consistently associated with a higher risk of cardiovascular disease. This is perhaps the best studied risk factor in relation to SED. A recent systematic review of the relationship between SED and obesity reported that 144 relevant studies were published between 1960 and the mid 1980s and from 1998 to 2004 a further 344 studies were identified.[171] Again, many of the studies that have been referenced above in relation to other risk factors have reported an inverse relationship between SED and obesity.[74,146,147,151] Multiple measures of obesity have been used, BMI, waist hip ratio, as have multiple measures of SED.[171] Overall, McLaren *et al*[171] concluded from their comprehensive review that in developed countries socioeconomic deprivation is associated with higher rates of obesity in women though in men the association is less clear with many studies reporting non-significant associations. In the UK, however, there have been reports that this disparity is widening.[146]

Lung function

Lung function is an understudied risk factor for cardiovascular disease. In a study of the Renfrew Paisley cohort, FEV1 was strongly associated with all cause mortality.[172] Multiple studies have reported that reduction in a number of measures of lung capacity such as forced vital capacity and FEV1 are associated with higher cardiovascular risk.[173-177] The risk of coronary heart disease, myocardial infarction and stroke are all higher in those with reduced lung function. The Framingham investigators have also reported that reduced lung function predicts the development of heart failure.[178] Poorer lung function is associated with socioeconomic deprivation.[179,180] Vital capacity, FEV1 and the ratio of the two measures are all reduced in the most deprived. FEV1 may be reduced by up to 300ml in men and 200ml in women in the most deprived when compared to the least deprived individuals.[179]

Whilst lung function is related to SED, it has been noted above that smoking is related to SED and may confound this relationship. However, in one of the largest studies to examine the relationship between SED (in this case determined by occupation) and lung function, FEV1 in 32,905 people was 2.7% lower in the most deprived compared to the least

deprived.[181] This difference was present after correction for height, age, smoking status and respiratory illnesses. Amongst non-smokers the association also exists.[182]

Cardiomegaly

Enlargement of the heart is a well studied cardiovascular risk factor.[183] Increased left ventricular mass or chamber size as measured by echocardiography is associated with greater cardiovascular risk.[184] Cardiomegaly on a chest x-ray (defined as a cardiac to thoracic ratio of greater than 50%) is a simpler measure of cardiac enlargement. The presence of cardiomegaly on a chest x-ray increases the risk of developing heart failure (over and above the finding of left ventricular hypertrophy on an ECG) in the Framingham studies[140] and is also a marker of poor outcome in those with heart failure.[185] A report from the Whitehall II study found that cardiomegaly is also associated with an approximately doubling of the risk of cardiovascular and coronary heart disease mortality over 25 years of follow up independently of cardiovascular risk factors such as age, systolic BP, diastolic BP, heart rate, total cholesterol, smoking, history of angina and ECG abnormalities.[186]

Socioeconomic status is related to cardiomegaly. In the Renfrew paisley cohort, a greater proportion of the most deprived had cardiomegaly on their chest x-ray[154] and was a predictor of future heart failure[125]. Whilst chest radiography may be a crude method to assess cardiac size, echocardiography allows more accurate quantification of cardiac mass and chamber size. In an echocardiographic study, SED as measured by education, was inversely related to cardiac mass.[184]

Other cardiovascular risk factors and socioeconomic deprivation

A number of other novel cardiovascular risk factors have been examined in relation to SED. These include other biochemical and haematological risk factors such as fibrinogen[71,166,187], c-reactive protein[71,166,188,189], interleukin-6[71,166,189,190], von Willebrand factor[166],intercellular adhesion molecule 1[71,189], homocysteine[71,191], serum amyloid A[188] and monocyte chemoattractant protein-1[189]. With the exception possibly of c-reactive protein [192] none of these markers have found their way into everyday clinical use.

Other physiological risk factors for CVD have been associated with SED. These include heart rate variability[193], blood pressure reactivity[194], functional capacity and heart rate recovery[195]. Whilst these have been studied in an effort to explain the differential outcomes observed according to SED, no definitive proof of their role is forthcoming.

Finally, one hypothesis that has linked the relationship between SED and CVD is that of infection as a cause of CVD. Studies have linked pathogen burden to the risk of CHD.[196] It was hypothesised that greater SED and hence poorer living conditions would expose and individual to more pathogens and hence a higher risk of CVD. In a study of the Whitehall II cohort, seropositivity for Chlamydia pneumoniae, cytomegalovirus and herpes simplex virus 1 did not explain the risk of CHD associated with SED.[180]

Summary

It is clear from the literature above that SED is related to a number of cardiovascular diseases. However, as has been demonstrated most studies have focussed on fatal outcomes hence less is known about non-fatal outcomes. Similarly, the majority of prior studies have focussed on either coronary heart disease or stroke, hence little is known about the effect of, and comparative relationship between, socioeconomic deprivation on the incidence of (and outcomes from) other types of CVD such as heart failure. As a consequence of relatively small cohort sizes, and, short follow-up, almost all studies have focused on first events and have been unable to describe the relationship between SED and recurrent cardiovascular events i.e. the complete burden of the disease on secondary care services. Another limitation of past studies is the extent of baseline characterisation of the subjects and consequent ability to perform comprehensive multivariate analysis in order to determine whether socioeconomic deprivation is truly an independent predictor of outcome. This is especially important as each of the classical cardiovascular risk factors and a number of other risk factors vary by SED. In this thesis I will seek to fill these gaps in our knowledge of SED and cardiovascular disease. To do this I will utilise the Renfrew Paisley study which is a prospective cohort study of 7,048 men and 8,354 women on whom comprehensive cardiorespiratory measurements are available and who have been followed for over 25 years. This will be achieved through the aims and objectives outlined in the next chapter.

Aims and Objectives

Aims

As a result of the literature review the following aim of this thesis was developed

- To describe the association between SED and a number of cardiovascular outcomes in an entire cohort of men and women adjusting for cardiovascular risk factors.

The above aim was translated in to the following objectives

Objectives

- To describe the baseline characteristics and cardiovascular risk factors according to SED.

- To examine the independent effect of socioeconomic deprivation on the risk of admission to hospital with a specific cardiovascular diagnosis.

- To compare the absolute and relative strength of association between socioeconomic deprivation and cardiovascular morbidity.

- To examine the effect of socioeconomic deprivation on the risk of recurrent cardiovascular events as well as on first events and the effect on subsequent mortality from specific cardiovascular diseases and a number of other composite end points.

- To examine the impact of socioeconomic deprivation on hospital sector costs.

- To estimate the impact of socioeconomic deprivation on the population burden of cardiovascular disease, premature mortality, any cardiovascular mortality and all cause mortality.

Methods

Data Source

The Midspan studies are four separate occupational and general population cohort studies based in Scotland[197]. The original three studies were conducted between 1964 and 1976. The Main and Tiree study, 1964-68, was a study of an industrial group of 3,931 individuals from 13 factories in the central belt of Scotland. The Collaborative study, 1970-1973, was an occupational cohort study of 7,028 individuals from 27 workplaces in the central belt of Scotland. The Renfrew/Paisley study, conducted between 1972-1976, was a general population cohort from the two towns of Renfrew and Paisley in the outskirts of Glasgow (Figure 1).

Figure 1 Map of Scotland showing the position of Glasgow and Paisley (Red box outlines area of detail in Figure 2)

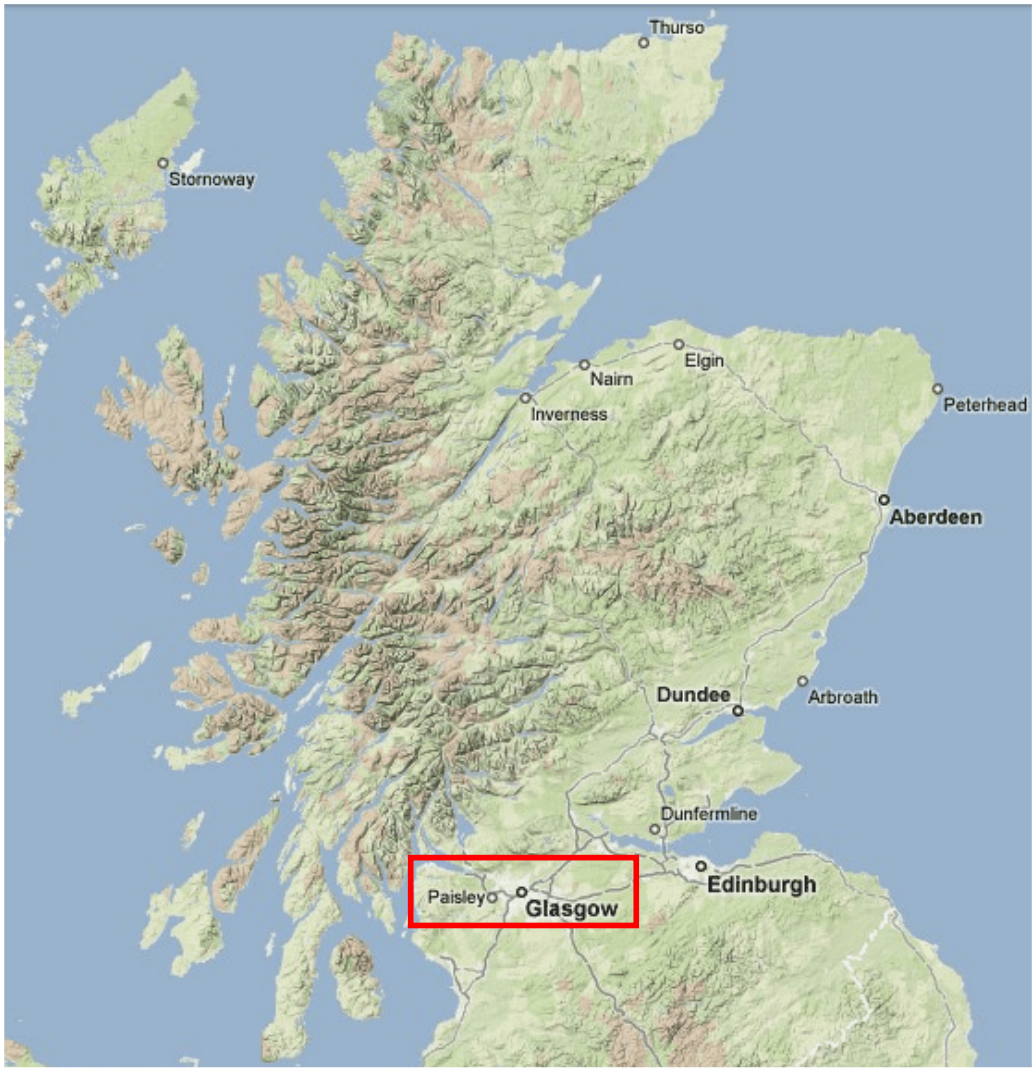


Figure 2 Area of detail showing the location of Renfrew and Paisley in relation to Glasgow

A fourth study, the Family study, was conducted in 1993-1994 and is a cohort study of the offspring of 1,477 families who took part in the original Renfrew/Paisley cohort. The Midspan studies originated from a post war drive to control pulmonary tuberculosis using mass miniature radiography. In addition to improving the detection and control of tuberculosis, the Midspan studies utilised this effective screening method to examine cardiovascular and respiratory risk and disease. For this thesis data from the Renfrew/Paisley study were used and will be discussed in more detail.

Population Sample

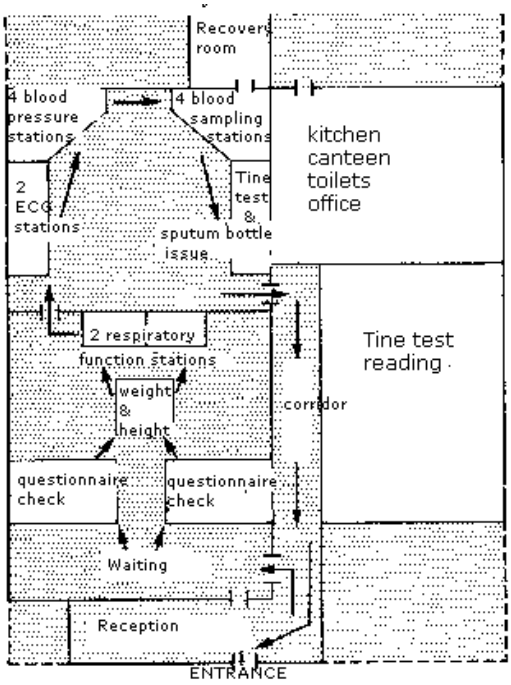
The Renfrew/Paisley study is a general population cohort study consisting of 7,048 men and 8,354 women who lived in the industrialised towns of Renfrew and Paisley, to the west of Glasgow in the west of Scotland. The Renfrew/Paisley study was funded by the by the Renfrewshire King Edward Memorial Trust. Eligibility for the Renfrew/Paisley study was established by a door-to-door census of all households in the two towns in 1972. Between 1972 and 1976, all persons aged 45-64 years who met residency criteria were invited to complete a questionnaire and attend for a screening examination at one of twelve nearby temporary screening centres. Participation rates at baseline were 78.8% of the target population in Renfrew and 77.9% in Paisley. Approximately 60% of participants re-attended for repeat screening between 1977 and 1979.

Baseline Data

Each subject's demographic profile and cardiorespiratory health status was documented during their screening visit. Figure 3 shows a floor plan of the accommodation, examination stations and route that participants took through a typical temporary examination centre as used in the Renfrew/Paisley study. A mobile X-ray unit was positioned outside the entrance to perform the chest radiographs. Approximately ten

participants arrived every 10 minutes during each session. Individual questionnaires were checked and standardised. Investigations lasting approximately 20 minutes were undertaken as participants moved through the examination stations. A further visit six weeks later was arranged for participants whose clinical measurements required confirmation or clarification.

Figure 3 Layout of the screening station used in the Renfrew/Paisley cohort study



The questionnaire used in the Renfrew/Paisley study was very similar in appearance to that used in the Collaborative study but some new questions were included and others (e.g. questions on diet and early life) omitted. The data were coded and entered onto computer, anonymously. The original questionnaires are currently stored at the University of Glasgow archive. The data gathered from the questionnaire are detailed in Table 10.

Table 10 Questionnaire data collected at screening

Questionnaire data
Sex
Marital status
Date of birth
Occupation
Exercise
Medical Research Council bronchitis questionnaire
Chest wheeze
Effect of weather on breathing
Smoking habit
Rose angina questionnaire
Severe chest pain
Diabetes
Past history of hospital admissions
Stroke symptoms
Treatment for blood pressure
Asthma / hay fever
Years in present home (Paisley only)

The standard Rose angina classification was used to define the presence of angina.[3,4] The validity of the Rose angina questionnaire has been tested in studies comparing it to a clinical diagnosis of angina, electrocardiogram abnormality, thallium scanning and as a predictor of coronary artery disease mortality.[5,6,7,8] In the classification, Grade I angina is defined as pain or discomfort when walking uphill or hurrying. Grade II angina is when the subject also reports chest pain or discomfort when walking at an ordinary pace on the level. Angina is further classified as "definite" if, in addition, the pain is sited in the sternum or the left chest and arm, causes the subject to stop or slow down and resolves within 10 minutes of the subject stopping or slowing down. If these additional criteria are not satisfied, angina is classified as "possible". For the purpose of this study, "angina" was defined as Rose grade I and II "definite" angina and was not confirmed by investigation or evaluation. Possible MI (identified by a separate question on Rose questionnaire as having ever experienced a severe pain across the front of chest lasting for half an hour or more) was noted.[9] The diagnosis of chronic bronchitis was determined by the Medical Research Council's chronic bronchitis questionnaire.[10] A smoking history was recorded including average number of cigarettes smoked per day (never smoked, 1-14, 15-24, 25-34, 35 or more), ex-smoker (less than 5 years or 5 years or more) or pipe or cigar smoker. A history

of diabetes was obtained from the patient and was positive if they reported having been told they had diabetes by a doctor.

A number of clinical variables were also measured at screening (Table 11). Blood pressure was recorded as the mean of two measurements taken in the seated position and diastolic pressure was recorded at the disappearance of the fifth Korotkoff sound. Height and weight were measured and used to calculate body mass index in kg/m^2 (weight in kg divided by height in meters squared). Forced expiratory volume in 1 second (FEV1) was measured. An adjusted FEV1 was calculated as a percentage of the "expected" FEV1 (derived from a linear regression equation of age and height for men and women separately from a healthy subset of the sample who were non-smokers and had no respiratory symptoms) and the actual FEV1. These equations were:

Men: $FEV_1 = -185.92 - 2.86 \times age + 3.69 \times height$

Women: $FEV_1 = -22.47 - 2.89 \times age + 2.37 \times height$

The cardiothoracic ratio was based on a chest radiograph and cardiomegaly was defined as a cardiothoracic ratio <= 0.55. Plasma cholesterol and glucose concentrations were measured in a 10ml non-fasting blood sample. Glucose concentration was not measured during the whole screening period. A six-lead electrocardiogram (ECG) was also obtained (leads I, II, III, aVR, aVL and aVF) and coded using the Minnesota coding system.

Table 11 Clinical measurements made at screening

Clinical measurements
Blood pressure
Chest X-ray
Tine test
Sputum sample
Cholesterol (plasma, non-fasting)
Blood glucose*
Cardiothoracic ratio
Height
Weight
ECG (Minnesota code)
Respiratory function, FEV1, FVC
Biochemical tests*: Sodium (Renfrew only), potassium, Oxygen, Haemoglobin, carboxyhaemoglobin

* only available on some subjects

Measures of socioeconomic deprivation

Measures of SED have been discussed earlier. Two measures of SED were obtained in the Renfrew/Paisley study. The first was social class as determined by the participant's occupation recorded on the questionnaire. This was coded according to the Registrar General's classification. For housewives and retired women the occupation of their husband or father was used. The classification is outlined in Table 12. Class I is the most affluent class and class V the most deprived. Class VI, which denotes service in the armed forces, was not used in the cohort.

Table 12 Registrar General's Social Class Scheme

Grade	Example Occupations	
I Professional	Doctor, Lawyer, Executive	Non-Manual
II Intermediate	Sales Manager, Teacher	
III-N Skilled non-manual	Shop Assistant, Clerk	
III-M Skilled manual	Machinist, Brick layer	Manual
IV Partly skilled	Postman,	
V Unskilled	Labourer, Porters	
VI Armed forces		

The second measure was determined from a participant's postcode of residence. Postcode sectors were used to assign a Carstairs-Morris index category.[10] The index was originally developed in the 1980s using 1981 census data. It is composed of four indicators which were judged to represent disadvantage in the population (Table 13). The four indicators are combined to create a composite score. The deprivation score is divided into seven separate categories, ranging from the most deprived (category 7) to the least deprived (category 1). The seven categories were designed so as to retain the discriminatory features of the distribution of the deprivation score, rather than to ensure equality of numbers between each deprivation category. Some very small postcode sectors were excluded and do not have a score. The index was designed with the expectation that it would be mirrored by direct measurement of household income if that were possible. Whilst the cohort was recruited between 1972-1976, the Carstairs Morris index applied was derived from the 1981 census. Therefore, the index may not accurately reflect the socioeconomic conditions of the cohort at recruitment. However, previous analyses of the cohort [100,101,125,172,198] and their congruency with the published literature would suggest that this potential bias has little meaningful effect on the results of the study.

There are 1010 postcode sectors in Scotland, identified by a combination of the first five characters of the postcode (representing 937 areas) and the Council Area. The average population is 5012 (range 51 people to 20,512). A total of 15,370 participants (99.8% of the total cohort) had a documented postcode of residence that was used to determine SED based on the Carstairs–Morris Deprivation category. It should be noted that none of the postcode sectors of the participants in the Renfrew/Paisley study mapped to deprivation category 2.

Table 13 Constituent variables in the Carstairs Morris Index

Variable	Definition
Degree of Overcrowding	Persons in private households living at a density of more than one person per room as a proportion* of all persons in private households
Level of Male unemployment	Proportion of economically active males who are seeking work
Proportion in Social class 4 or 5	Proportion of all persons in private households with head of household in social class 4 or 5
Ownership of a car	Proportion of all persons in private households with no car

Ethical approval and Follow-up

Written consent was given at the time of enrolment into the study for hospital records to be subsequently monitored. Latterly ethical permission was obtained from Argyll and Clyde local and regional ethics committee for linkage with the Scottish Morbidity Record (SMR) system. Electronic linkage to hospital and death records is possible for all residents of Scotland through the SMR.

Scottish Morbidity Record (SMR)

Healthcare data for individual patients in Scotland is collected as a series of Scottish Morbidity Records.[199] The record type denotes the general type of healthcare received during an episode. The hospital activity SMRs are outpatient attendances (SMR00), all discharges from acute hospitals (SMR01), maternity units (SMR02), psychiatric units (SMR04), neonatal units (SMR11) and geriatric long stay inpatients (SMR50). Analysis of SMR01 data were used for this study. An SMR01 record is an episode-based patient record relating to all inpatient or day case discharges from non-obstetric and non-psychiatric specialties. Elective and emergency admissions are included. A SMR01 record is generated when a patient is discharged home from hospital, transferred to another clinician (either at

the same or a different hospital), changes specialty (either under the same or a different clinician), or dies. Data collected include patient identifiable and demographic information as well as episode management details (such as length of stay) and general clinical information. Each patient is given a principal diagnosis and up to five secondary diagnoses and up to four operative procedures. These secondary diagnoses are recorded if they affect the management of the patient or are associated with the main condition or are chronic conditions. Diagnosis at discharge is coded using the World Health Organisation (WHO) International Classification of Diseases (ICD) system. Diseases are coded initially using the eighth revision (ICD-8, a small number of initial episodes), the ninth revision (ICD-9) up to March 31st 1996 and the tenth revision (ICD-10) thereafter. The data are abstracted from case notes and then transcribed onto an SMR01 form. The Information and Statistics Division (ISD) of the NHS Scotland collates the data at National level. The General Register Office for Scotland records the causes of death for all Scottish residents. The codes used to classify deaths are allocated using the WHO International Classification of Diseases. ICD9 was used between 1979 and 1999 and ICD10 has been used since 1st January 2000. Classification of the cause of death is based on information collected on the medical certificate of cause of death which contains information on the underlying cause of death and up to three other causes considered to have contributed to death.

Since the 1970's these datasets, SMR and death registration records, belonging to the same patient in Scotland have been linked together in the Scottish Record Linkage System.[199] Therefore, the linked data set holds hospital discharge records for non-psychiatric, non-obstetric specialties (SMR01) together with Registrar General's death records from 1981 until the present day. Ad hoc linkages can also be carried out dating back to 1968. Records from individual hospital episodes from different SMR schemes and records from the Registrar General are linked using probability matching record linkage to provide profiles for each patient. Over the last thirty years, methods of probability matching have been developed and refined in Oxford, Scotland and Canada and are used by the Record Linkage System to allow for inaccuracies in the identifying information.[199] When records are linked, two records are compared using identifying items such as surname, first initial, sex, year, month and day of birth and postcode and a decision is made as to whether they belong to the same individual. Surnames are changed to coded format in order to avoid the effects of differences in spelling. A computer algorithm calculates a score for each pair of records that is proportional to the likelihood that they belong to the same person. The huge volume of data would mean it is be impossible to carry out probability matching on all pairs of records involved in the linkage and blocking is used to cut down the number of comparisons required. Only those records that have a minimum level of agreement in

identifying items are compared. Probability matching then allows mathematically precise assessment of the implications of the levels of agreement and disagreement between records.

Quality of the data

The self-completed health questionnaire at baseline screening was checked by experienced interviewers at the screening examination.

The linkage process is largely automatic as a threshold score based on probability matching dictates the decision as to whether the records belong together. Clerical checking has shown that the accuracy of probability matching is 98%. The accuracy of follow up using this method has been validated against standard follow up using a clinical trial. In comparison to the standard method of follow up, linkage of records to SMR compared favourably.[144]

The Quality Assessment and Accreditation Unit of Information and Statistics Division of NHS Scotland monitors the quality of SMR data, by assessing accuracy, completeness, consistency and fitness for purpose. It carries out routine validation of a sample of SMR01 records where data held on the sampled records are compared with information contained in the medical case notes. An assessment of the accuracy of SMR01 data, carried out between 2000 and 2002, on a 2% sample of SMR01 data found the accuracy for recording of clinical data at the three-digit level was 88% for the main diagnosis falling to 81% at the four-digit level.[200] The accuracy of the main diagnosis was 89% from the 1997/98 audit. The accuracy for main procedure/ operation was 91% accurate and other procedures/ operations 92% accurate. The accuracy for non-clinical data items was 97%. Cardiovascular diagnoses were 91% accurate overall.

Organisation and extraction of the data

The Renfrew/Paisley study is co-ordinated from the Department of Public Health and Health Policy in the University of Glasgow. Data pertaining to the initial and follow-up screening visits are held in SPSS file format. The cohort is updated for mortality on a three monthly basis including full checks on the status (dead/alive) of the oldest participants. At the time of commencing these studies subsequent hospital admission data for the cohort were available to the date of 31st of March 2004. In collaboration with Midspan staff, Dr

Carole Hart and Mrs Pauline McKinnon, a data extraction specification was written which detailed the nature of the baseline and follow-up data required for the studies in this thesis.

Ethical approval and data extracted for present studies

The Midspan Steering Committee approved the studies. Permission was given by the Privacy Advisory Committee of the Information and Statistics Division to use the linked data. All studies were approved by the University of Glasgow ethics committee.

Each patient record contained all information available from the baseline questionnaire. Date of death and cause of death until 31st March 2004 were also included. In addition the date of all hospitalisations and cause of all hospitalisations was also available up until this date. Date of censorship was from the date of each individual's initial screening visit to death, end of follow up or in a few cases date of emigration. Loss to follow up occurred in less than 1% of the cohort.

Statistical analysis

All analyses were undertaken using Stata (Version 10, Stata Corporation, College Station, Texas, USA). All tests of statistical significance were two tailed. Statistical significance was taken at the conventional level of 5% ($P<0.05$). The use and limitations of, p values has been widely discussed in the scientific literature.[201,202] The p value dichotomises the results of statistical analyses into "significant" or "non-significant" and removes any further interpretation of the data.[203] A non-significant p value indicates that there is no difference between two or more groups, or that that the study is underpowered to detect the difference between groups; it does not indicate which of these two options is true.[204] A more appropriate analysis is to calculate a confidence interval which allows an assessment of the strength of evidence.[205] For analyses in this thesis 95% confidence intervals were calculated. Major scientific journals insist on the presentation of confidence intervals.[201,205,206] As Altman[204] states "The main purpose of confidence intervals is to indicate the (im)precision of the sample study estimates as population values." He discusses the interpretation of confidence intervals, making a number of important points about their interpretation.[204] Firstly, values outside of the interval are not excluded by the interval, they are simply less likely. Secondly, the middle of the interval is more likely to contain the true population value than the two extreme quarters. The final, and perhaps the most often overlooked aspect of the interpretation of confidence intervals, is that regardless

of the width of the confidence interval, the sample estimate is the best indicator of the true population value.

Confidence intervals, as with p values, are open to misuse.[206] The most common misuse of confidence intervals occurs when they include the null value (the confidence interval crosses the value of no effect).[203,204,207,208] In this case the confidence interval is often interpreted as proof of no effect.[208] Whilst this is based on a correct link with the p value, interpretations of confidence intervals in this way effectively dichotomise the interval back into "significant" or "non-significant" test. This denies the reader the option of making a more informative interpretation of the interval as outlined above.[204,207] Therefore, the 95% confidence intervals calculated are interpreted as intervals, following the above, and not as tests of significance.[204] Finally, epidemiologists such as Bradford Hill[209] suggest that the results of analyses should be interpreted in relation to the other analyses performed and of other published literature.[210] Therefore, analyses were interpreted in relation to each other and whether they were consistent with the published literature if available.

Rates

Rates were calculated from date of screening to the date of event or censoring (death or end of follow up). Rates are expressed per 1000 person years follow up. Rate ratios were calculated using the Mantel-Cox method.

Cox regression

Cox proportional hazards regression[211] was used to model the effect of a number of covariates and their association with the risk of various events. Models were used to adjust for the variation in distribution of various risk factors between individuals of differing SED. Initially variables which have been consistently associated with cardiovascular risk, were entered into the model to adjust for their variable distribution between socioeconomic groups. Next variables that are not considered "traditional" risk factors but have previously been shown to be associated with cardiovascular disease, body mass index, adjusted FEV1, history of bronchitis and cardiomegaly, were entered into the model. Backwards stepwise regression was used to determine those additional variables that would be adjusted for in further analyses after adjustment for the "traditional" cardiovascular risk factors, age, sex, smoking, blood pressure, cholesterol and diabetes mellitus. The significance level of the likelihood ratio test of these variables is given in table 14.

Table 14 Significance level of additional variables entered into the model

Variable	P
Body mass index	0.0004
Adjusted FEV1	<0.0001
Bronchitis on MRC questionnaire	0.0013
Cardiomegaly (cardiothoracic ratio of >=0.5 on chest radiograph)	<0.0001

Therefore, the final models used in these analyses included, age, sex, SED (measured by Carstairs Morris index or social class), diabetes, smoking, cholesterol, systolic blood pressure, body mass index, adjusted FEV1, bronchitis and cardiomegaly.

Inequality was measured by comparing the hazard and rate ratio in the most versus the least deprived. It was also measured using the population attributable fraction. These are the most common methods of exploring health inequalities in the literature. Other methods do exist and have advantages and disadvantages, in particular they describe the relationship between health outcomes and the whole distribution of SED.[212-215] The Gini coefficient, modified Gini coefficient and index of dissimilarity all enable inequalities in health to be measured from the most to least deprived and all levels between.[212,213] However, they are univariate measures and were therefore unsuitable for examining the aims of this thesis.[212] The concentration index[212,214,215] can discriminate between a situation where the most deprived are the sickest and where the least deprived are the sickest whilst describing the gradient in inequality (the Gini index cannot and will arrive at the same answer in both of these situations). However, it can only be used where the socioeconomic categories can be ranked in strict hierarchical order, for example when using education or income as a measure of SED. This measure is not suitable for measures such as social class where this very strict ordering is not true. Multivariable measures do exist. Regression coefficients and Pearson's correlation coefficients may be calculated to fully describe the relationship between SED and health.[214] However, they require that the health outcome and scale used to measure socioeconomic status are continuous variables. As such they were not appropriate for use in the setting of survival analysis as in this thesis. Finally, the slope index of inequality and a transformation of this, the relative index of inequality may also be used to describe the frequency of a health outcome and socioeconomic category.[212,214,215] However, the indices rely on the assumptions of linear regression, and, most importantly, that again the socioeconomic categories must be strictly hierarchical. Therefore, these indices are not useful in the current thesis as linear regression would not

be a valid technique for the analysis of survival times and the measures of SED are not strictly hierarchical.

As noted above, in this thesis I will examine inequalities in outcomes through the rate ratio and comparison of the hazard ratio of the most versus the least deprived. The hazard ratio has a number of advantages over the other measures outlined above. Firstly, it is easily interpretable. Secondly, the technique of survival analysis can be employed which is the most appropriate method of analysing these longitudinal data. Thirdly, adjustment can be made for traditional risk factors in examining the relationship between CVD and SED which is difficult with the above techniques. Finally, none of the techniques outlined above allow the relationship between SED and an outcome to be compared across outcome types which can be done using the Cox model and this is one of the aims of the thesis. Survival analysis and rate ratios are also the most commonly used methods in the literature for examining health inequalities making the analyses in this thesis easily comparable. These advantages outweigh the limitation of this approach, that only the ends of the socioeconomic spectrum will be described and not the relationship across all categories.

The proportional hazards assumption was tested using Schoenfeld residuals[216] and was met for all variables in the model.

Risk of a first Cardiovascular Hospitalisation

In this section I will present the results of analyses examining the association between SED and the risk of a number of first cardiovascular hospitalisations after adjustment for a number of recognised risk factors. The relationship is examined using traditional methods of survival analysis and competing risks analysis to account for the risk of various different cardiovascular diseases. As a result, I aim to determine if SED is associated with a higher risk of certain cardiovascular outcomes. In addition, a range of composite endpoints will be examined including endpoints incorporating all cause mortality.

Methods

Introduction to the competing risks model

Cox regression is a well studied and frequently used method of analysing the survival experience of a cohort. Standard survival data measure the time from one point until the event of interest occurs e.g. myocardial infarction or death. In a typical setting, such as clinical trial, the effect of an intervention such as a new pharmacotherapy that is thought to prevent the outcome of interest is examined on the time to outcome in relation to a gold standard treatment or more commonly placebo. In epidemiological studies data are obtained from observational studies such as the present cohort study. In such studies we are interested in the association between a variable (in this case SED) and the event of interest. However, in cohort studies (and indeed clinical trials) more than one type of event can occur during follow up and the variable under study may be associated with a higher risk of more than one type of event. This situation arises in the current study where SED is associated with multiple cardiovascular outcomes and also death. Whilst one event is usually chosen as the event of interest the occurrence of the other event may prevent the event of interest from occurring (e.g. death prevents an individual experiencing a myocardial infarction) or it may lead to a change in therapy that alters the risk of the event of interest from occurring (e.g. the prescription of secondary prevention following a myocardial infarction). Similarly, as in this thesis, we may be concerned with the relationship between a variable and a number of different outcomes. In such a situation caution should be exercised when estimating the probability of the event of interest occurring in the presence of these "competing risks". Treating the events of the competing causes as censored observations, as is done in standard survival analysis techniques such as Kaplan-Meier analysis, will lead to a bias in the Kaplan-Meier estimate if one of the

fundamental assumptions underlying the Kaplan-Meier estimate is violated: the assumption of independence of the time to event and the censoring distributions. The Cox proportional hazards model can still be used in this situation though interpretation of the results becomes more problematic. One other situation where the competing risks approach is of use is worthy of mention at this point as I will not be expanding further on this in the thesis. Individuals throughout life, despite the best efforts of health care professionals, move between different states of ill-health and health. One simple example is that of a cancer that can be put into remission. An individual may start as "healthy", during follow up develop the cancer of interest and receive treatment and then enter remission. This individual may then move between the state of remission and disease throughout follow up or indeed die from the cancer at any point during follow up. A similar parallel in cardiovascular medicine would be angina. One may develop angina, receive revascularisation therapy and be free of angina though develop it again later in follow up whilst all the time being at risk of myocardial infarction. Therefore, instead of survival data or time-to-event data, data on the history of events are available. Multi-state models provide a framework that allow for the analysis of such event history data and they can be seen as an extension of competing risk models.[217] I will not examine multistate models in this thesis though more detail can be found elsewhere.[217]

Bias of the Kaplan Meier estimates

The need for the competing risk approach comes from the finding that in certain situations the Kaplan-Meier approach is flawed because the assumptions of the technique are violated in this setting. The assumption of independence of the censoring distribution, i.e. the distribution of the time to the competing events is violated in a competing events situation. Putter *et al* [218]succinctly state that *"If the competing event time distributions were independent of the distribution of time to the event of interest, this would imply that at each point in time the hazard of the event of interest is the same for subjects that have not yet failed and are still under follow-up as for subjects that have experienced a competing event by that time. However, a subject that is censored because of failure from a competing risk will with certainty NOT experience the event of interest. Since subjects that will never fail are treated as if they could fail (they are censored), the naive Kaplan-Meier overestimates the probability of failure (and hence underestimates the corresponding survival probability)."* An example is censoring people who die during follow up when examining a non-fatal event. This is theoretically different from censoring due to end of study or loss to follow-up. In the latter situation, individuals may still fail at a later time point. In such a

situation the naive Kaplan-Meier estimates describe what would happen if the competing event could be prevented, thus creating an imaginary world in which an individual remains at risk for failure from the event of interest. These issues have been the subject of debate in the literature though it is now accepted that in the presence of competing risks the Kaplan-Meier estimates are biased. Putter *et al*[218] in their paper explore the issues in much greater detail than I am able to do so here, and they are also succinctly discussed by Rao and Schoenfeld in another article [219].

The analysis of competing risk data

As noted the competing risks approach makes the used of traditional methods such as the Kaplan-Meier estimate problematic. Instead the presentation of cumulative survival curves is the preferred method for presenting these analyses. The mathematical derivation of cumulative incidence curves is beyond the scope of this thesis but is eloquently explained through worked examples by Putter *et al*[218]. In essence however the cumulative incidence curves are simply plots of the proportion of patients with the event of interest or the competing event as time progresses. In Kaplan-Meier analysis the two curves or groups of interest can be compared using a log-rank test and the association between the outcome and variable of interest examined using a Cox regression analysis whilst adjusting for other risk factors. In a competing risks situation, the equivalent steps are to generate cumulative incidence curves then test the difference between cumulative incidence curves using the Fine and Gray[220] method, and perform a competing risk regression analysis. Again for the same reasons that the Kaplan-Meier plot is not suitable in this situation the standard Cox proportional hazards model analysis is not adequate in the presence of competing risks. This is because the cause-specific Cox model treats the competing risks of the event of interest as censored observations. To overcome this problem two methods of regression analysis have been proposed in the setting of competing risks, regression on cause-specific hazards, which will be used in this thesis, and regression on the cumulative incidence functions.

Regression on the cause-specific hazards

If the covariate is continuous or association between the cause-specific event is of interest, a competing risks analogue of a Cox proportional hazards model is possible as the regression on the cause-specific hazards is possible. In proportional hazards regression on the cause-specific hazards, we model the cause-specific hazard of cause k for a subject

with covariate vector Z, observation time t as

$$\lambda_k(t|\mathbf{Z}) = \lambda_{k,0}(t)\exp(\boldsymbol{\beta}_k^\top \mathbf{Z})$$

One advantage of this method over that of regression on the cumulative incidence functions is that the equality of covariate effects across different events or outcomes can be assessed. It is this feature of regression on the cause-specific hazards that will be utilised in this thesis to determine if the effect of SED on the risk of a cardiovascular event is equal across a number of different cardiovascular event types.

Regression on the cumulative incidence functions

Fine and Gray[220] described a method to perform a regression directly on cumulative incidence functions that are calculated in a competing risk analysis.

The Fine and Gray regression does not yet allow the flexibility (e.g. in testing for or assuming equality of covariate effects across different failures or events) of regression on cause-specific hazards. Given this limitation of this approach in not allowing the equality of covariate effects across different events, the Fine and Gray method is not used here.

Implementation of the technique

Both techniques are available in standard statistical packages. The method of Fine and Gray, regression on cumulative incidence is implemented in R using the cmprsk command. However, I have used the stcompet module in Stata to implement the regression on cause-specific hazards in this thesis. Further information on implementing this command can be found online at http://www.stata.com/support/faqs/stat/stmfail.html.

The use of composite endpoints to deal with competing risks

One method of examining competing risks that has not been discussed above is the use of composite endpoints. The use of composite endpoints is widespread in the medical literature. They are commonly used to examine an outcome of interest in the presence of

other outcomes of interest or competing outcomes such as death. Their use is widely debated in the medical literature.[221-224] They can be useful from a number of standpoints:

1. To decrease the sample size required to show and effect of the treatment in a clinical trial

2. To examine the totality of effect of a therapy or association with a variable.

3. To deal with competing risks

I will concentrate on their third use above, that of a method to deal with competing risks. For example, if we take the scenario of a study of patients with angina, an endpoint of hospitalisation for myocardial infarction would be problematic as it does not account for death. In such an analysis deaths would be censored, however these deaths are ‘‘informative’’. A patient who is censored due to death is not at the same risk of hospitalisation, had they survived, as a patient who survived as long and is still at risk for hospitalisation but say censored because they emigrated and left the study. If censoring because of death varied by groups of interest, the estimate of effect would be biased. Therefore, a composite of death or myocardial infarction hospitalisation is used. Therefore, in this thesis I also examine composite endpoints to assess the impact of SED on cardiovascular outcomes.

The impact of regression dilution

During the multivariable regression analyses, follow up was taken until the end of the study i.e. 28 years. For first hospitalisations models were also constructed at 5 year intervals up until this point. From the results of the multivariable analysis there was evidence of regression dilution when analyses were extended past 25 years. Regression dilution is a phenomenon that occurs when the association between a variable and outcome is underestimated because of the long period of time between the measurement of the variable and the occurrence of the event of interest.[225] Whilst methods exist to account for regression dilution bias, given the magnitude of the potential loss to follow up by limiting analyses to a period where regression dilution was not occurring (i.e. the loss of 3 years of follow up), limiting the length of follow up was the most appropriate method. This did not alter the conclusions of the studies and removed this bias. Therefore, univariable and survival analyses are limited to 25 years of follow up. Hazard ratios for 28 years of follow

up are presented in the table of regression analyses of first cardiovascular hospitalisations to demonstrate this phenomenon.

Results

Model Building and baseline characteristics of the cohort

Model Building

Prior to commencing analyses of the association between SED and cardiovascular disease a multivariable model was built and variables associated with the development of cardiovascular disease were examined. Individuals with no prior history suggestive of CHD were identified. Prior CHD was defined by a positive answer to the questions on MI in Rose questionnaire or definite angina as defined by the Rose questionnaire or ECG findings compatible with previous MI (Q waves or left bundle branch block). The outcome of admission for CVD was used as the endpoint in the model building stage. Initially variables which have been consistently associated with cardiovascular risk were entered into the model to adjust for their variable distribution between socioeconomic groups. Next, variables that are not considered "traditional" risk factors but have previously been shown to be associated with CVD, body mass index, adjusted FEV1 , history of bronchitis and cardiomegaly, were entered into the model. Backwards stepwise regression was used to determine those additional variables that would be adjusted for in further analyses after adjustment for the "traditional" cardiovascular risk factors outlined in Table 15. The significance level of the likelihood ratio test of these variables is given in Table 15 for SED measured by Carstairs Morris index of deprivation and Table 16 for SED measured by social class.

Table 15 Significance level of cardiovascular risk factors in a multivariable model when Carstairs Morris index is used as a measure of socioeconomic deprivation

Variable	P
Carstairs Morris index	0.0022
Age	<0.0001
Sex	<0.0001
Diabetes	<0.0001
Smoking	<0.0001
Cholesterol	<0.0001
Systolic blood pressure	<0.0001

Table 16 Significance level of cardiovascular risk factors in a multivariable model when social class is used as a measure of socioeconomic deprivation

Variable	P
Social Class	0.0066
Age	<0.0001
Sex	<0.0001
Diabetes	0.0007
Smoking	<0.0001
Cholesterol	<0.0001
Systolic blood pressure	<0.0001

The relative contribution of these factors to the model can be measured using the Chi squared distribution and is given in Table 17. As can be seen from the Chi square value the largest contributor to the model is systolic blood pressure followed by age. These two variables contributed most to the model when modelling all cause cardiovascular hospitalisation. As can be seen from the values SED as measured by the Carstairs Morris index made a greater contribution to the model than either cholesterol or diabetes.

A similar pattern was seen when social class was used as the measure of SED. This was a greater contributor to the model than diabetes (Table 18).

Table 17 Contribution of each variable to the multivariable model when Carstairs Morris index is used to measure socioeconomic deprivation

Variable	Chi
Systolic blood pressure	225.1
Age	178.4
Sex	150.7
Smoking	116
Carstairs Morris Index	**31.2**
Cholesterol	18.4
Diabetes	9.6

Table 18 Contribution of each variable to the multivariable model when Social Class is used to measure socioeconomic deprivation

Variable	Chi
Systolic blood pressure	222.8
Age	182.4
Sex	140.8
Smoking	125.9
Cholesterol	23.7
Social Class	**16.1**
Diabetes	14.4

As noted above the contribution of each of the variables to the model was again tested for a model that included the variables of BMI, adjusted FEV1, history of bronchitis and cardiomegaly on chest x-ray. This was examined both for Carstairs Morris index of deprivation (Table 19) and social class (Table 20) as measures of deprivation.

Table 19 Significance level of variables in the multivariable model with Carstairs Morris index as the measure of deprivation after stepwise selection of additional risk factors

Variable	P
Carstairs Morris Index	0.0022
Age	<0.0001
Sex	<0.0001
Diabetes	<0.0001
Smoking	<0.0001
Cholesterol	<0.0001
Systolic blood pressure	<0.0001
BMI	0.0004
FEV1	<0.0001
Bronchitis	0.0013
Cardiomegaly	<0.0001

Table 20 Significance level of variables in the multivariable model with Social Class as the measure of deprivation after stepwise selection of additional risk factors

Variable	P
Social Class	0.035
Age	<0.0001
Sex	<0.0001
Diabetes	<0.0001
Smoking	<0.0001
Cholesterol	<0.0001
Systolic blood pressure	<0.0001
BMI	0.0003
FEV1	<0.0001
Bronchitis	0.0009
Cardiomegaly	<0.0001

Interactions

Finally, for each of the main types of cardiovascular hospitalisation, interactions between age and sex and SED measured using the Carstairs Morris index and social class were examined (Table 21 and 22). No interactions were found with the exception of that between social class and age. This was the only interaction found, it was not congruent with the Carstairs Morris index or strongly suggested by previous literature and therefore it was not entered into the models.

Table 21 P value of interactions between age and sex with socioeconomic deprivation measured by Carstairs Morris index

	Deprivation Age	Deprivation Sex
CVD	0.6693	0.4215
MI	0.5575	0.2446
Stroke	0.3041	0.1364
HF	0.4129	0.8635
CHD	0.2151	0.8368

Table 22 P value of interactions between age and sex with socioeconomic deprivation measured by social class

	Social Class Age	Social Class Sex
CVD	0.7379	0.9768
MI	0.0069	0.1529
Stroke	0.9696	0.2513
HF	0.7923	0.8454
CHD	0.7307	0.0709

Baseline characteristics

The baseline characteristics of the cohort according to SED are outlined in table 23 and 24 according to both Carstairs Morris index and social class.

As can be seen from Table 23 a number of variables were statistically significantly distributed unevenly across categories of the Carstairs Morris index. For example, mean age in the least deprived was 54.9 years and 54.6 in the most deprived ($P<0.001$). Similarly cholesterol and body mass index varied across groups and reached statistical significance. Each of systolic blood pressure, adjusted FEV1, the proportion of men, smokers, those with cardiomegaly and bronchitis was also statistically significantly different across each group.

When individuals were split by social class mean age in the most deprived was higher than the least deprived. Similarly systolic blood pressure, adjusted FEV1, the proportion of men, smokers, those with cardiomegaly or bronchitis was also statistically significantly different across social groups. Cholesterol and body mass index were also statistically significantly different.

Missing data

No variables were clinically significantly different between those with missing SED by Carstairs Morris index and those assigned SED (Table 20). Those with missing social class had a slightly higher blood pressure (149.3mmHg (SD 24.3mmHg)) than those who has social class assigned (151.8 (SD 25.8)), P=0.04. They were also less men, P<0.001 and less smokers, P<0.001. All other variables were not different between those with and without social class assigned.

In those with missing social class there were fewer men, smokers, and less with cardiomegaly (Table 24).

Table 23 Baseline characteristics of individuals according to Carstairs Morris index of deprivation

	1		3		4		5		6 & 7		P	Missing		P
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Test for trend (excluding missing SED)	Mean	SD	Missing vs. rest
Age (years)	54.9	(5.5)	53.7	(5.5)	54.0	(5.5)	53.7	(5.5)	54.6	(5.6)	<0.001	53.6	(5.7)	0.3
Systolic BP (mmHg)	148.9	(23.7)	149.4	(23.6)	145.5	(23.1)	151.3	(24.4)	147.9	(24.2)	<0.001	145.8	(23.1)	0.55
Cholesterol (mmol/l)	6.1	(1.0)	6.2	(1.0)	6.2	(1.0)	6.1	(1.1)	6.1	(1.0)	<0.001	6.3	(1.0)	0.48
Body mass index (kg/m^2)	25.3	(3.6)	25.4	(3.7)	25.5	(3.8)	25.8	(4.0)	25.9	(4.3)	<0.001	25.9	(2.8)	0.98
adjusted FEV1 (% predicted)	97.7	(22.0)	95.7	(20.5)	92.8	(22.2)	91.8	(22.0)	88.2	(23.0)	<0.001	97.1	(27.9)	0.15
	N	%	N	%	N	%	N	%	N	%		N	%	
Men	363	(42.2)	830	(47.1)	1,236	(44.2)	2,100	(45.9)	1,213	(43.4)	0.03	20	(66.7)	0.01
Smoker	597	(60.3)	1,281	(61.5)	2,242	(67.0)	3,837	(69.3)	2,402	(70.9)	<0.001	20	(58.8)	0.28
Diabetes	7	(0.7)	28	(1.3)	40	(1.2)	69	(1.3)	46	(1.4)	0.6	7	(0.5)	0.51
Cardiomegaly	251	(25.4)	451	(21.6)	749	(22.4)	1,322	(23.9)	930	(27.4)	<0.001	6	(23.1)	0.81
Bronchitis	24	(2.4)	68	(33)	154	(4.6)	276	(4.9)	231	(6.8)	<0.001	2	(5.8)	0.79

Table 24 Baseline characteristics of individuals according to Social Class

	I		II		III (NM)		III (M)		IV		V		P	Missing		P
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Test for trend (excluding missing SED)	Mean	SD	Missing vs. rest
Age (years)	52.9	(5.1)	53.6	(5.4)	53.8	(5.5)	54.2	(5.6)	54.8	(5.4)	54.5	(5.8)	<0.001	54.5	(5.8)	0.04
Systolic BP (mmHg)	146.1	(20.9)	146.7	(23.0)	147.7	(23.6)	150.1	(23.7)	149.0	(24.7)	151.6	(26.0)	<0.001	151.2	(24.81)	0.04
Cholesterol (mmol/l)	6.2	(1.0)	6.2	(1.0)	6.3	(1.1)	6.0	(1.1)	6.1	(1.1)	6.1	(1.0)	<0.001	6.1	(1.2)	0.58
Body mass index (kg/m^2)	25.2	(3.4)	25.6	(3.6)	25.2	(3.8)	26.0	(3.9)	25.8	(4.1)	26.2	(4.6)	<0.001	25.2	(4.2)	0.08
adjusted FEV1 (% predicted)	99.5	(21.3)	97.4	(21.2)	95.1	(21.6)	90.6	(21.9)	89.4	(22.4)	87.0	(23.1)	<0.001	90.5	(22.6)	0.08
	N	%	N	%	N	%	N	%	N	%				N	%	
Men	302	(64.4)	829	(43.3)	673	(27.9)	2,302	(65.5)	1,274	(40.7)	326	(31.1)	<0.001	56	(16.2)	<0.001
Smoker	296	(63.1)	1,199	(62.6)	1,459	(60.7)	2,557	(72.7)	2,114	(67.6)	726	(69.3)	<0.001	185	(53.6)	<0.001
Diabetes	5	(1.1)	22	(1.2)	20	(0.8)	34	(0.9)	36	(1.2)	14	(1.3)	0.77	6	(1.8)	0.08
Cardiomegaly	70	(15.4)	374	(20.6)	549	(23.6)	775	(25.8)	302	(29.7)	773	(25.8)	<0.001	93	(27.7)	0.26
Bronchitis	3	(0.6)	30	(1.6)	49	(2.0)	139	(3.9)	110	(3.5)	52	(4.8)	<0.001	7	(2.0)	0.78

Study participants

Of the 15,344 cohort members (which excludes 24 individuals who were lost to follow up) with an assigned deprivation category, 2,594 were excluded from the present analyses as they had a history of ischaemic heart disease, leaving 5,742 men and 7,053 women in the analyses. Of the 14,995 assigned to social class, 2,475 were excluded with a history of ischaemic heart disease (leaving 5,706 men and 6,774 women).

The numbers of each type of first cardiovascular hospitalisation experienced by each deprivation group is outlined in Table 25 according to Carstairs Morris index and Table 26 according to social class.

Table 25 Number of cardiovascular hospitalisations by Carstairs Morris index category and years of follow up

	Years	1	3	4	5	6 & 7
CVD	5	49	93	145	224	170
	10	85	188	289	503	388
	15	152	305	494	848	612
	20	211	450	732	1295	878
	25	273	594	956	1646	1060
CHD	5	18	29	32	84	59
	10	25	58	76	195	136
	15	51	111	159	339	233
	20	71	182	256	526	333
	25	89	239	346	679	408
MI	5	13	24	28	75	46
	10	20	49	61	174	114
	15	42	84	130	291	186
	20	59	136	200	419	250
	25	70	174	256	510	304
Stroke	5	4	6	17	31	23
	10	12	34	44	88	68
	15	23	62	88	180	127
	20	37	101	173	308	218
	25	64	159	261	447	307
HF	5	3	1	6	12	9
	10	7	5	16	34	24
	15	14	19	42	86	55
	20	29	40	80	167	118
	25	42	64	135	251	169

Table 26 Number of cardiovascular hospitalisations by social class and years of follow up

	Years	I	II	III M	III NM	IV	V
CVD	5	19	100	129	206	153	64
	10	35	196	264	444	367	124
	15	62	340	422	740	597	206
	20	105	515	646	1066	871	297
	25	143	680	837	1311	1082	380
CHD	5	8	30	38	83	43	19
	10	13	62	84	175	112	40
	15	21	128	147	311	206	72
	20	38	194	245	450	315	108
	25	55	266	320	553	405	136
MI	5	6	24	29	75	35	16
	10	11	51	70	157	94	31
	15	18	103	117	265	168	57
	20	28	150	189	366	244	79
	25	43	186	235	432	302	101
Stroke	5	1	9	13	29	16	13
	10	6	23	35	83	72	25
	15	9	51	81	142	134	49
	20	25	100	150	237	221	83
	25	38	157	221	345	321	130
HF	5	1	4	2	12	8	4
	10	4	7	9	26	25	12
	15	6	25	29	71	58	22
	20	14	53	62	135	124	40
	25	20	97	100	200	173	59

Rates of cardiovascular hospitalisations

The rate of non-fatal cardiovascular hospital discharges, after 25 years of follow up, was highest amongst the most deprived compared to the least deprived rate ratio (RR) = 1.48 (95% confidence interval (CI) 1.23-1.61) (Figure 4). The strongest inverse relationship appeared to be between stroke and SED, RR most deprived vs. least deprived = 1.75(95%CI 1.34-2.29), although 95% confidence intervals overlapped substantially. Similar results were observed when social class was examined as the measure of SED (Figure 5)

Figure 4 Rate of cardiovascular events during 25 years of follow up by socioeconomic deprivation measured by Carstairs Morris index.

Category 1 = least deprived, categories 6&7 = most deprived. RR = rate ratio with 95% confidence interval, CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, Stroke = stroke, HF = chronic heart failure

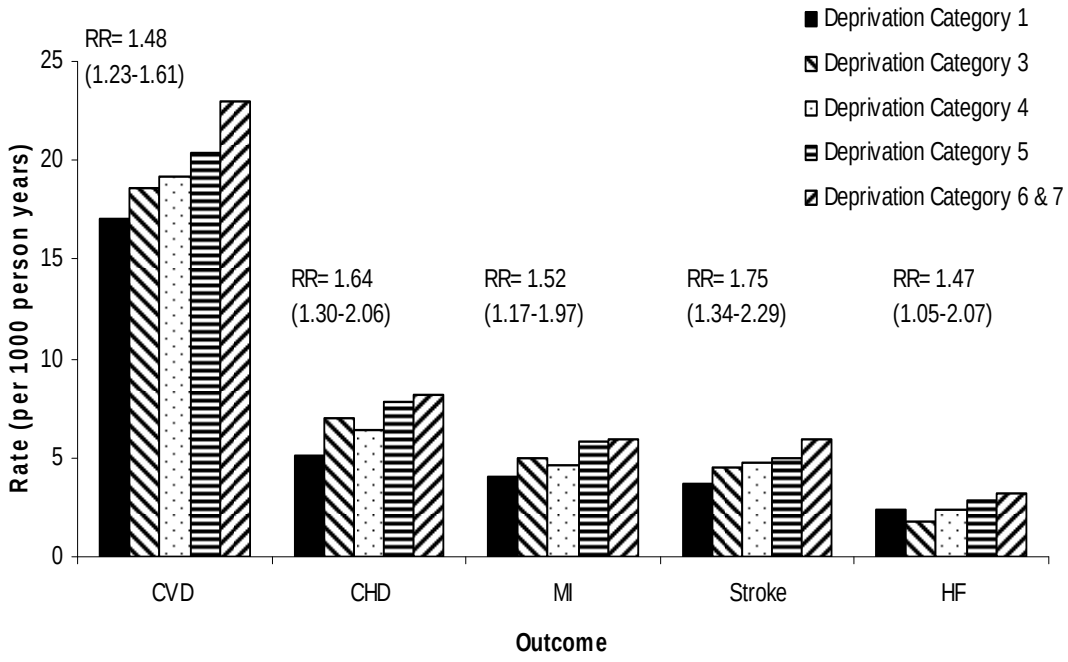
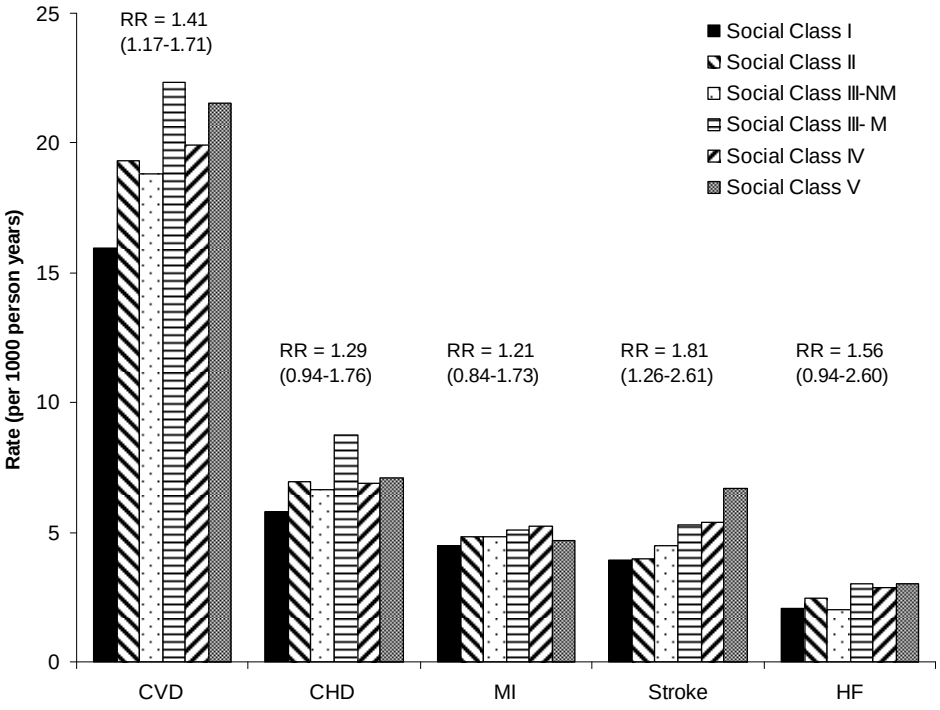


Figure 5 Rate of cardiovascular events during 25 years of follow up by social class

Class I=least deprived, Class V=most deprived. RR = rate ratio with 95% confidence interval, CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, Stroke = stroke, HF = chronic heart failure.



Unadjusted Kaplan Meier survival

Survival from enrolment to experiencing a cardiovascular hospitalisation discharge was analysed using the Kaplan Meier estimates of survival (Figures 6-16). SED was significantly associated with the risk of a CVD, CHD, MI, stroke and HF hospitalisations. The association was present when both Carstairs Morris index and social class were used as the measures of SED.

Figure 6 Kaplan Meier estimates of survival to a first cardiovascular hospitalisation by Carstairs Morris index of deprivation over 25 years of follow up

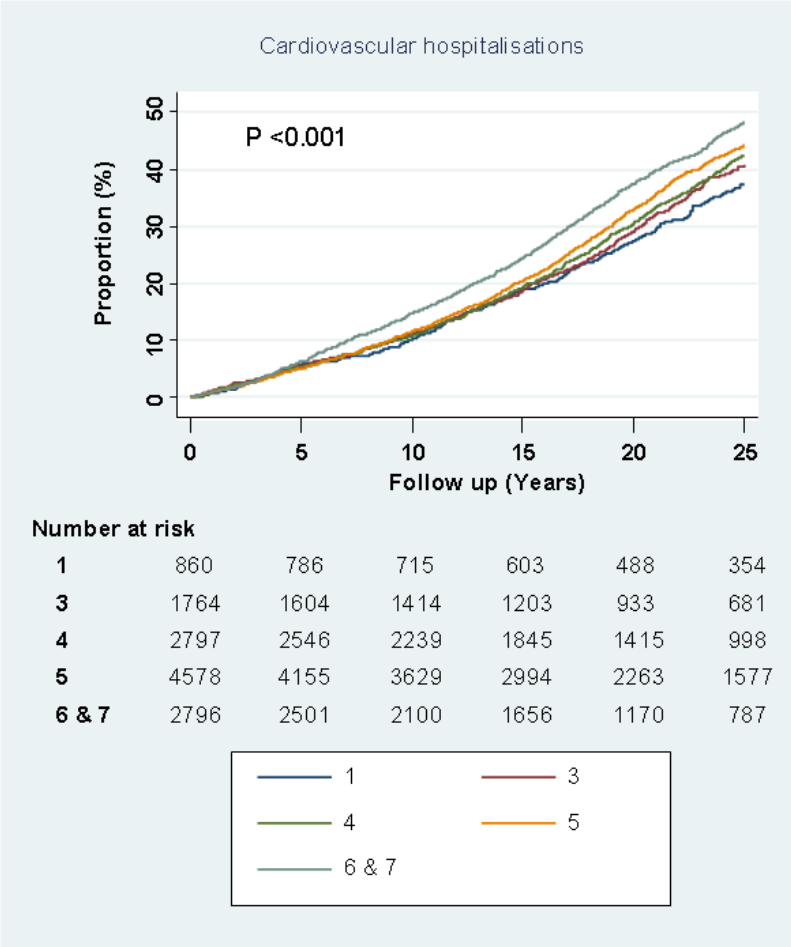


Figure 7 Kaplan Meier estimates of survival to a first cardiovascular hospitalisation by social class over 25 years of follow up

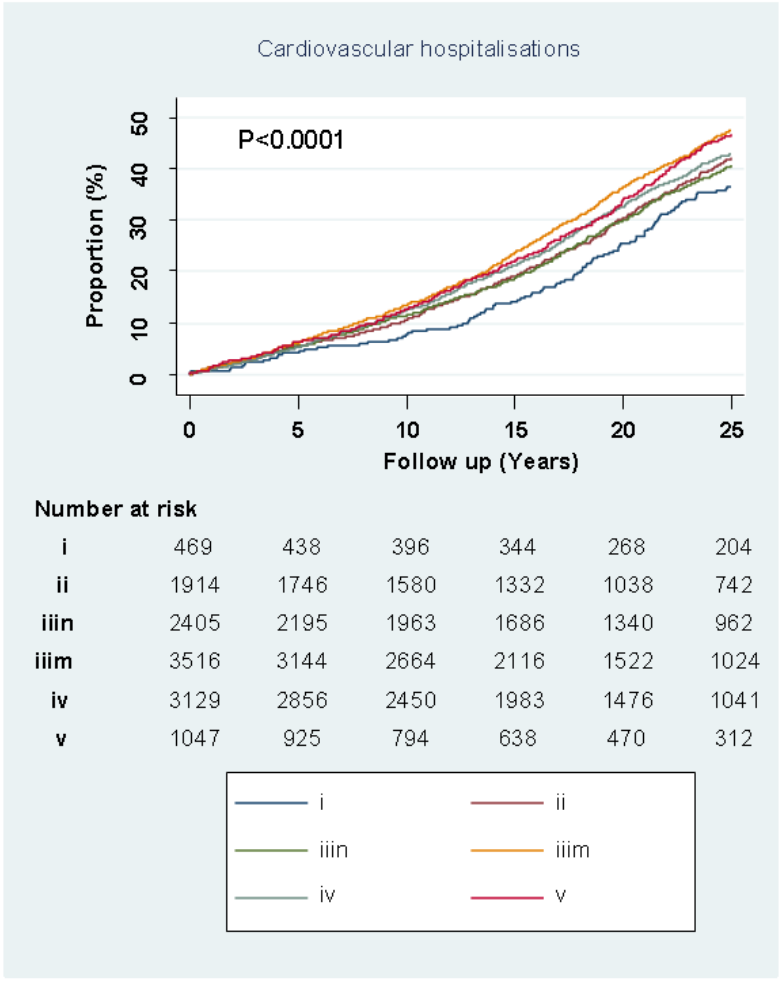
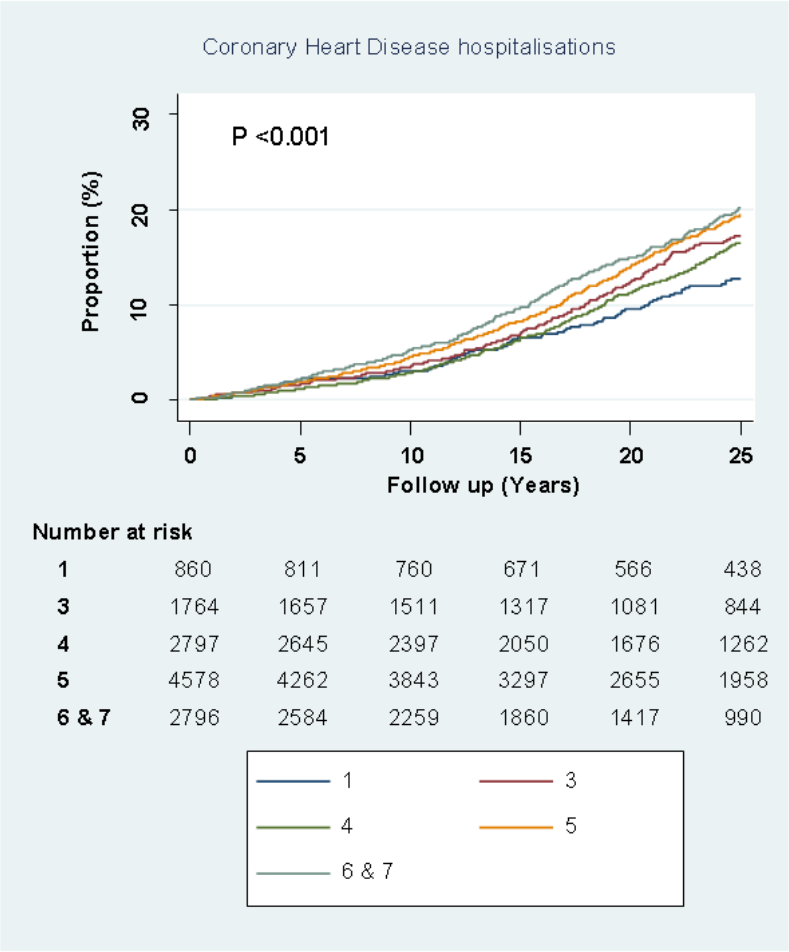


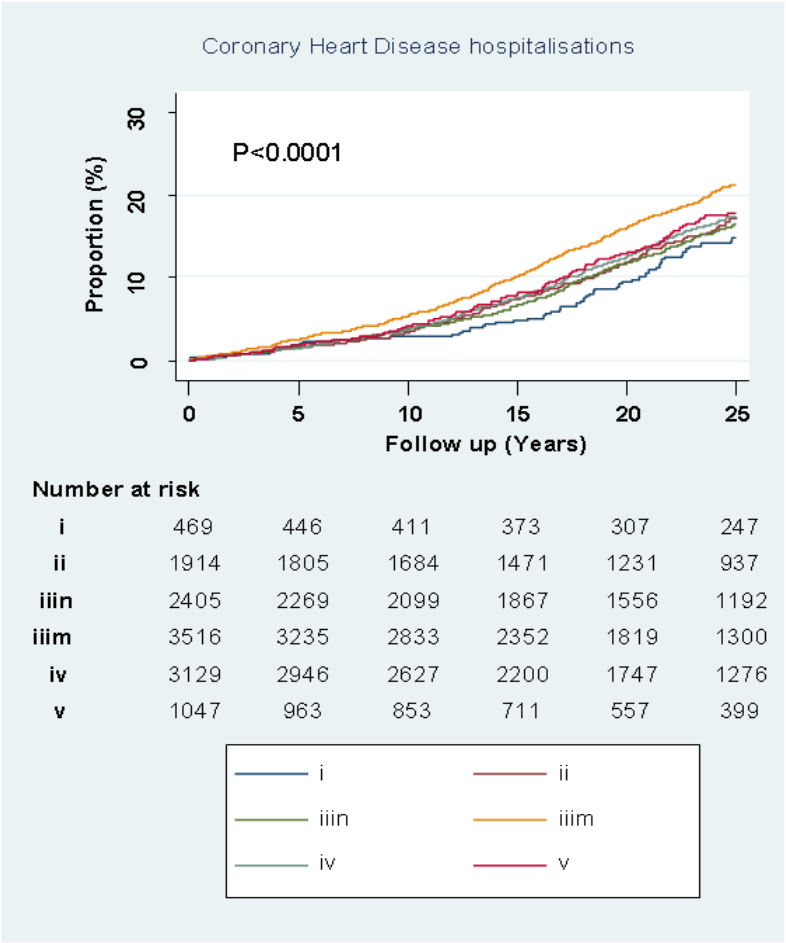
Figure 8 Kaplan Meier estimates of survival to a first coronary heart disease hospitalisation by Carstairs Morris index of deprivation over 25 years of follow up



Number at risk

1	860	811	760	671	566	438
3	1764	1657	1511	1317	1081	844
4	2797	2645	2397	2050	1676	1262
5	4578	4262	3843	3297	2655	1958
6 & 7	2796	2584	2259	1860	1417	990

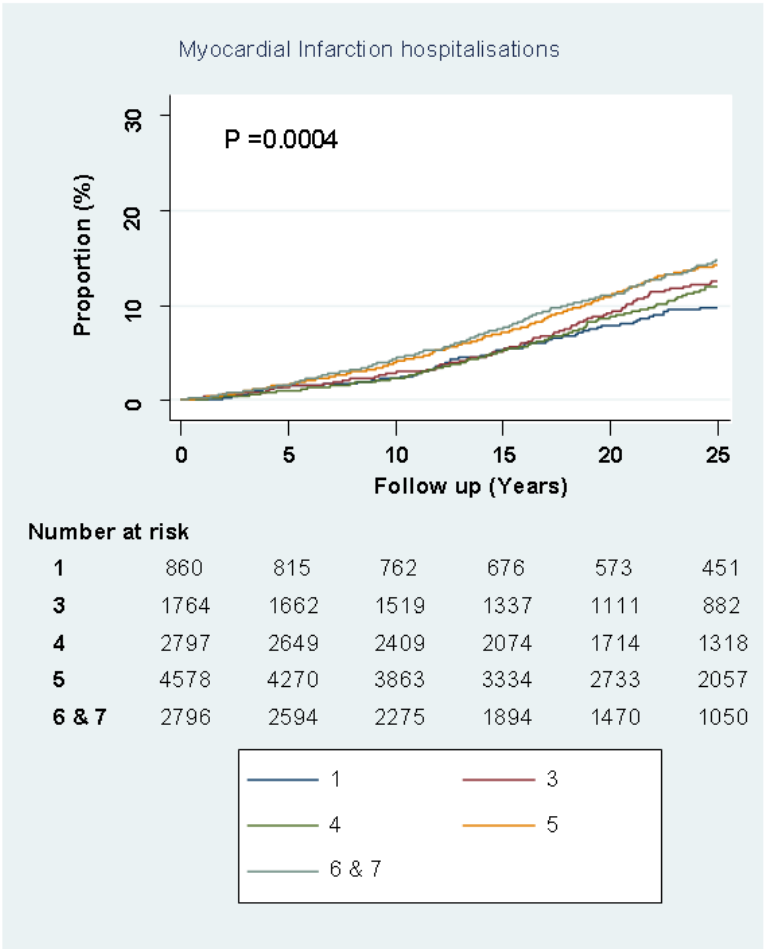
Figure 9 Kaplan Meier estimates of survival to a first coronary heart disease hospitalisation by social class over 25 years of follow up



Number at risk

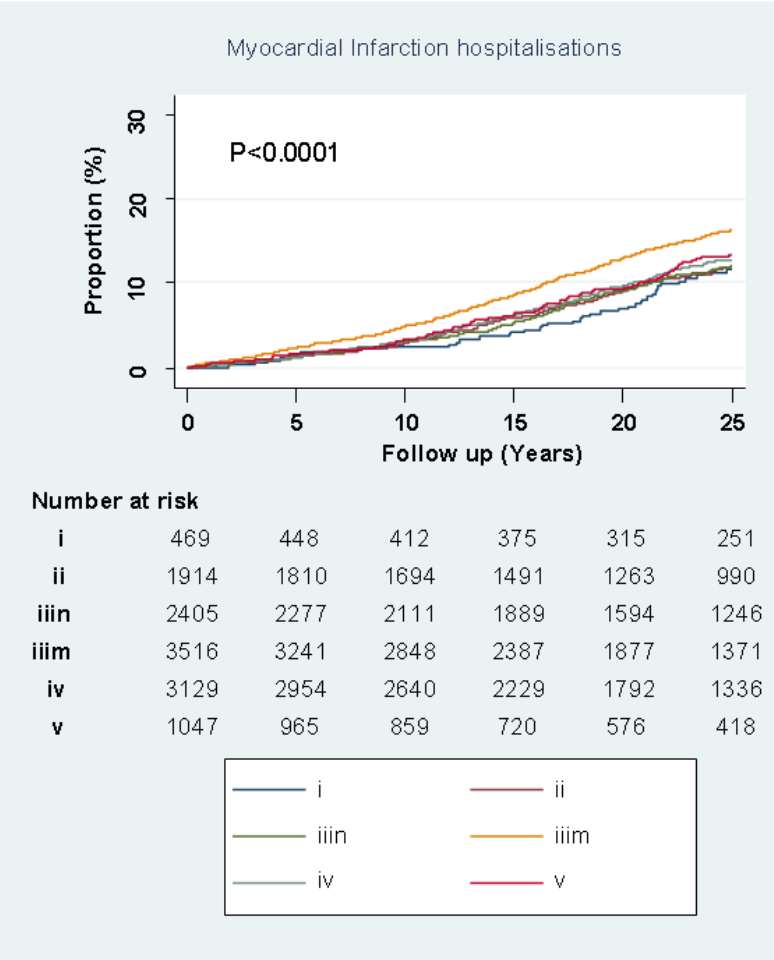
i	469	446	411	373	307	247
ii	1914	1805	1684	1471	1231	937
iiin	2405	2269	2099	1867	1556	1192
iiim	3516	3235	2833	2352	1819	1300
iv	3129	2946	2627	2200	1747	1276
v	1047	963	853	711	557	399

Figure 10 Kaplan Meier estimates of survival to a first myocardial infarction hospitalisation by Carstairs Morris index of deprivation over 25 years of follow up



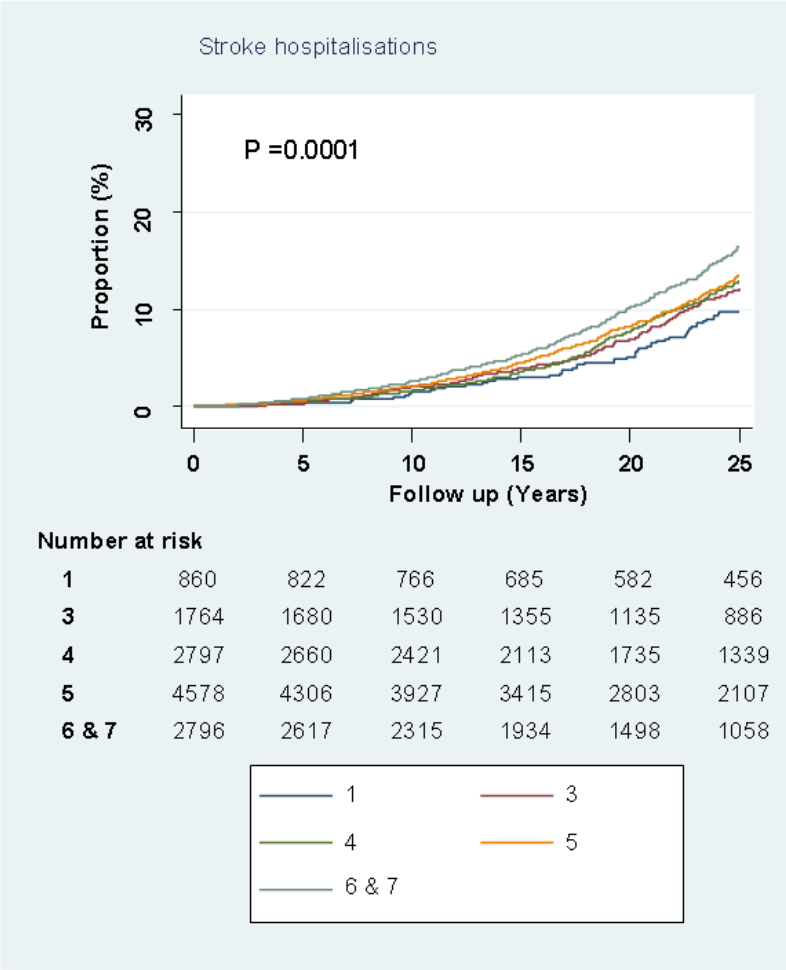
Number at risk						
1	860	815	762	676	573	451
3	1764	1662	1519	1337	1111	882
4	2797	2649	2409	2074	1714	1318
5	4578	4270	3863	3334	2733	2057
6 & 7	2796	2594	2275	1894	1470	1050

Figure 11 Kaplan Meier estimates of survival to a first myocardial infarction hospitalisation by social class over 25 years of follow up



Number at risk						
i	469	448	412	375	315	251
ii	1914	1810	1694	1491	1263	990
iiin	2405	2277	2111	1889	1594	1246
iiim	3516	3241	2848	2387	1877	1371
iv	3129	2954	2640	2229	1792	1336
v	1047	965	859	720	576	418

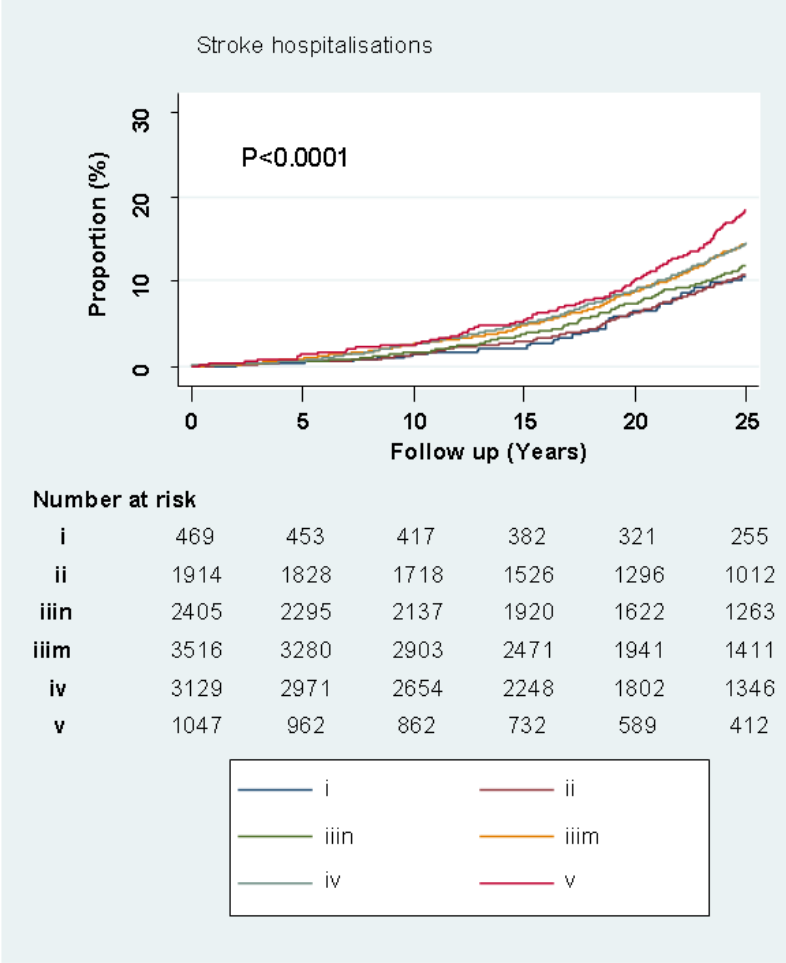
Figure 12 Kaplan Meier estimates of survival to a first stroke hospitalisation by Carstairs Morris index of deprivation over 25 years of follow up



Number at risk

1	860	822	766	685	582	456
3	1764	1680	1530	1355	1135	886
4	2797	2660	2421	2113	1735	1339
5	4578	4306	3927	3415	2803	2107
6 & 7	2796	2617	2315	1934	1498	1058

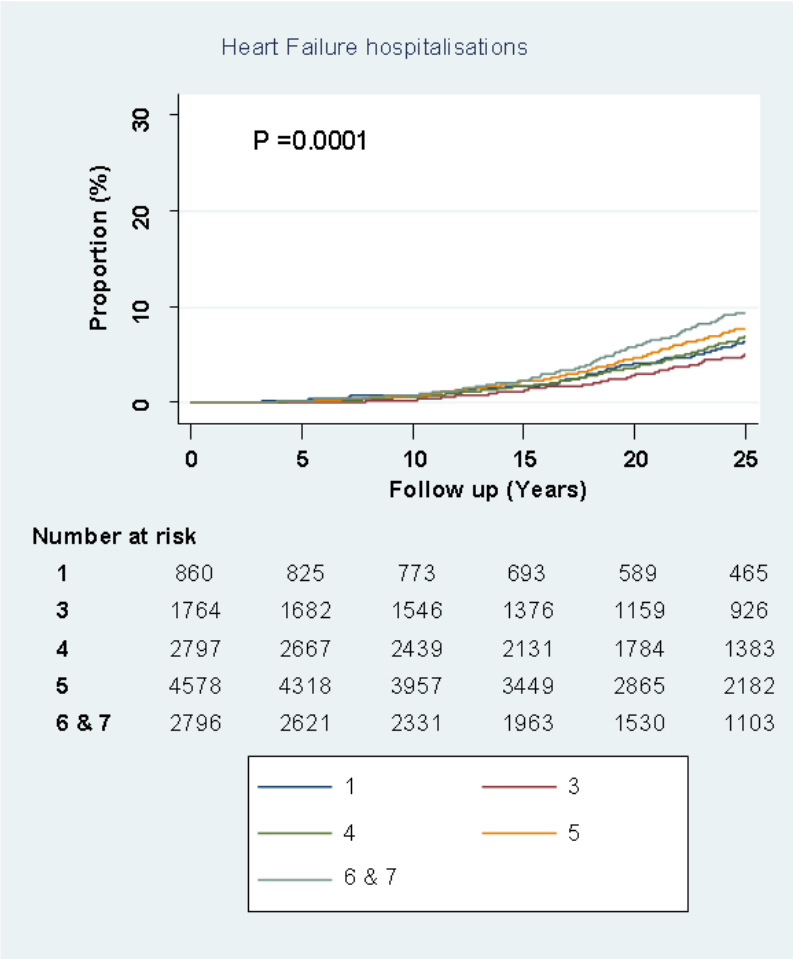
Figure 13 Kaplan Meier estimates of survival to a first stroke hospitalisation by social class over 25 years of follow up



Number at risk

i	469	453	417	382	321	255
ii	1914	1828	1718	1526	1296	1012
iiin	2405	2295	2137	1920	1622	1263
iiim	3516	3280	2903	2471	1941	1411
iv	3129	2971	2654	2248	1802	1346
v	1047	962	862	732	589	412

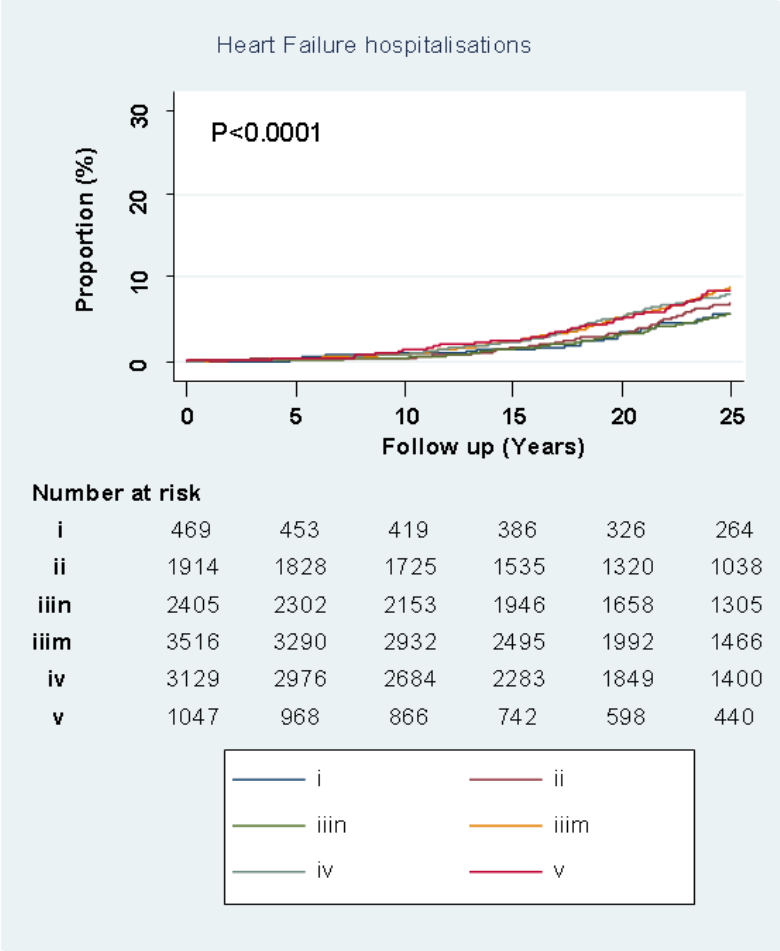
Figure 14 Kaplan Meier estimates of survival to a first heart failure hospitalisation by Carstairs Morris index of deprivation over 25 years of follow up



Number at risk

1	860	825	773	693	589	465
3	1764	1682	1546	1376	1159	926
4	2797	2667	2439	2131	1784	1383
5	4578	4318	3957	3449	2865	2182
6 & 7	2796	2621	2331	1963	1530	1103

Figure 15 Kaplan Meier estimates of survival to a first heart failure hospitalisation by social class over 25 years of follow up



Number at risk

i	469	453	419	386	326	264
ii	1914	1828	1725	1535	1320	1038
iiin	2405	2302	2153	1946	1658	1305
iiim	3516	3290	2932	2495	1992	1466
iv	3129	2976	2684	2283	1849	1400
v	1047	968	866	742	598	440

Adjusted risk of cardiovascular hospitalisation

The higher risk associated with higher deprivation was similar for each type of cardiovascular event, with the exception of HF where there was a weaker association. For example in the most deprived individuals (measured by Carstairs Morris index) the unadjusted risk of a non-fatal cardiovascular hospitalisation over 25 years was 42% higher than the least deprived (hazard ratio HR=1.42, 95% CI 1.24-1.62) (Table 27). Again stroke displayed one of the strongest gradients of association with SED with an approximate doubling of risk in the most versus least deprived. Whilst adjustment for "traditional" cardiovascular risk factors attenuated these associations, the relationship was clearly evident with all outcomes. Further adjustment for body mass index, FEV1 and cardiomegaly attenuated the relationship only slightly. The excess risk associated with higher SED was evident, albeit non-significant, after 5 years follow up, was clearer and significant by 10 years, and persisted over 25 years of follow up. Similar results were observed when social class was used as the measure of SED (Table 28). In analyses of both Carstairs Morris index and social class, by 28 years of follow up (i.e. until the end of follow up), the HR associated with SED started to fall. This most likely represents regression dilution. In subsequent models in this chapter, follow up for 25 years only is therefore presented.

The results of the full models with the HR associated with each variable, in each model, are presented in Appendix 1. Only the results for the hospitalisations of any cardiovascular diseases are presented, however, results for the other outcomes analysed separately were similar.

Table 27 Unadjusted and adjusted risk of non-fatal cardiovascular hospitalisation over 28 years at 5 year intervals by Carstairs Morris index of deprivation

Hazard ratio for deprivation category 6&7 (most deprived) versus 1 (least deprived). CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, HF = heart failure

		Unadjusted				Adjusted ("traditional" risk factors*)				Fully adjusted **			
	Follow up (years)	HR	95% CI		P	HR	95% CI		P	HR	95%CI		P
CVD	5	1.07	0.78	1.48	0.656	1.02	0.74	1.40	0.904	0.97	0.70	1.35	0.855
	10	1.46	1.15	1.85	0.002	1.38	1.09	1.75	0.007	1.34	1.05	1.71	0.019
	15	1.33	1.12	1.59	0.001	1.28	1.07	1.53	0.007	1.22	1.01	1.46	0.035
	20	1.45	1.25	1.69	<0.001	1.41	1.21	1.64	<0.001	1.33	1.14	1.56	<0.001
	25	1.42	1.24	1.62	<0.001	1.39	1.21	1.58	<0.001	1.30	1.14	1.49	<0.001
	28	1.36	1.20	1.54	<0.001	1.34	1.18	1.51	<0.001	1.27	1.11	1.44	<0.001
CHD	5	1.02	0.60	1.72	0.955	1.02	0.60	1.72	0.955	0.97	0.56	1.67	0.905
	10	1.73	1.13	2.65	0.012	1.65	1.08	2.53	0.022	1.62	1.04	2.50	0.032
	15	1.51	1.12	2.05	0.008	1.45	1.07	1.96	0.017	1.45	1.06	1.98	0.021
	20	1.63	1.26	2.10	<0.001	1.57	1.22	2.03	0.001	1.55	1.19	2.02	0.001
	25	1.66	1.32	2.08	<0.001	1.61	1.28	2.02	<0.001	1.57	1.24	1.99	<0.001
	28	1.55	1.25	1.91	<0.001	1.51	1.22	1.86	<0.001	1.46	1.18	1.81	0.001
MI	5	1.10	0.59	2.03	0.767	1.04	0.56	1.92	0.903	1.08	0.57	2.04	0.824
	10	1.81	1.13	2.92	0.014	1.73	1.07	2.78	0.024	1.77	1.08	2.88	0.023
	15	1.46	1.04	2.03	0.028	1.38	0.99	1.93	0.058	1.42	1.00	2.01	0.049
	20	1.45	1.09	1.92	0.011	1.39	1.04	1.84	0.024	1.40	1.04	1.88	0.026
	25	1.53	1.18	1.99	0.001	1.48	1.14	1.92	0.003	1.49	1.14	1.95	0.004
	28	1.48	1.16	1.89	0.002	1.43	1.12	1.83	0.004	1.43	1.11	1.84	0.005
Stroke	5	1.78	0.62	5.15	0.286	1.74	0.60	5.05	0.305	1.55	0.53	4.55	0.424
	10	1.80	0.98	3.33	0.059	1.73	0.94	3.20	0.079	1.56	0.84	2.90	0.16
	15	1.82	1.16	2.83	0.009	1.78	1.14	2.78	0.011	1.53	0.98	2.40	0.063
	20	2.04	1.44	2.89	<0.001	2.04	1.44	2.90	<0.001	1.87	1.31	2.68	0.001
	25	1.75	1.34	2.29	<0.001	1.78	1.36	2.33	<0.001	1.60	1.22	2.11	0.001

	28	1.66	1.31	2.12	<0.001	1.71	1.34	2.17	<0.001	1.56	1.22	2.00	<0.001
HF	5	0.93	0.25	3.44	0.916	0.88	0.24	3.25	0.846	0.88	0.18	4.19	0.87
	10	1.09	0.47	2.54	0.836	1.03	0.44	2.40	0.938	0.78	0.31	1.95	0.6
	15	1.30	0.72	2.34	0.379	1.26	0.70	2.27	0.436	1.05	0.56	1.99	0.869
	20	1.42	0.95	2.13	0.089	1.41	0.94	2.12	0.097	1.11	0.73	1.70	0.628
	25	1.48	1.05	2.07	0.024	1.49	1.06	2.09	0.022	1.22	0.86	1.74	0.258
	28	1.32	0.98	1.78	0.066	1.34	0.99	1.80	0.055	1.10	0.81	1.49	0.555

*age, sex, smoking, cholesterol, diabetes, systolic BP

** age, sex, smoking, cholesterol, diabetes, systolic BP, BMI, adjusted FEV1, cardiomegaly

Table 28 Unadjusted and adjusted risk of non-fatal cardiovascular events over 28 years at 5 year intervals by social class

Hazard ratio for social class V (most deprived) versus I (least deprived). RR= rate ratio with 95% confidence interval, CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, HF = chronic heart failure

		Unadjusted				Adjusted ("traditional" risk factors)*				Fully adjusted*			
	Follow Up (Years)	HR	95% CI		P	HR	95% CI		P	HR	95% CI		P
CVD	5	1.55	0.93	2.58	0.095	1.64	0.98	2.75	0.061	1.68	0.96	2.93	0.07
	10	1.68	1.15	2.44	0.007	1.69	1.16	2.46	0.007	1.63	1.10	2.42	0.015
	15	1.63	1.23	2.17	0.001	1.67	1.26	2.23	<0.0001	1.63	1.21	2.20	0.001
	20	1.44	1.15	1.80	0.001	1.48	1.19	1.86	0.001	1.40	1.11	1.76	0.005
	25	1.40	1.16	1.70	0.001	1.44	1.19	1.75	<0.0001	1.36	1.11	1.66	0.003
	28	1.36	1.14	1.63	0.001	1.40	1.17	1.68	<0.0001	1.31	1.08	1.57	0.005
CHD	5	1.08	0.47	2.47	0.855	1.31	0.57	3.02	0.524	1.65	0.65	4.19	0.295
	10	1.43	0.76	2.67	0.265	1.63	0.87	3.06	0.129	1.77	0.90	3.49	0.099
	15	1.65	1.02	2.69	0.043	1.94	1.19	3.16	0.008	1.99	1.19	3.33	0.008
	20	1.42	0.98	2.06	0.061	1.65	1.13	2.39	0.009	1.60	1.09	2.35	0.017
	25	1.28	0.94	1.75	0.122	1.47	1.07	2.02	0.016	1.42	1.03	1.97	0.035
	28	1.23	0.93	1.63	0.153	1.43	1.07	1.90	0.015	1.37	1.02	1.84	0.035
MI	5	1.22	0.48	3.11	0.682	1.47	0.57	3.78	0.427	1.80	0.65	4.96	0.257
	10	1.31	0.66	2.60	0.443	1.49	0.75	2.99	0.255	1.65	0.80	3.38	0.175
	15	1.52	0.89	2.58	0.121	1.77	1.04	3.01	0.037	1.82	1.05	3.14	0.033
	20	1.40	0.91	2.16	0.124	1.64	1.06	2.53	0.026	1.61	1.03	2.51	0.036
	25	1.20	0.84	1.71	0.323	1.41	0.98	2.02	0.061	1.39	0.96	2.02	0.078
	28	1.22	0.88	1.71	0.23	1.44	1.03	2.01	0.032	1.41	1.00	1.99	0.049
Stroke	5	5.95	0.78	45.48	0.086	4.99	0.65	38.49	0.123				0
	10	1.97	0.81	4.79	0.137	1.39	0.57	3.41	0.471	1.44	0.54	3.81	0.462
	15	2.65	1.30	5.39	0.007	1.99	0.97	4.07	0.059	1.91	0.90	4.07	0.093
	20	1.68	1.08	2.63	0.023	1.41	0.90	2.22	0.134	1.29	0.81	2.06	0.276
	25	1.81	1.26	2.59	0.001	1.57	1.09	2.26	0.015	1.45	0.99	2.11	0.054

	28	1.71	1.23	2.38	0.001	1.50	1.07	2.09	0.017	1.36	0.97	1.92	0.076
HF	5	1.83	0.20	16.38	0.589	1.56	0.17	14.24	0.692	1.08	0.12	10.02	0.946
	10	1.41	0.45	4.37	0.553	1.22	0.39	3.83	0.737	0.74	0.23	2.37	0.612
	15	1.79	0.73	4.42	0.206	1.68	0.67	4.16	0.266	1.09	0.43	2.72	0.858
	20	1.47	0.80	2.69	0.218	1.39	0.75	2.57	0.294	1.06	0.56	2.01	0.853
	25	1.57	0.95	2.61	0.081	1.47	0.88	2.46	0.138	1.22	0.71	2.09	0.476
	28	1.90	1.21	3.00	0.006	1.78	1.12	2.81	0.014	1.43	0.88	2.31	0.146

*age, sex, smoking, cholesterol, diabetes, systolic BP

** age, sex, smoking, cholesterol, diabetes, systolic BP, BMI, adjusted FEV1, cardiomegaly

Accounting for the impact of all cause mortality

A number of composite outcomes incorporating all cause mortality were also examined. As with each individual cardiovascular disease type, the most deprived displayed higher rates of each of the composite outcomes (Tables 29 and 30 and Figures16 and 17). For example, the risk of a non-fatal cardiovascular hospitalisations or all cause mortality was higher in the most deprived vs. the least deprived measured using Carstairs Morris index RR=1.44(95%CI 1.30-1.59). Similarly the higher unadjusted risk associated with SED was observed for each of the composite outcomes (Table 31), for example the unadjusted hazard of death or cardiovascular disease was HR=1.44 (95%CI 1.31-1.59). The association again persisted after adjustment for “traditional” major cardiovascular risk factors and following the addition of further risk factors (Table 31). Again, similar results were seen using social class as the measure of SED (Table 32).

Table 29 Number of events by composite outcome according to Carstairs Morris index of deprivation

		1	3	4	5	6 & 7
Death/CVD	5	25/49	64/93	99/145	191/224	120/170
	10	59/85	155/188	249/289	430/503	292/388
	15	104/152	248/305	429/494	716/848	507/612
	20	160/211	370/450	619/732	999/1295	727/878
	25	232/273	475/594	811/956	1334/1646	928/1060
Death/CHD	5	31/18	75/29	113/32	224/84	148/59
	10	73/25	188/58	303/76	523/195	385/136
	15	135/51	328/111	558/159	921/339	682/233
	20	220/71	490/182	833/256	1375/526	1025/333
	25	330/89	667/239	1156/346	1918/679	1377/408
Death/ MI	5	32/13	75/24	113/28	225/75	151/46
	10	76/20	189/49	306/61	524/174	391/114
	15	193/42	335/84	563/130	932/291	695/186
	20	225/59	506/136	851/200	1404/419	1055/250
	25	336/70	694/174	1190/256	1988/510	1421/304
Death/Stroke	5	34/4	75/6	113/17	233/31	151/23
	10	80/12	193/34	311/44	547/88	397/68
	15	147/23	339/62	566/88	963/180	714/127
	20	236/37	517/101	857/173	1445/308	1059/218
	25	335/64	705/159	1164/261	2001/447	1410/307
Death/ HF	5	32/3	78/1	117/6	240/12	161/9
	10	78/7	206/5	321/16	570/34	425/24
	15	148/14	361/19	594/42	1022/86	757/55
	20	237/29	554/40	901/80	1523/167	1127/118
	25	348/42	760/64	1246/135	2121/251	1503/169
Death/ MI / Stroke	5	31/13/4	72/24/6	107/27/17	211/75/27	137/45/20

	10	71/19/12	174/49/33	287/60/43	486/172/76	348/112/64
	15	127/41/23	302/84/58	508/128/85	834/288/155	616/181/121
	20	205/57/37	447/135/93	752/195/161	1234/409/265	916/240/202
	25	297/66/60	599/170/142	1020/245/244	1712/495/388	1209/290/281
Death/ CHD / Stroke	5	30/18/4	72/29/6	107/30/17	21/84/27	137/58/20
	10	69/24/11	173/58/33	285/74/43	485/193/76	342/135/63
	15	124/50/22	295/111/58	504/156/83	824/336/153	64/227/120
	20	201/69/36	432/179/91	736/249/158	1209/512/260	890/321/197
	25	292/85/59	575/233/139	991/333/235	1657/659/373	1172/392/271
Death/ MI / Stroke/ HF	5	28/9/4/2	72/17/6/1	107/22/16/6	205/45/28/12	133/40/20/8
	10	67/14/11/6	172/97/33/5	282/46/41/15	468/119/89/32	336/87/64/23
	15	118/33/22/12	289/63/59/18	488/96/80/41	798/206/159/80	587/134/120/53
	20	190/46/35/27	426/98/93/36	714/146/154/76	1153/297/275/158	856/177/204/112
	25	273/54/61/40	564/127/148/60	961/187/236/126	1589/372/396/237	1118/213/286/160
Death/ CHD / Stroke/ HF	5	27/13/4/2	72/22/1/6	107/24/16/6	204/51/28/12	130/51/20/8
	10	65/18/11/6	171/45/33/5	281/55/41/15	467/136/83/32	330/106/64/23
	15	115/41/22/12	282/85/59/18	485/115/80/41	790/242/159/80	575/174/120/53
	20	186/55/35/27	413/136/94/35	702/186/154/76	1135/377/275/158	834/244/204/112
	25	269/69/61/40	543/183/149/59	941/251/236/126	1553/496/396/237	1087/299/286/160

Table 30 Number of events by composite outcome according to social class

		I	II	III N	III M	IV	V
Death/CVD	5	12/19	61/100	77/129	158/206	117/153	57/64
	10	35/35	125/196	169/264	391/444	298/367	126/124
	15	60/62	227/340	285/422	638/740	529/597	197/206
	20	93/105	346/515	406/646	903/1066	761/871	273/297
	25	119/143	476/680	593/837	1155/1311	984/1082	347/380
Death/CHD	5	15/8	72/30	94/38	190/83	137/43	64/19
	10	42/13	153/62	213/84	490/175	376/112	151/40
	15	72/21	298/128	378/147	830/311	703/206	258/72
	20	12/38	472/194	590/245	1221/450	1046/315	375/108
	25	164/55	693/266	878/320	1636/553	1426/405	504/136
Death/ MI	5	15/6	73/24	95/29	192/75	137/35	65/16
	10	43/11	154/51	215/70	493/157	381/94	154/31
	15	73/18	303/103	386/117	841/265	712/168	267/57
	20	123/28	484/150	608/189	1247/366	1072/244	385/79
	25	172/43	720/186	909/235	1686/432	1469/302	520/101
Death/Stroke	5	15/1	70/9	93/13	199/29	139/16	71/13
	10	43/6	158/23	224/35	513/83	389/72	157/25
	15	75/9	320/51	391/81	879/142	727/134	260/49
	20	120/25	501/100	619/150	1311/237	1084/221	368/83
	25	173/38	727/157	906/221	1732/345	1439/321	497/130
Death/ HF	5	15/1	75/4	97/2	206/12	142/8	74/4
	10	43/4	167/7	234/9	540/26	406/25	166/12
	15	74/6	337/25	417/29	925/71	768/58	277/22
	20	126/14	524/53	671/62	1361/135	1134/124	402/40
	25	182/20	761/97	985/100	1821/200	1533/173	540/59
Death/ MI / Stroke	5	14/0/6	66/24/9	89/29/12	179/75/25	130/34/15	61/15/13

	10	40/11/4	140/51/23	201/34/68	448/156/76	351/92/66	142/30/23
	15	68/18/7	270/103/50	350/114/72	753/263/131	636/164/122	235/55/46
	20	107/28/20	430/146/94	529/183/130	1106/362/217	944/233/200	332/76/77
	25	148/42/33	623/179/145	777/225/197	1464/421/310	1256/288/286	438/96/119
Death/ CHD / Stroke	5	14/8/0	65/30/9	88/38/12	177/82/25	130/42/15	60/18/13
	10	40/13/3	139/62/23	199/173/76	446/173/76	346/110/66	139/39/23
	15	68/21/6	265/128/50	342/145/71	744/307/130	627/201/121	230/70/44
	20	106/38/19	420/190/92	512/240/126	1084/439/213	920/302/198	323/104/75
	25	143/54/30	599/259/140	748/311/192	1427/535/299	1218/389/279	425/129/114
Death/ MI / Stroke/ HF	5	13/5/0/1	64/18/9/4	87/21/12/2	175/50/26/10	127/24/14/8	60/14/13/4
	10	38/9/3/4	136/41/23/7	197/48/33/9	435/114/79/23	337/65/69/25	140/23/23/11
	15	65/13/6/6	257/74/50/25	339/86/73/26	718/195/133/66	603/117/119/56	225/45/45/21
	20	100/22/19/14	403/109/92/52	504/140/133/57	1036/265/222/123	877/164/197/119	315/60/77/39
	25	138/33/32/20	576/139/144/93	733/174/195/94	1365/314/322/184	1162/208/289/165	405/76/119/5613
Death/ CHD / Stroke/ HF	5	13/6/0/1	63/23/9/4	86/27/12/2	173/57/26/10	127/30/14/8	59/17/13/4
	10	38/10/3/4	135/50/23/7	195/59/33/9	433/128/79/23	333/79/69/25	137/31/23/11
	15	65/14/6/6	252/94/50/25	331/111/73/26	711/231/133/66	595/147/119/56	220/56/45/21
	20	100/28/19/14	394/144/93/51	488/188/133/57	1020/327/222/123	860/216/197/119	307/84/77/39
	25	136/40/32/20	557/201/145/92	709/247/195/94	1341/401/322/184	1134/288/289/165	394/104/119/56

Figure 16 Rate of composite cardiovascular events during 25 years of follow up by socioeconomic deprivation measured by Carstairs Morris index deprivation category

Category 1 = least deprived, categories 6&7 = most deprived. RR = rate ratio with 95% confidence interval, CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, Stroke = stroke, HF = chronic heart failure.

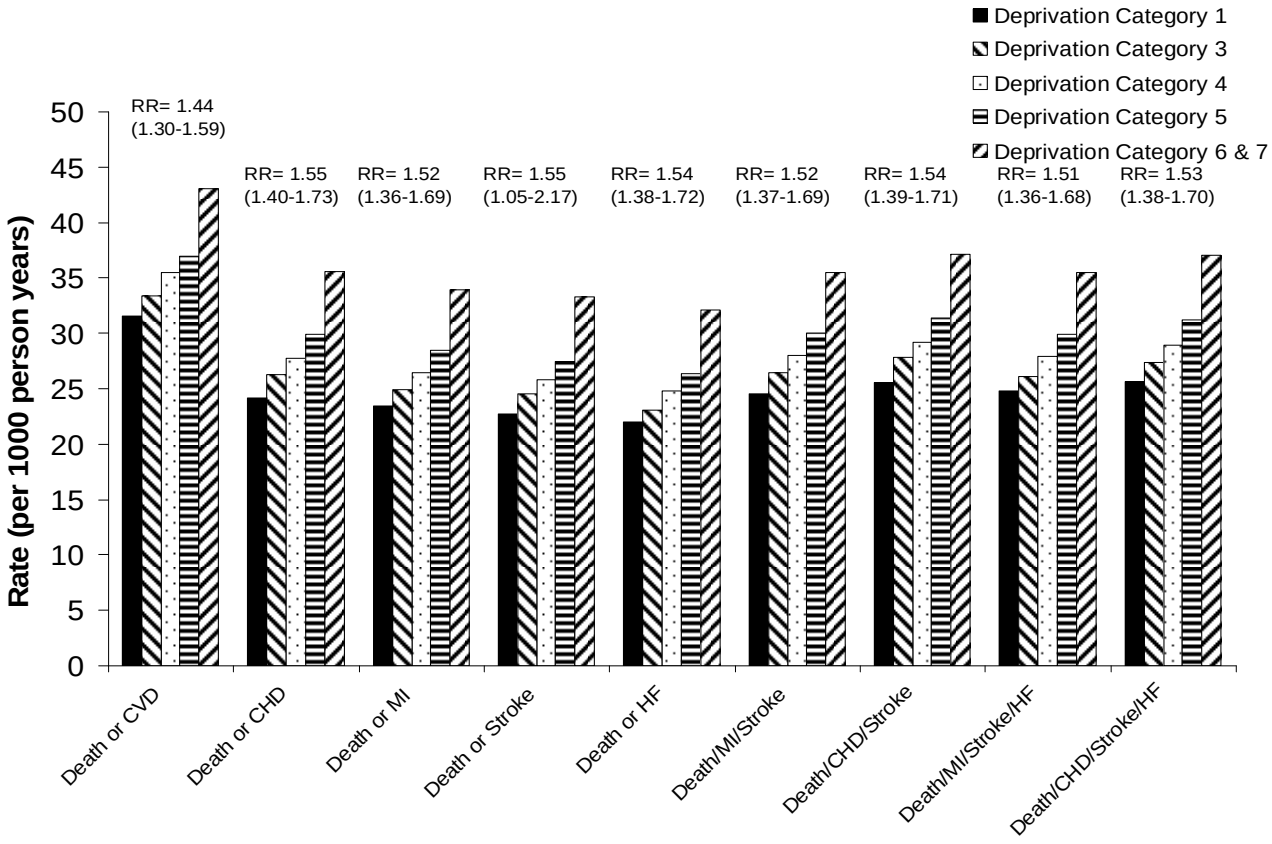


Figure 17 Rate of composite events during 25 years of follow up by social class

Class I=least deprived, Class V=most deprived, RR = rate ratio with 95% confidence interval, CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, Stroke = stroke, HF = chronic heart failure.

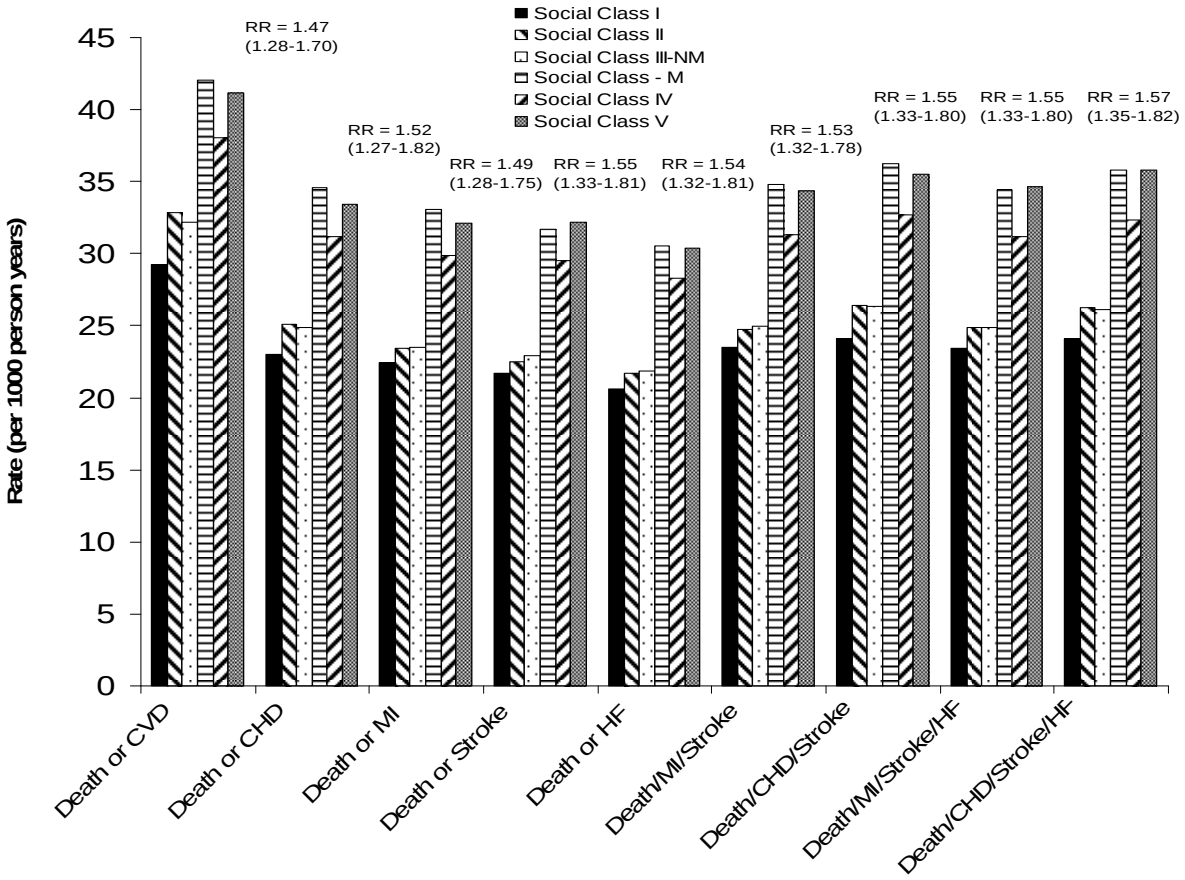


Table 31 Unadjusted and adjusted risk of composite endpoints with death

Hazard ratio for deprivation category 6&7 (most deprived) versus 1 (least deprived). CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, Stroke = stroke, HF = chronic heart failure.

		Unadjusted				Adjusted ("traditional" risk factors*)				Fully adjusted **			
	Years	HR	95% CI		P	HR	95% CI		P	HR	95%CI		P
Death or CVD	5	1.21	0.94	1.57	0.136	1.16	0.90	1.50	0.254	1.08	0.83	1.40	0.58
	10	1.51	1.26	1.81	<0.001	1.45	1.21	1.73	<0.001	1.34	1.12	1.62	0.002
	15	1.45	1.27	1.66	<0.001	1.40	1.22	1.60	<0.001	1.30	1.13	1.49	<0.001
	20	1.51	1.35	1.69	<0.001	1.47	1.31	1.65	<0.001	1.37	1.22	1.54	<0.001
	25	1.44	1.31	1.59	<0.001	1.42	1.28	1.56	<0.001	1.31	1.19	1.45	<0.001
Death or CHD	5	1.31	0.96	1.79	0.089	1.25	0.92	1.71	0.155	1.17	0.85	1.61	0.342
	10	1.70	1.37	2.10	<0.001	1.64	1.32	2.03	<0.001	1.49	1.19	1.85	<0.001
	15	1.63	1.39	1.90	<0.001	1.58	1.35	1.85	<0.001	1.45	1.24	1.71	<0.001
	20	1.62	1.43	1.84	<0.001	1.59	1.40	1.81	<0.001	1.47	1.29	1.67	<0.001
	25	1.55	1.40	1.73	<0.001	1.54	1.38	1.71	<0.001	1.41	1.27	1.58	<0.001
Death or MI	5	1.36	0.98	1.88	0.064	1.30	0.94	1.80	0.111	1.22	0.87	1.70	0.246
	10	1.66	1.34	2.06	<0.001	1.61	1.29	2.00	<0.001	1.47	1.17	1.83	0.001
	15	1.59	1.35	1.86	<0.001	1.54	1.32	1.81	<0.001	1.42	1.20	1.67	<0.001
	20	1.57	1.38	1.78	<0.001	1.54	1.35	1.75	<0.001	1.42	1.24	1.62	<0.001
	25	1.52	1.36	1.69	<0.001	1.51	1.36	1.68	<0.001	1.39	1.24	1.55	<0.001
Death or Stroke	5	1.42	1.00	2.02	0.05	1.36	0.96	1.94	0.083	1.24	0.87	1.78	0.235
	10	1.61	1.28	2.01	<0.001	1.56	1.25	1.95	<0.001	1.39	1.11	1.75	0.005
	15	1.62	1.37	1.91	<0.001	1.58	1.34	1.87	<0.001	1.42	1.20	1.68	<0.001
	20	1.60	1.40	1.82	<0.001	1.59	1.39	1.81	<0.001	1.45	1.27	1.66	<0.001
	25	1.54	1.38	1.72	<0.001	1.55	1.39	1.73	<0.001	1.41	1.26	1.58	<0.001
Death or HF	5	1.51	1.05	2.17	0.027	1.45	1.00	2.08	0.047	1.30	0.90	1.89	0.166
	10	1.68	1.33	2.12	<0.001	1.63	1.29	2.05	<0.001	1.45	1.14	1.84	0.002
	15	1.64	1.39	1.94	<0.001	1.61	1.36	1.90	<0.001	1.44	1.21	1.71	<0.001
	20	1.60	1.40	1.82	<0.001	1.58	1.39	1.81	<0.001	1.43	1.24	1.63	<0.001
	25	1.53	1.37	1.71	<0.001	1.54	1.38	1.72	<0.001	1.39	1.24	1.56	<0.001
Death/MI/Stroke	5	1.31	0.95	1.79	0.097	1.25	0.91	1.72	0.162	1.18	0.85	1.63	0.317

	10	1.64	1.33	2.03	<0.001	1.59	1.28	1.96	<0.001	1.45	1.17	1.80	<0.001
	15	1.59	1.36	1.85	<0.001	1.54	1.32	1.81	<0.001	1.42	1.21	1.67	<0.001
	20	1.57	1.38	1.78	<0.001	1.54	1.36	1.75	<0.001	1.43	1.26	1.63	<0.001
	25	1.52	1.37	1.69	<0.001	1.52	1.36	1.69	<0.001	1.40	1.25	1.56	<0.001
Death/CHD/Stroke	5	1.26	0.93	1.71	0.131	1.21	0.89	1.64	0.216	1.13	0.83	1.55	0.425
	10	1.66	1.35	2.05	<0.001	1.60	1.30	1.97	<0.001	1.45	1.17	1.80	0.001
	15	1.61	1.38	1.88	<0.001	1.56	1.34	1.83	<0.001	1.44	1.23	1.68	<0.001
	20	1.60	1.42	1.82	<0.001	1.58	1.39	1.78	<0.001	1.46	1.29	1.66	<0.001
	25	1.54	1.39	1.71	<0.001	1.53	1.38	1.70	<0.001	1.41	1.27	1.57	<0.001
Death/MI/Stroke/HF	5	1.45	1.05	2.02	0.026	1.40	1.00	1.94	0.047	1.29	0.92	1.80	0.137
	10	1.66	1.34	2.07	<0.001	1.61	1.30	2.00	<0.001	1.45	1.17	1.81	0.001
	15	1.60	1.36	1.87	<0.001	1.56	1.33	1.82	<0.001	1.42	1.21	1.67	<0.001
	20	1.56	1.38	1.77	<0.001	1.54	1.36	1.75	<0.001	1.42	1.25	1.62	<0.001
	25	1.51	1.36	1.67	<0.001	1.50	1.35	1.67	<0.001	1.38	1.24	1.54	<0.001
Death/CHD/Stroke/HF	5	1.41	1.03	1.94	0.034	1.36	0.98	1.87	0.062	1.25	0.90	1.73	0.181
	10	1.67	1.35	2.07	<0.001	1.61	1.30	2.00	<0.001	1.45	1.17	1.81	0.001
	15	1.61	1.38	1.88	<0.001	1.57	1.34	1.83	<0.001	1.43	1.22	1.68	<0.001
	20	1.60	1.42	1.82	<0.001	1.58	1.39	1.79	<0.001	1.46	1.28	1.66	<0.001
	25	1.53	1.38	1.70	<0.001	1.53	1.38	1.69	<0.001	1.40	1.26	1.56	<0.001

*age, sex, smoking, cholesterol, diabetes, systolic BP

** age, sex, smoking, cholesterol, diabetes, systolic BP, BMI, adjusted FEV1, cardiomegaly

Table 32. **Unadjusted and adjusted risk of composite endpoints with death at 5 year intervals**

Hazard ratio for social class V (most deprived) versus I (least deprived). (CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction, Stroke = stroke, HF = chronic heart failure)

		Unadjusted				Adjusted ("traditional" risk factors)*				Fully adjusted**			
	Years	HR	95% CI		P	HR	95% CI		P	HR	95% CI		P
Death or CVD	5	1.79	1.21	2.66	0.004	1.75	1.18	2.61	0.006	1.66	1.10	2.53	0.017
	10	1.69	1.30	2.21	<0.0001	1.64	1.26	2.14	<0.0001	1.52	1.15	2.00	0.003
	15	1.62	1.33	1.99	<0.0001	1.61	1.31	1.98	<0.0001	1.47	1.19	1.81	<0.0001
	20	1.47	1.25	1.73	<0.0001	1.47	1.25	1.73	<0.0001	1.33	1.13	1.57	0.001
	25	1.47	1.28	1.69	<0.0001	1.46	1.27	1.68	<0.0001	1.33	1.15	1.54	<0.0001
Death or CHD	5	1.64	1.04	2.61	0.035	1.56	0.98	2.48	0.061	1.55	0.95	2.54	0.082
	10	1.61	1.20	2.18	0.002	1.54	1.14	2.08	0.005	1.44	1.05	1.96	0.024
	15	1.71	1.36	2.15	<0.0001	1.68	1.34	2.12	<0.0001	1.50	1.18	1.90	0.001
	20	1.52	1.27	1.82	<0.0001	1.51	1.26	1.81	<0.0001	1.37	1.13	1.65	0.001
	25	1.52	1.31	1.78	<0.0001	1.50	1.28	1.75	<0.0001	1.34	1.14	1.57	<0.0001
Death or MI	5	1.76	1.09	2.85	0.021	1.66	1.02	2.69	0.041	1.61	0.97	2.66	0.066
	10	1.59	1.18	2.16	0.003	1.51	1.12	2.06	0.008	1.41	1.03	1.93	0.033
	15	1.70	1.34	2.14	<0.0001	1.66	1.31	2.10	<0.0001	1.46	1.15	1.86	0.002
	20	1.53	1.28	1.84	<0.0001	1.52	1.26	1.83	<0.0001	1.36	1.13	1.65	0.001
	25	1.49	1.28	1.75	<0.0001	1.47	1.25	1.71	<0.0001	1.31	1.12	1.54	0.001
Death or Stroke	5	2.41	1.41	4.11	0.001	2.11	1.23	3.62	0.006	1.89	1.08	3.29	0.025
	10	1.75	1.28	2.40	0.001	1.56	1.13	2.14	0.006	1.38	1.00	1.91	0.052
	15	1.78	1.40	2.27	<0.0001	1.65	1.29	2.10	<0.0001	1.42	1.11	1.82	0.005
	20	1.56	1.30	1.88	<0.0001	1.49	1.24	1.80	<0.0001	1.33	1.09	1.61	0.004
	25	1.55	1.33	1.81	<0.0001	1.47	1.26	1.72	<0.0001	1.32	1.12	1.55	0.001
Death or HF	5	2.23	1.30	3.82	0.004	1.93	1.12	3.32	0.017	1.74	0.99	3.04	0.052
	10	1.77	1.29	2.45	<0.0001	1.61	1.16	2.22	0.004	1.42	1.02	1.98	0.037
	15	1.80	1.41	2.31	<0.0001	1.69	1.32	2.17	<0.0001	1.45	1.13	1.87	0.004
	20	1.58	1.31	1.92	<0.0001	1.52	1.25	1.84	<0.0001	1.34	1.10	1.63	0.004
	25	1.54	1.32	1.81	<0.0001	1.47	1.25	1.72	<0.0001	1.31	1.11	1.55	0.001
Death/MI/Stroke	5	2.04	1.26	3.32	0.004	1.93	1.19	3.15	0.008	1.77	1.07	2.92	0.026

	10	1.66	1.23	2.24	0.001	1.56	1.15	2.11	0.004	1.41	1.04	1.92	0.028
	15	1.75	1.39	2.20	<0.0001	1.69	1.34	2.13	<0.0001	1.47	1.16	1.86	0.001
	20	1.57	1.31	1.88	<0.0001	1.56	1.30	1.87	<0.0001	1.39	1.15	1.67	0.001
	25	1.53	1.31	1.78	<0.0001	1.51	1.29	1.76	<0.0001	1.35	1.15	1.58	<0.0001
Death/CHD/Stroke	5	1.89	1.19	3.01	0.007	1.81	1.13	2.89	0.013	1.70	1.04	2.78	0.034
	10	1.68	1.25	2.26	0.001	1.59	1.18	2.14	0.002	1.44	1.06	1.96	0.02
	15	1.75	1.40	2.20	<0.0001	1.72	1.36	2.16	<0.0001	1.50	1.19	1.90	0.001
	20	1.55	1.30	1.85	<0.0001	1.54	1.29	1.85	<0.0001	1.38	1.15	1.66	0.001
	25	1.54	1.33	1.80	<0.0001	1.53	1.31	1.78	<0.0001	1.36	1.17	1.59	<0.0001
Death/MI/Stroke/HF	5	2.20	1.34	3.61	0.002	2.04	1.24	3.36	0.005	1.86	1.12	3.11	0.017
	10	1.71	1.27	2.31	<0.0001	1.59	1.17	2.15	0.003	1.43	1.05	1.95	0.024
	15	1.81	1.44	2.29	<0.0001	1.75	1.38	2.21	<0.0001	1.50	1.18	1.91	0.001
	20	1.60	1.34	1.92	<0.0001	1.58	1.32	1.90	<0.0001	1.40	1.16	1.68	<0.0001
	25	1.55	1.33	1.80	<0.0001	1.53	1.31	1.78	<0.0001	1.37	1.17	1.60	<0.0001
Death/CHD/Stroke/HF	5	2.13	1.32	3.46	0.002	2.00	1.23	3.26	0.005	1.91	1.14	3.18	0.013
	10	1.72	1.28	2.32	<0.0001	1.61	1.19	2.18	0.002	1.46	1.07	1.99	0.016
	15	1.83	1.45	2.30	<0.0001	1.78	1.41	2.25	<0.0001	1.55	1.22	1.97	<0.0001
	20	1.60	1.34	1.91	<0.0001	1.59	1.33	1.90	<0.0001	1.42	1.18	1.71	<0.0001
	25	1.57	1.35	1.82	<0.0001	1.56	1.34	1.81	<0.0001	1.39	1.19	1.62	<0.0001

*age, sex, smoking, cholesterol, diabetes, systolic BP

** age, sex, smoking, cholesterol, diabetes, systolic BP, BMI, adjusted FEV1, cardiomegaly

In a competing risk multivariable regression (Table 33), the most deprived (measured using Carstairs Morris index) displayed a higher risk of a cardiovascular hospitalisation than the least deprived (HR=1.47 95%CI 1.27-1.69), whilst also exhibiting a higher risk of all cause mortality (HR=1.41, 95%CI 1.24-1.61) before adjustment for the "traditional" risk factors. This association persisted after adjustment so that the most deprived were at higher risk of cardiovascular events than the least deprived (HR=1.45 95%CI 1.26-1.68) whilst still displaying a higher risk of all cause mortality (HR= 1.39 95%CI 1.24-1.58). Again, similar results were observed when social class was used to determine SED (Table 34)

Comparison of the association of SED with different cardiovascular events

Although the relationship between SED and various cardiovascular outcomes were broadly similar it appeared that the relationship with stroke was strongest. This was formally tested in a competing events analysis between all coronary heart disease and stroke, and, myocardial infarction and stroke (Tables 33 and 34). The unadjusted risk of coronary heart disease was higher in the most versus least deprived HR=1.67 (95%CI 1.33-2.12) whilst the risk of stroke was also higher HR=1.72 (95%CI 1.29-2.28). When these hazards were formally tested no statistically significant difference was found indicating the risk associated with socioeconomic deprivation and coronary heart disease is not statistically different from that with stroke. The relationship did not change after adjustment. The risk associated with SED was also not different when myocardial infarction was compared with stroke. Whilst the association with HF was the weakest this could not be tested due to a lack of statistical power.

This comparison is displayed graphically in the cumulative incidence curves for death and cardiovascular disease (Figures 18 and 19), coronary heart disease and stroke (Figures 20 and 21) and myocardial infarction and stroke (Figures 22 and 23). As can be seen from the plots the relationship between SED and each outcome is similar as tested by the competing risks analysis.

Table 33. **Unadjusted and adjusted risk of non-fatal cardiovascular events as composite endpoints and in a competing risk model by Carstairs Morris index**

Hazard ratio for deprivation category 6&7 (most deprived) versus 1 (least deprived). CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction.

	N Category 6&7	Events Category 6&7	Unadjusted	95% CI		Adjusted ("traditional" risk factors*)	95% CI		Fully adjusted **	95% CI	
Death or CVD Competing risk (Death and CVD)	2796	1060 deaths, 928 CVD	1.47	1.28	1.69	1.46	1.27	1.68	1.33	1.15	1.54
Death	2796	1060	1.41	1.24	1.61	1.39	1.24	1.58	1.30	1.13	1.49
CVD	2796	928	1.47	1.27	1.69	1.45	1.26	1.68	1.32	1.14	1.53
CHD or Stroke Competing risk (CHD or Stroke)	2796	392 CHD, 271 Stroke	1.69	1.41	2.02	1.67	1.21	1.71	1.60	1.33	1.92
CHD	2796	392	1.67	1.33	2.12	1.62	1.28	2.05	1.60	1.26	2.04
Stroke	2796	271	1.72	1.29	2.28	1.74	1.31	2.30	1.58	1.19	2.11
MI or Stroke Competing risk (MI or Stroke)	2796	290 MI, 281 Stroke	1.64	1.35	1.99	1.62	1.33	1.96	1.56	1.28	1.9
MI	2796	290	1.56	1.19	2.03	1.50	1.15	1.96	1.52	1.15	2.00
Stroke	2796	281	1.73	1.31	2.29	1.75	1.33	2.32	1.60	1.20	2.13

*age, sex, smoking, cholesterol, diabetes, systolic BP

** age, sex, smoking, cholesterol, diabetes, systolic BP, BMI, adjusted FEV1, cardiomegaly

Table 34 Unadjusted and adjusted risk of non-fatal cardiovascular events as composite endpoints and in a competing risk model by social class

Hazard ratio for social class V (most deprived) versus social class I (least deprived). CVD = all cardiovascular disease, CHD = coronary heart disease, MI = acute myocardial infarction

	N Social Class V	Events Social Class V	Unadjusted	95% CI		Adjusted ("traditional" risk factors*)	95% CI		Fully adjusted **	95% CI	
Death or CVD	1301	347 deaths, 380 CVD	1.40	1.16	1.70	1.58	1.23	2.02	1.48	1.15	1.92
Competing risk (Death and CVD)											
Death	1301	347	1.40	1.16	1.70	1.44	1.19	1.75	1.35	1.11	1.66
CVD	1301	380	1.55	1.26	1.91	1.47	1.20	1.82	1.30	1.05	1.60
CHD or Stroke	1301	176 CHD, 137 Stroke	1.52	1.19	1.95	1.58	1.23	2.02	1.39	1.00	1.93
Competing risk (CHD or Stroke)											
CHD	1301	176	1.24	0.91	1.71	1.45	1.05	1.99	1.60	1.26	2.04
Stroke	1301	137	2.03	1.35	3.03	1.75	1.17	2.63	1.59	1.05	2.41
MI or Stroke	1301	131 MI, 144 Stroke	1.50	1.15	1.95	1.54	1.78	2.00	1.45	1.11	1.91
Competing risk (MI or Stroke)											
MI	1301	131	1.17	0.82	1.68	1.39	0.97	2.00	1.37	0.94	2.00
Stroke	1301	144	1.92	1.30	2.81	1.66	1.13	2.46	1.50	1.01	2.24

*age, sex, smoking, cholesterol, diabetes, systolic BP

** age, sex, smoking, cholesterol, diabetes, systolic BP, BMI, adjusted FEV1, cardiomegaly

Figure 18 Cumulative incidence curve for death and all cardiovascular disease according to Carstairs Morris index of deprivation

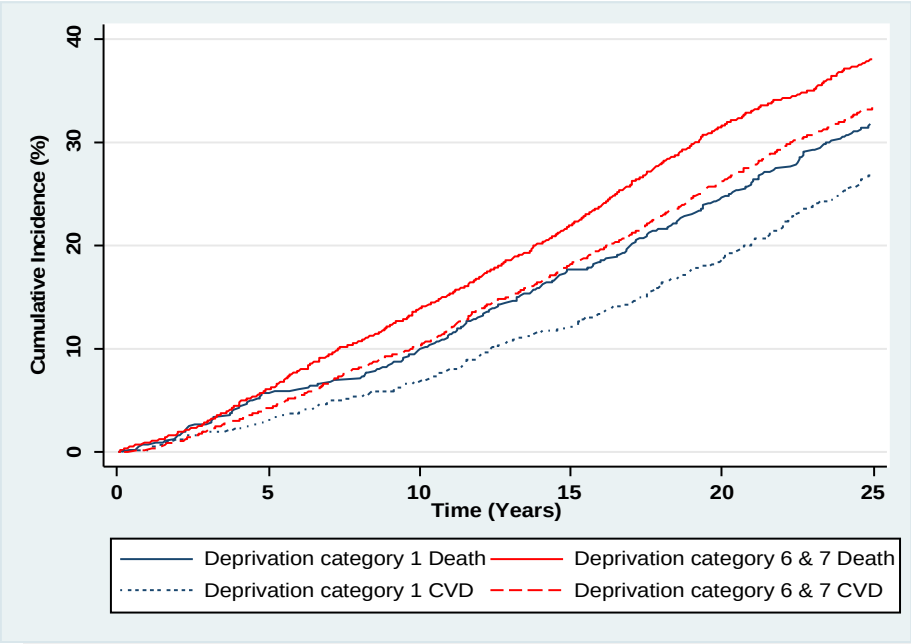


Figure 19 Cumulative incidence curve for death and all cardiovascular disease according to social class

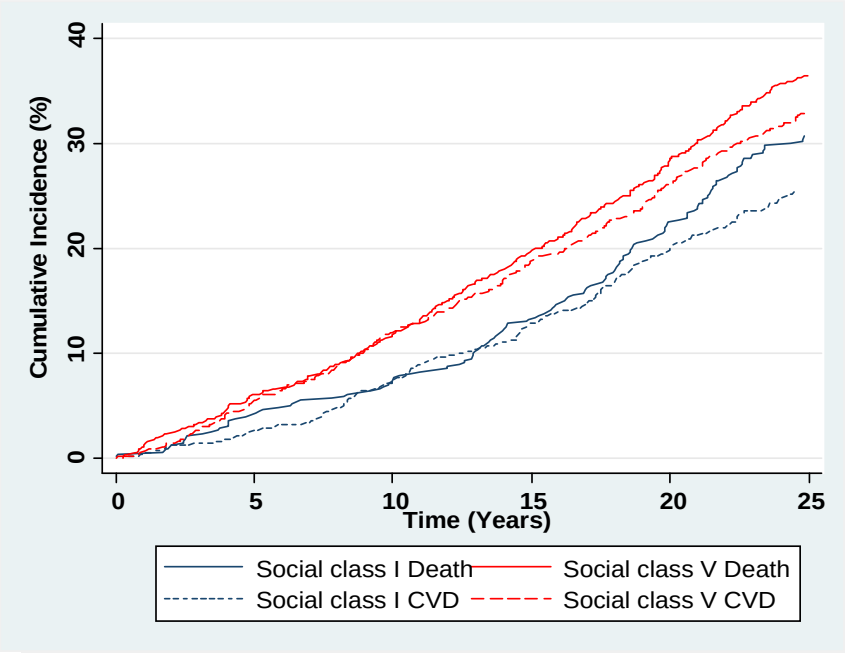


Figure 20 Cumulative incidence curve for coronary heart disease and stroke according to Carstairs Morris index of deprivation

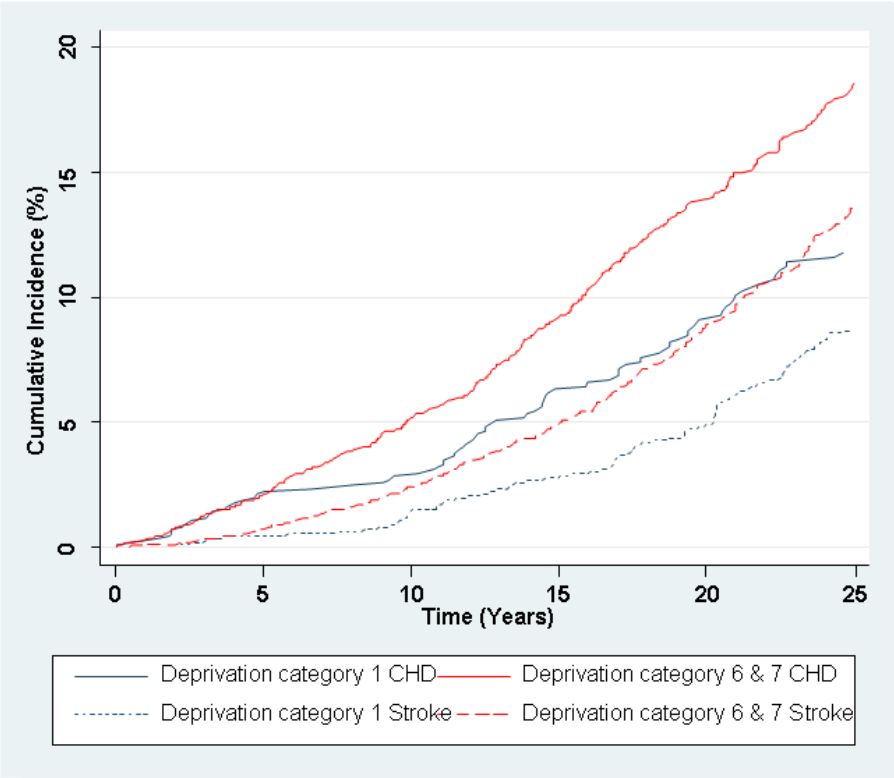


Figure 21 Cumulative incidence curve for coronary heart disease and stroke according to social class

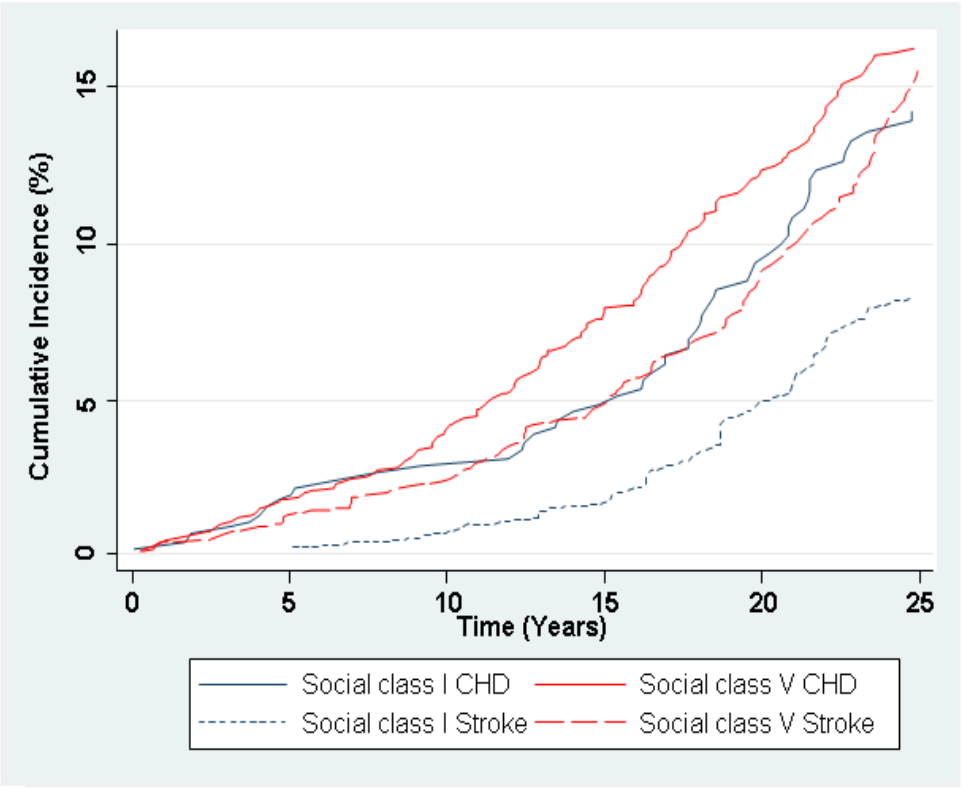


Figure 22 Cumulative incidence curve for myocardial infarction and stroke according Carstairs Morris index of deprivation

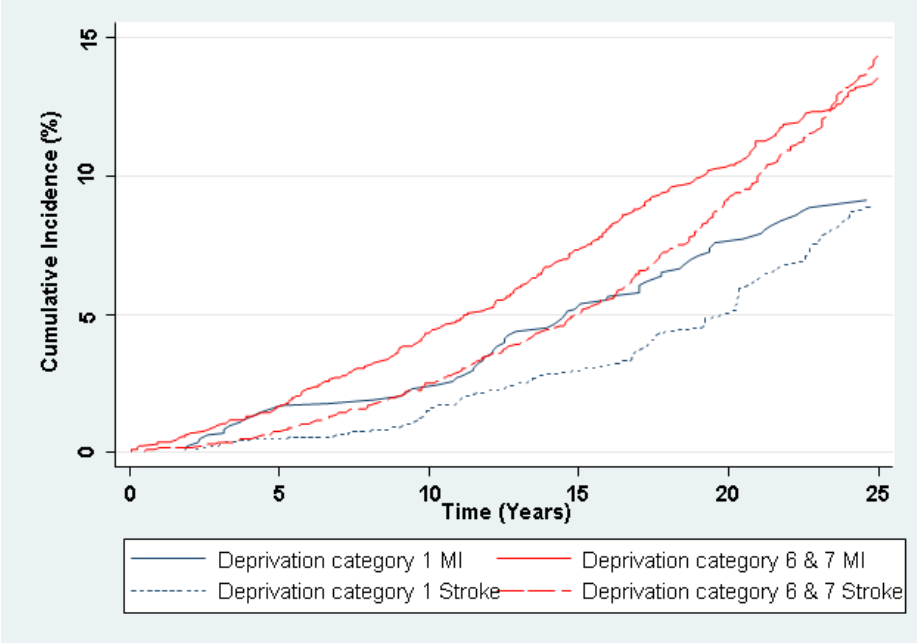
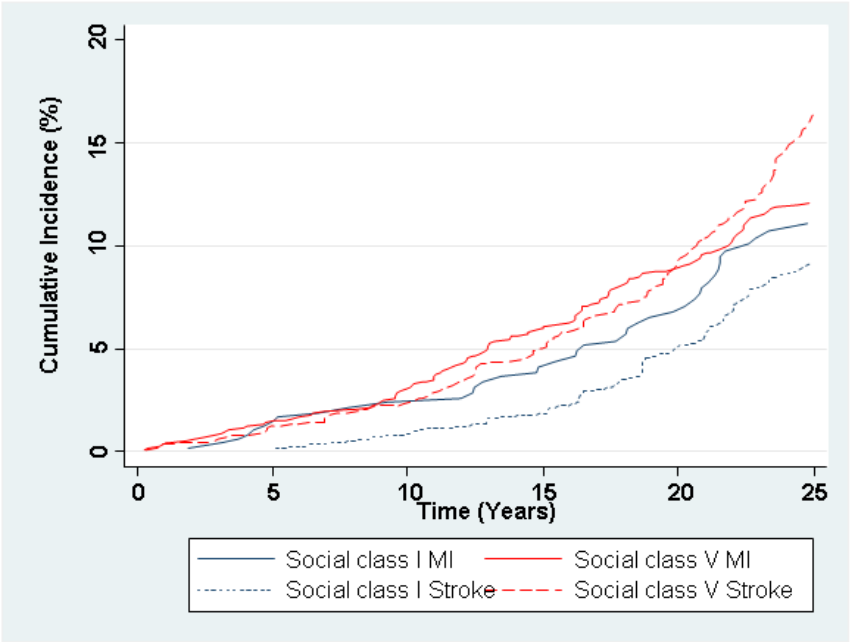


Figure 23 Cumulative incidence curve for myocardial infarction and stroke according to social class



Discussion

In this large prospective cohort study of men and women in the West of Scotland the risk of cardiovascular hospitalisation was higher in the most deprived. This association was persisted following adjustment for a number of "traditional" risk factors and importantly, the risk of a number of different forms of cardiovascular disease was higher in the most deprived. This risk was present despite the most deprived also being at a higher risk of all cause mortality. Finally, SED conferred a higher risk of a cardiovascular hospitalisation over a long period, 28 years.

Comparison of cardiovascular outcomes

Previous studies have examined cardiovascular outcomes in isolation [61,105,125] or composite cardiovascular outcomes[56,59]. Socioeconomic deprivation is associated with a higher risk of myocardial infarction[61], coronary heart disease[59], stroke[99,105] and heart failure[125]. However, this is the first study to compare the risk associated with SED on a number of cardiovascular outcomes in one single population. There was no statistical difference in the risk associated with SED and the cardiovascular outcome studied. This may suggest that the mechanism by which SED confers its higher risk (and there is debate as to how this occurs[38,169]) is via a mechanism that may be shared by each disease type. The finding would also suggest that any interventions aimed at improving the socioeconomic conditions of an individual may have the opportunity to reduce the risk of a number of cardiovascular diseases rather than one in particular.

Adjustment for "traditional" cardiovascular risk factors

In these analyses the risk associated with SED persisted after adjusting for "traditional" cardiovascular risk factors [140] of age, sex, smoking status, cholesterol, diabetes and systolic blood pressure. The relationship was evident after adjusting for further risk factors such as body mass index, FEV1 and cardiomegaly on a chest x-ray. Obviously this would suggest that I was unable to adjust for the factors that confer the excess risk, but as noted previously, it is unclear what these causal pathways are.[38,169] In a large study of 22,688 participants in the Women' health study, adjustment for a number of novel risk factors indicative of inflammation (C-reactive protein, intracellular adhesion molecule-1, fibrinogen and homocysteine), on top of the "traditional" risk factors of smoking, cholesterol, diabetes etc., did not completely attenuate the risk of CVD related to level of

education.[71] This finding in conjunction with that of mine and other authors[38,40,142,226] would suggest that the risk associated with SED is not completely mediated via traditional or even novel risk factors.

Prolonged excess risk

In the present study, the risk associated with low SED was evident after 5 years of follow up and persisted as individuals were followed through 28 years. Whilst others have reported such long lasting effects of SED on ischaemic heart disease mortality[40] few have examined the relationship with non-fatal cardiovascular outcomes over such long follow up[123]. The present analyses demonstrate that the excess risk is higher for a number of different types of cardiovascular disease and that the risk persists over a long period of time. However, there was evidence of regression dilution bias in the results at 28 years of follow up[225]. The cohort was not re-screened during follow up, and, therefore, I was not able to examine the effect of changing risk factor profiles on outcomes. Instead of using a correction technique for regression dilution I truncated follow up at 25 years to limit the observed impact of this bias. It is therefore possible that the risk of CVD associated with SED was underestimated in these analyses.[225]

The increased risk of death

Socioeconomic deprivation is associated with higher all cause[31] and cardiovascular mortality[7,32,227,228], therefore it is possible that the risk of non-fatal cardiovascular disease may be underestimated in this group as they succumb to fatal disease before they can experience a non-fatal event. I have reported that the risk of a number of composite cardiovascular events which included all cause mortality is higher in the most deprived. However, composite endpoints are only one method to account for the competing risk of death. In a further analysis where a competing events analysis was performed, despite a higher risk of all cause mortality, the risk of a cardiovascular hospitalisation was still higher in the most deprived as compared to the least deprived individuals. This suggests that the risk of cardiovascular hospitalisations is still higher despite the increased risk of death that the most deprived experience.

Summary

Socioeconomic deprivation as measured by an area based score and social class is associated with an increased risk of cardiovascular hospitalisations, irrespective of the

disease type studied. In the multivariable models, SED was as significant contributor to the model, as much as the traditional risk factors. The risk associated with SED is evident after adjustment for multiple cardiovascular risk factors and is present over a prolonged period of follow up. Furthermore, the most deprived are at a higher risk of cardiovascular events despite also being at a higher risk of all cause mortality.

In the next chapter I will go on to describe the results of analyses examining the impact of SED on the risk of a recurrent hospitalisation following this first cardiovascular hospitalisation.

Recurrent hospitalisations and subsequent survival

Introduction and aims

The literature surrounding the relationship between SED and cardiovascular disease is sparse in relation to recurrent (as opposed to "first" or "incident") cardiovascular events. While some data do exist on the risk of recurrent myocardial infarction[76,92,94] and stroke[105,117], only one study has examined the association between SED and readmission with heart failure[126]. No studies have examined the relationship in one cohort making comparison difficult. Finally, many studies have either performed unadjusted analyses or have adjusted for a number of different risk factors, again making comparison between studies difficult. In this chapter I will explore the relationship between SED and the risk of a subsequent cardiovascular hospitalisation. I will also examine the relationship between SED and subsequent survival following a first cardiovascular hospitalisation. Finally, I will explore the risk of suffering a subsequent cardiovascular hospitalisation in a composite outcome taking into account of death.

Methods

For each of the analyses presented the time of origin was specified as the time at which a person experienced a non-fatal cardiovascular hospitalisation. Age in the model was entered as the age at which the non-fatal cardiovascular hospitalisation occurred. Follow up continued to the point of a subsequent recurrent hospitalisation, or death, or a composite of these. Cox proportional hazards models were used to model these outcomes again adjusting for known cardiovascular risk factors. Of the cardiovascular risk factors smoking has one of the greatest potentials to change over time. In a study of men and women deprived women were more likely to quit smoking as they grew older than their least deprived counterparts.[150] No association was seen in men. Higher levels of education and occupation are associated with a higher likelihood of smoking cessation following an admission to a coronary care unit.[229] Therefore to explore this potential bias, a sensitivity analysis was conducted using models with and without smoking in the model.

Results

Baseline characteristics

The characteristics of those individuals that had experienced a cardiovascular hospitalisation during follow up were analysed according to SED.

Cardiovascular disease

Of those that experienced a cardiovascular hospitalisation during follow up, when SED was measured using Carstairs Morris index the most deprived were more likely to be smokers, have bronchitis and have a lower FEV1 (Table 35). Whilst other variables were statistically significantly different across SED groups, none showed a clear gradient of change. When social class was used as the measure of SED the most deprived were older, had higher systolic blood pressure, were less likely to be men and more likely to have cardiomegaly and bronchitis (Table 36).

The individuals who suffered a cardiovascular admission but could not be assigned a Carstairs Morris index deprivation category were more likely to have a history of bronchitis though the magnitude of this difference was negligible as numbers were small (Table 35). Those who were not assigned a social class that suffered a cardiovascular admission had higher blood pressure and were less likely to be men or smokers (Table 36).

Coronary Heart Disease

In statistical testing there were significant differences in the baseline characteristics of individuals according to Carstairs Morris index that experienced a coronary heart disease hospitalisation during follow up (Table 37). The same was observed using social class as the measure of SED, that the most deprived were older, had higher blood pressure, were less likely to be men but more likely to be smokers (Table 38).

Those with missing SED defined by Carstairs Morris index or social class were not different to those who were assigned a deprivation category by either classification system with the exception that those missing a social class classification were again less likely to be men.

Table 35 Characteristics of individuals with a non-fatal CVD hospitalisation according to Carstairs Morris index

	1		3		4		5		6 & 7		P	Missing		P
N	**320**		**711**		**1097**		**1912**		**1163**			**11**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	55.2	(5.5)	54.0	(5.4)	54.1	(5.6)	53.7	(5.5)	54.7	(5.7)	<0.001	53.6	(5.7)	0.89
Systolic BP (mmHg)	153.3	(24.0)	151.7	(24.2)	147.6	(24.0)	154.2	(25.2)	150.7	(25.1)	<0.001	148.3	(27.7)	0.87
Cholesterol (mmol/l)	6.2	(1.1)	6.2	(1.0)	6.2	(1.0)	6.2	(1.1)	6.2	(1.0)	0.29	6.3	(1.0)	0.70
Body mass index (kg/m^2)	25.7	(3.6)	25.6	(3.6)	25.7	(3.9)	26.3	(4.1)	26.4	(4.6)	<0.001	26.7	(2.7)	0.99
adjusted FEV1 (% predicted)	98.2	(20.7)	95.4	(20.4)	92.9	(21.1)	91.6	(21.4)	88.3	(22.7)	<0.001	91.9	(34.2)	0.81
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	153	(47.8)	387	(54.4)	519	(47.3)	929	(48.5)	529	(45.4)	0.005	7	(63.7)	0.35
Smoker	203	(63.4)	453	(63.7)	743	(67.7)	1345	(70.3)	858	(73.7)	<0.001	20	(58.8)	0.25
Diabetes	3	(0.9)	8	(1.1)	17	(1.6)	25	(1.3)	22	(1.9)	0.59	0	(0)	0.64
Cardiomegaly	81	(26.2)	139	(20.0)	259	(24.9)	485	(26.3)	344	(31.1)	<0.001	2	(25.0)	0.57
Bronchitis	7	(2.2)	17	(2.4)	26	(2.4)	47	(2.5)	63	(5.4)	<0.001	1	(5.8)	0.09

Table 36 Characteristics of individuals with a non-fatal CVD hospitalisation according to social class

	I		II		III - NM		III-M		IV		V		P	Missing		P
N	**169**		**782**		**989**		**1483**		**1246**		**422**			**123**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	52.7	(5.5)	53.9	(5.4)	54.1	(5.5)	54.0	(5.5)	54.4	(5.7)	54.9	(5.5)	0.0002	54.8	(6.0)	0.48
Systolic BP (mmHg)	148.1	(20.4)	149.4	(23.9)	150.4	(25.0)	152.1	(23.7)	151.9	(25.7)	155.8	(27.5)	<0.001	156.8	(25.9)	0.01
Cholesterol (mmol/l)	6.2	(1.0)	6.3	(1.0)	6.4	(1.1)	6.0	(1.0)	6.2	(1.1)	6.2	(0.9)	<0.001	6.1	(1.0)	0.5
Body mass index (kg/m^2)	25.3	(3.3)	25.9	(3.8)	25.5	(3.8)	26.4	(3.8)	26.9	(4.9)	25.7	(4.4)	<0.001	25.7	(4.4)	0.9
adjusted FEV1 (% predicted)	98.0	(20.8)	96.5	(19.6)	94.5	(22.6)	90.5	(21.3)	88.5	(22.3)	90.2	(23.3)	<0.001	102.9	(20.1)	0.5
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	116	(68.6)	387	(49.5)	308	(31.1)	1022	(68.9)	535	(42.9)	134	(31.8)	<0.001	22	(17.9)	<0.001
Smoker	110	(65.1)	518	(66.2)	637	(64.4)	1111	(74.9)	874	(70.1)	290	(68.7)	<0.001	71	(57.7)	0.05
Diabetes	3	(1.8)	11	(1.4)	10	(1.0)	15	(1.0)	23	(1.9)	9	(2.1)	0.27	4	(3.2)	0.12
Cardiomegaly	33	(20.5)	174	(23.5)	242	(25.3)	347	(24.5)	341	(28.5)	133	(32.6)	0.001	40	(33)	0.08
Bronchitis	2	(1.2)	12	(1.5)	20	(2.3)	56	(3.8)	49	(3.9)	20	(4.7)	0.001	2	(1.6)	0.66

Table 37 Characteristics of individuals with a non-fatal CHD hospitalisation according to Carstairs Morris index

	1		3		4		5		6 & 7		P	Missing		P
N	**108**		**296**		**406**		**788**		**1163**			**5**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	54.7	(5.7)	53.5	(5.3)	53.4	(5.6)	53.4	(5.8)	54.	(5.8)	0.009	56.6	(5.4)	0.29
Systolic BP (mmHg)	152.3	(23.5)	152.5	(23.1)	147.5	(24.1)	152.6	(23.1)	151.4	(24.3)	0.009	148.3	(27.7)	0.95
Cholesterol (mmol/l)	6.3	(1.1)	6.4	(1.0)	6.3	(1.1)	6.2	(1.2)	6.3	(1.0)	0.28	6.4	(0.9)	0.90
Body mass index (kg/m^2)	25.8	(3.6)	25.9	(3.6)	25.9	(3.8)	26.4	(3.8)	26.7	(4.8)	0.009	26.0	(2.7)	0.85
adjusted FEV1 (% predicted)	97.4	(19.5)	97.5	(18.0)	93.1	(19.8)	92.5	(19.8)	89.2	(21.1)	<0.001	82.8	(46.4)	0.37
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	62	(57.4)	182	(61.5)	223	(54.9)	425	(48.3)	232	(51.7)	0.15	4	(80.0)	0.24
Smoker	77	(71.3)	203	(68.6)	295	(72.7)	566	(71.8)	346	(77.1)	0.12	5	(100)	0.17
Diabetes	2	(1.9)	4	(1.4)	6	(1.5)	9	(1.1)	5	(1.1)	0.97	5	(0)	0.77
Cardiomegaly	20	(19.2)	58	(19.8)	93	(23.7)	195	(25.6)	139	(32.3)	0.004	1	(20)	0.83
Bronchitis	4	(3.7)	6	(2.0)	9	(2.2)	20	(2.5)	19	(4.2)	0.29	1	(20)	0.14

Table 38 Characteristics of individuals with a non-fatal CHD hospitalisation according to social class

	I		II		III - NM		III-M		IV		V		P	Missing		P
N	**69**		**305**		**377**		**635**		**467**		**158**			**41**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	51.5	(5.7)	53.4	(5.2)	53.4	(5.5)	53.7	(5.5)	54.0	(5.7)	54.5	(5.5)	0.004	55.2	(6.0)	0.16
Systolic BP (mmHg)	148.2	(22.1)	150.2	(23.6)	149.2	(22.5)	151.6	(22.6)	151.6	(25.1)	156.5	(26.9)	0.02	155.1	(20.5)	0.09
Cholesterol (mmol/l)	6.1	(1.0)	6.4	(1.0)	6.5	(1.2)	6.2	(1.1)	6.2	(1.1)	6.3	(1.1)	0.001	6.0	(1.1)	0.5
Body mass index (kg/m^2)	25.6	(2.7)	26.1	(3.4)	25.4	(3.6)	26.8	(3.9)	26.4	(4.7)	27.0	(5.0)	<0.001	24.8	(3.6)	0.3
adjusted FEV1 (% predicted)	97.9	(18.9)	96.2	(18.6)	95.2	(22.2)	92.5	(21.3)	88.5	(21.1)	93.9	(19.2)	<0.001	93.9	(19.2)	0.8
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	53	(76.8)	187	(61.3)	145	(38.5)	459	(72.2)	233	(47.8)	49	(31.1)	<0.001	12	(29.3)	<0.001
Smoker	47	(68.1)	213	(69.8)	258	(68.4)	492	(77.5)	341	(73.0)	112	(70.8)	0.02	29	(70.7)	0.9
Diabetes	1	(1.5)	3	(1.0)	3	(1.0)	6	(1.0)	83	(1.7)	4	(2.5)	0.56	1	(2.4)	0.36
Cardiomegaly	16	(24.6)	64	(22.1)	88	(24.0)	150	(24.3)	123	(27.2)	51	(33.3)	0.13	14	(35)	0.32
Bronchitis	1	(1.5)	5	(1.6)	9	(2.4)	17	(2.7)	20	(4.3)	7	(4.4)	0.2	0	(0)	0.78

Acute myocardial infarction

Of those that experienced a hospitalisation for myocardial infarction during follow up, the most deprived individuals, as measured by Carstairs Morris index were more likely to be smokers and also have a lower adjusted FEV1 and to have cardiomegaly (Table 39). When social class was used as the measure of SED the most deprived were older, had higher blood pressure , lower adjusted FEV1, and less likely to be male (Table 40). Of those who experienced a myocardial infarction admission during follow up, those who could not be assigned a SED category (either using Carstairs Morris index or social class) were not different with respect to baseline variables from those who could be assigned a SED category. The only exception was that those who were not assigned a social class were again less likely to be male.

Stroke

In the individuals who were discharged from hospital with a diagnosis of stroke the most deprived (measured by Carstairs Morris index) were more likely to have lower adjusted FEV1 and have cardiomegaly or bronchitis (Table 41). When social class was used to define SED, the most deprived were less likely to be men and have lower adjusted FEV1. Whilst other statistically significant differences were found they were not of clinically relevant magnitudes (Table 42). Again, no difference was found in those who were assigned a deprivation category by either method as compared to those who were not. The only exception was that those who were not assigned a social class were again less likely to be male.

Heart failure

A lower adjusted FEV1, younger age, lower systolic blood pressure and more cardiomegaly and bronchitis was observed in the most deprived who experienced an hospitalisation with HF as compared to the least deprived as measured by the Carstairs Morris index(Table 43). When social class was examined the most deprived had lower adjusted FEV1, were less likely to be men and had more bronchitis (Table 44). Again only the proportion of men in those unassigned a social class was statistically significantly different

Table 39 Characteristics of individuals with a non-fatal myocardial infarction hospitalisation according to Carstairs Morris index

	1		3		4		5		6 & 7		P	Missing		P
N	**81**		**204**		**290**		**566**		**332**			**2**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	54.5	(5.7)	53.8	(5.3)	53.7	(5.7)	53.4	(5.8)	54.5	(5.6)	0.25	58.5	(4.9)	0.28
Systolic BP (mmHg)	152.4	(23.8)	152.2	(22.1)	148.3	(25.0)	154.1	(24.0)	151.7	(23.8)	0.02	145.0	(4.2)	0.7
Cholesterol (mmol/l)	6.3	(1.0)	6.3	(1.1)	6.3	(1.0)	6.2	(1.3)	6.3	(1.0)	0.59	6.7	(1.3)	0.58
Body mass index (kg/m^2)	25.8	(3.6)	25.9	(3.4)	25.9	(3.8)	26.3	(3.9)	26.7	(4.7)	0.07	27.6	(0.2)	0.7
adjusted FEV1 (% predicted)	97.2	(20.1)	96.9	(17.7)	92.9	(20.8)	93.5	(19.2)	88.8	(21.4)	<0.001	75.7	(3.7)	0.3
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	49	(60.5)	133	(65.2)	170	(58.6)	318	(56.2)	181	(54.5)	0.14	1	(50)	0.85
Smoker	59	(72.8)	144	(70.6)	211	(72.6)	422	(72.8)	269	(81.0)	0.04	2	(100)	0.4
Diabetes	2	(2.7)	4	(1.9)	5	(1.7)	8	(1.4)	2	(0.6)	0.86	2	(100)	0.85
Cardiomegaly	14	(18.8)	36	(17.8)	65	(22.7)	139	(25.5)	99	(30.9)	0.01	1	(50)	0.5
Bronchitis	3	(3.7)	5	(2.0)	6	(2.1)	18	(3.2)	16	(4.8)	0.36	21	(100)	0.7

Table 40 Characteristics of individuals with a non-fatal myocardial infarction hospitalisation outcome according to social class

	I		II		III - NM		III-M		IV		V		P	Missing		P
N	**50**		**207**		**268**		**469**		**343**		**87**			**21**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	50.6	(5.4)	53.7	(5.6)	53.6	(5.4)	54.3	(5.5)	54.3	(5.7)	54.8	(5.5)	0.0001	54.5	(5.6)	0.7
Systolic BP (mmHg)	145.8	(22.1)	151.7	(23.9)	150.3	(22.5)	152.3	(22.8)	152.7	(25.7)	156.5	(26.5)	0.1	150.1	(17.3)	0.9
Cholesterol (mmol/l)	6.1	(1.0)	6.4	(1.0)	6.5	(1.2)	6.1	(1.1)	6.3	(1.1)	6.4	(1.0)	0.002	6.2	(1.1)	0.6
Body mass index (kg/m^2)	25.6	(2.4)	26.1	(3.3)	25.5	(3.7)	26.5	(3.8)	26.4	(4.8)	26.6	(4.4)	0.01	24.6	(4.1)	0.23
adjusted FEV1 (% predicted)	98.4	(20.2)	96.9	(18.6)	95.9	(21.2)	92.0	(18.8)	90.5	(22.1)	88.99	(22.1)	<0.001	90.9	(16.7)	0.48
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	40	(80.0)	131	(63.3)	115	(42.9)	345	(73.6)	174	(50.7)	42	(35.9)	<0.001	5	(23.8)	0.0002
Smoker	34	(68.0)	149	(72.0)	184	(68.7)	377	(80.4)	260	(75.8)	87	(74.5)	0.009	16	(76.2)	0.77
Diabetes	1	(2.0)	2	(0.9)	3	(1.1)	5	(1.1)	6	(1.7)	3	(2.6)	0.79	1	(4.8)	0.61
Cardiomegaly	9	(18.7)	44	(22.2)	64	(24.4)	111	(24.1)	87	(26.2)	33	(28.9)	0.67	64	(30)	0.99
Bronchitis	1	(2.0)	3	(1.5)	8	(2.9)	14	(2.9)	16	(4.6)	6	(5.1)	0.3	0	(0)	0.46

Table 41 Characteristics of individuals with a non-fatal stroke hospitalisation according to Carstairs Morris index

	1		3		4		5		6 & 7		P	Missing		P
N	**81**		**216**		**340**		**546**		**356**			**4**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	55.8	(5.5)	55.0	(5.2)	55.4	(5.8)	54.6	(5.4)	56.1	(5.6)	0.003	54.5	(5.8)	0.27
Systolic BP (mmHg)	156.1	(25.7)	154.6	(23.6)	149.3	(22.9)	158.6	(26.2)	154.9	(26.2)	<0.001	130.8	(13.8)	0.2
Cholesterol (mmol/l)	6.3	(1.2)	6.2	(1.1)	6.2	(1.0)	6.2	(1.1)	6.2	(1.1)	0.79	6.0	(1.3)	0.77
Body mass index (kg/m^2)	25.3	(3.5)	25.2	(3.5)	25.6	(3.5)	26.7	(4.2)	26.5	(4.5)	<0.001	26.7	(2.2)	0.9
adjusted FEV1 (% predicted)	98.1	(19.8)	93.9	(20.8)	93.6	(20.3)	90.4	(22.0)	88.9	(22.8)	<0.001	102.9	(20.1)	0.4
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	29	(35.8)	109	(50.5)	151	(44.4)	254	(46.5)	128	(35.9)	0.002	3	(75)	0.11
Smoker	48	(59.2)	138	(63.8)	227	(66.8)	375	(68.7)	238	(66.9)	0.4	2	(50)	0.7
Diabetes	1	(1.2)	3	(1.4)	6	(1.7)	11	(2.0)	7	(1.9)	0.97	4	(100)	0.77
Cardiomegaly	22	(27.9)	48	(22.5)	80	(24.9)	157	(29.7)	107	(32.0)	0.01	1	(25)	0.6
Bronchitis	2	(2.5)	4	(1.9)	7	(2.1)	15	(2.1)	23	(6.5)	0.005	4	(100)	0.1

Table 42 Characteristics of individuals with a non-fatal stroke hospitalisation according to social class

	I		II		III - NM		III-M		IV		V		P	Missing		P
N	**47**		**200**		**280**		**428**		**404**		**146**			**38**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	54.5	(5.5)	54.9	(5.4)	55.2	(5.6)	54.9	(5.5)	55.4	(5.7)	55.9	(5.3)	0.43	54.9	(5.8)	0.39
Systolic BP (mmHg)	147.3	(20.7)	152.6	(23.7)	155.4	(27.3)	153.6	(23.7)	156.4	(26.1)	157.4	(26.5)	0.08	162.3	(24.4)	0.17
Cholesterol (mmol/l)	6.2	(1.1)	6.3	(1.0)	6.1	(1.2)	6.2	(1.0)	6.3	(1.1)	6.3	(1.0)	0.015	6.2	(0.8)	0.57
Body mass index (kg/m^2)	25.0	(3.3)	25.8	(3.9)	25.6	(3.9)	26.2	(3.8)	26.6	(4.4)	26.2	(4.8)	0.009	26.3	(5.0)	0.31
adjusted FEV1 (% predicted)	96.7	(17.3)	94.9	(21.1)	93.8	(22.0)	91.2	(21.0)	88.9	(21.5)	90.6	(23.1)	0.004	92.79	(26.3)	0.59
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	26	(55.3)	85	(42.5)	85	(30.4)	282	(65.9)	152	(37.6)	41	(28.1)	<0.001	3	(7.9)	<0.001
Smoker	32	(68.0)	130	(65.0)	179	(63.9)	307	(71.7)	265	(65.8)	98	(67.1)	0.28	17	(44.7)	0.02
Diabetes	1	(2.1)	7	(3.5)	6	(2.1)	4	(1.0)	5	(1.2)	3	(2.0)	0.28	2	(5.2)	0.11
Cardiomegaly	10	(22.2)	47	(25.0)	80	(29.2)	103	(24.8)	121	(31.6)	38	(26.9)	0.27	16	(43.2)	0.021
Bronchitis	1	(2.1)	4	(2.0)	7	(2.5)	17	(3.9)	13	(3.2)	8	(5.5)	0.47	1	(2.6)	0.82

Table 43 Characteristics of individuals with a non-fatal heart failure hospitalisation outcome according to Carstairs Morris index

	1		3		4		5		6 & 7		P	Missing		P
N	**56**		**91**		**173**		**327**		**195**			**2**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	57.3	(5.3)	55.3	(5.5)	54.9	(5.8)	54.6	(5.5)	55.5	(5.7)	0.003	61.5	(3.5)	0.27
Systolic BP (mmHg)	159.8	(21.3)	154.4	(27.0)	149.4	(22.2)	157.9	(25.9)	154.2	(24.7)	0.004	197	(21.2)	0.02
Cholesterol (mmol/l)	6.1	(0.9)	6.2	(1.0)	6.3	(1.0)	6.2	(1.2)	6.2	(1.0)	0.79	6.3	(0.9)	0.90
Body mass index (kg/m^2)	25.3	(3.5)	25.2	(3.5)	25.6	(3.5)	26.7	(4.2)	26.5	(4.5)	<0.001	26.7	(2.2)	0.9
adjusted FEV1 (% predicted)	98.1	(19.8)	93.9	(20.8)	93.6	(20.3)	90.4	(22.0)	88.9	(22.8)	<0.001	102.9	(20.1)	0.4
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	28	(50.0)	44	(48.4)	85	(49.1)	163	(49.9)	92	(47.2)	0.98	1	(50)	0.98
Smoker	35	(62.6)	568	(61.5)	121	(70.0)	237	(72.4)	139	(71.3)	0.4	2	(50)	0.7
Diabetes	1	(1.2)	3	(1.4)	6	(1.7)	11	(2.0)	7	(1.9)	0.97	4	(100)	0.77
Cardiomegaly	22	(27.9)	48	(22.5)	80	(24.9)	157	(29.7)	107	(32.0)	0.01	1	(25)	0.6
Bronchitis	2	(2.5)	4	(1.9)	7	(2.1)	15	(2.1)	23	(6.5)	0.005	4	(100)	0.1

Table 44 Characteristics of individuals with a non-fatal heart failure hospitalisation outcome according to social class

	I		II		III - NM		III-M		IV		V		P	Missing		P
N	**24**		**127**		**139**		**243**		**214**		**82**			**15**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Test for trend (excluding missing SED)**	**Mean**	**SD**	**Missing vs. rest**
Age (years)	54.4	(5.8)	55.6	(5.6)	54.9	(5.8)	54.6	(5.5)	55.5	(5.7)	55.5	(5.6)	0.48	55.8	(5.9)	0.94
Systolic BP (mmHg)	159.6	(24.4)	150.5	(23.7)	154.3	(27.3)	155.8	(24.3)	155.9	(25.3)	158.3	(27.4)	0.22	156.8	(30.4)	0.78
Cholesterol (mmol/l)	6.0	(1.0)	6.3	(1.2)	6.3	(1.1)	6.1	(1.0)	6.3	(1.1)	6.2	(1.0)	0.044	5.9	(1.3)	0.86
Body mass index (kg/m^2)	27.1	(5.5)	26.8	(4.4)	26.6	(3.9)	27.4	(4.1)	26.9	(5.0)	28.8	(5.3)	0.012	25.3	(4.6)	0.49
adjusted FEV1 (% predicted)	92.6	(21.3)	92.9	(19.5)	90.9	(23.4)	87.9	(22.6)	87.1	(22.1)	83.8	(24.8)	0.035	89.39	(24.9)	0.27
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		**N**	**%**	
Men	17	(70.8)	60	(47.2)	45	(32.8)	170	(70.0)	94	(43.9)	22	(26.8)	<0.001	5	(33.3)	0.003
Smoker	15	(62.5)	89	(70.1)	89	(64.0)	190	(78.2)	147	(68.7)	51	(62.2)	0.02	8	(53.3)	0.26
Diabetes	1	(4.1)	0	(0)	1	(0.7)	3	(1.2)	9	(4.2)	2	(2.4)	0.06	0	(0)	0.42
Cardiomegaly	5	(22.7)	43	(34.7)	46	(35.1)	76	(32.5)	71	(34.6)	30	(37.5)	0.84	76	(46.8)	0.24
Bronchitis	0	(0)	3	(2.4)	2	(1.4)	14	(5.8)	17	(7.9)	3	(3.6)	0.04	0	(0)	0.93

The risk of recurrent hospitalisation

Crude rates of recurrent hospitalisation

The number of recurrent hospitalisations is outlined in Table 45 and 46. The rate of recurrent hospitalisation after an initial cardiovascular disease type by SED as measured by Carstairs Morris index is displayed in Figure 24. A trend towards higher rates of recurrent hospitalisation was seen for each initial disease type. The rate ratio (RR) for CVD was 1.03 (95% CI 0.78-0.86), p=0.08. For CHD this was 1.28 (0.87-1.88), p=0.21, MI 1.21(0.65-2.25) p=0.55, stroke=0.99 (0.97-1.62), p=0.97 and HF 1.12(0.64-1.93), p=0.13 (Table 47).A similar trend was observed when social class was used as the marked of SED (Table 48 and Figure 25).

Table 45 Numbers of individuals according to Carstairs Morris index who experienced a recurrent cardiovascular admission

1st hospitalisation	Recurrent hospitalisation	1	3	4	5	6 & 7
CVD	CVD	149	335	533	908	547
CHD	CHD	31	116	152	271	159
MI	MI	12	45	63	113	57
Stroke	Stroke	20	41	87	116	83
HF	HF	16	23	55	95	60

Table 46 Numbers of individuals according to social class who experienced a recurrent cardiovascular admission

1st hospitalisation	Recurrent hospitalisation	I	II	IIIN	IIIM	IV	V
CVD	CVD	88	374	471	683	587	213
CHD	CHD	25	111	129	235	164	54
MI	MI	9	39	49	102	66	23
Stroke	Stroke	13	51	44	95	90	43
HF	HF	10	43	42	61	64	25

Table 47 Rate ratio of most versus least deprived (measured by Carstairs Morris index) for a recurrent cardiovascular hospitalisation

1st hospitalisation	Recurrent hospitalisation	RR	95% CI		P
CVD	CVD	1.03	0.86	1.23	0.77
CHD	CHD	1.28	0.87	1.89	0.20
MI	MI	1.21	0.65	2.26	0.54
Stroke	Stroke	0.99	0.61	1.61	0.97
HF	HF	1.11	0.64	1.93	0.72

Table 48 Rate ratio of most versus least deprived (measured by social class) for a recurrent cardiovascular hospitalisation

1st hospitalisation	Recurrent hospitalisation	RR	95% CI		P
CVD	CVD	1.00	0.78	1.28	0.97
CHD	CHD	0.97	0.60	1.58	0.91
MI	MI	1.10	0.51	2.38	0.81
Stroke	Stroke	1.05	0.56	1.96	0.88
HF	HF	0.65	0.31	1.37	0.25

Kaplan Meier Analysis of Recurrent cardiovascular hospitalisation

In a Kaplan Meier analysis of recurrent cardiovascular hospitalisation there was no significant difference in the rates of recurrent cardiovascular disease hospitalisation according to SED measured by Carstairs Morris index or social class (Figures 26-35).

Figure 24 Rate of subsequent cardiovascular hospitalisation of the same type according to SED measured by Carstairs Morris index.

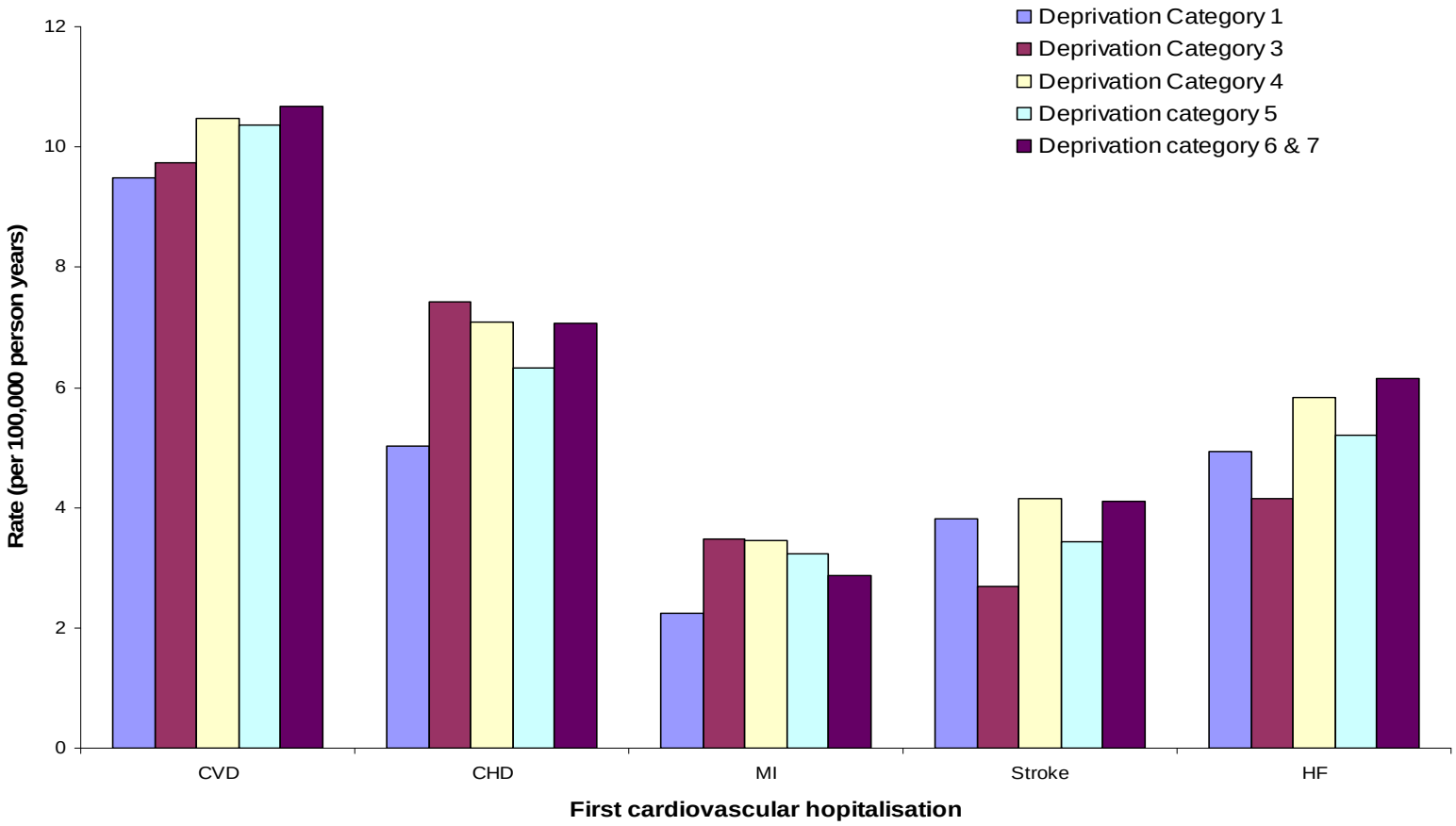


Figure 25 Rate of subsequent cardiovascular hospitalisation of the same type according to SED measured by social class

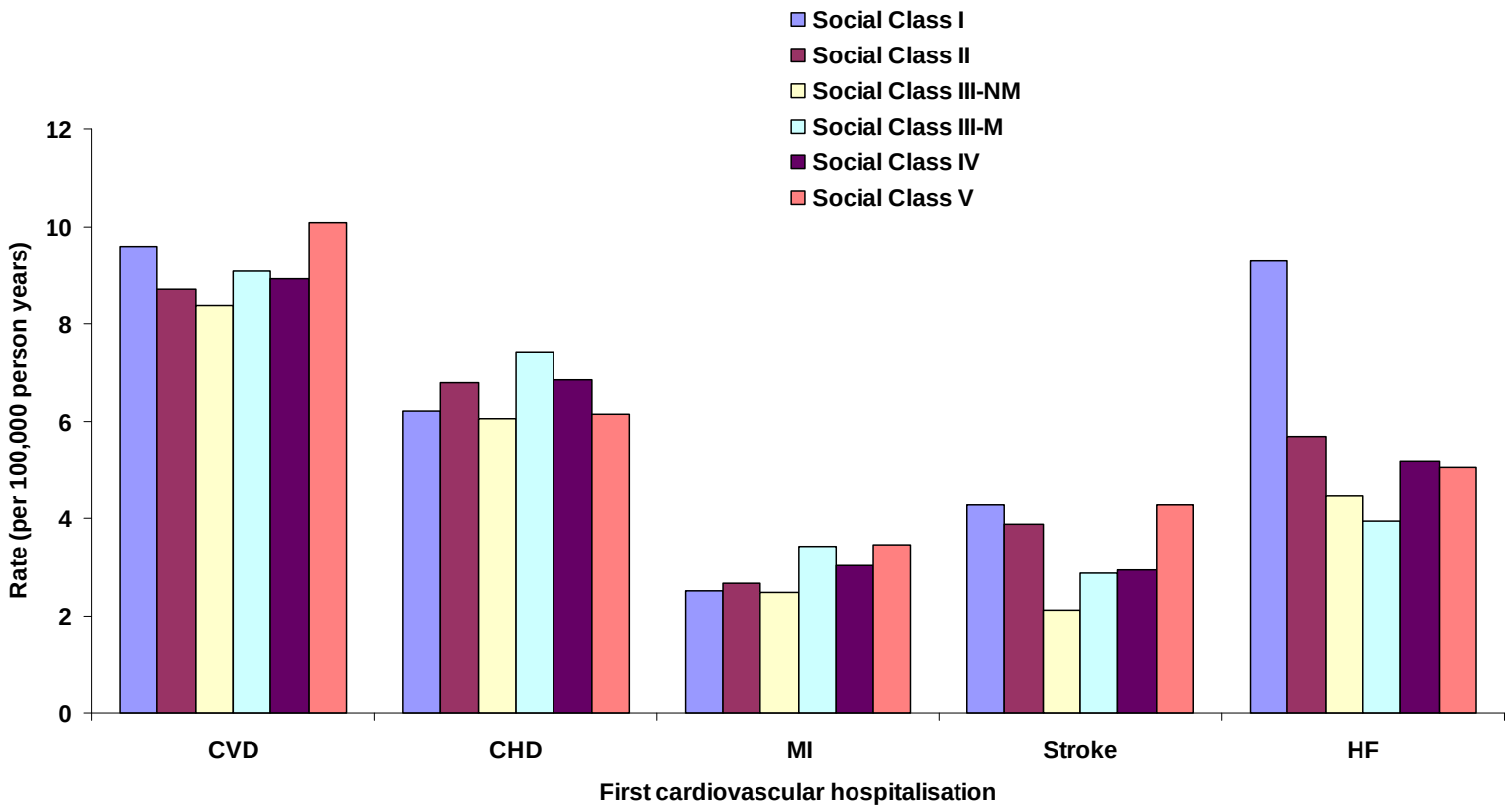
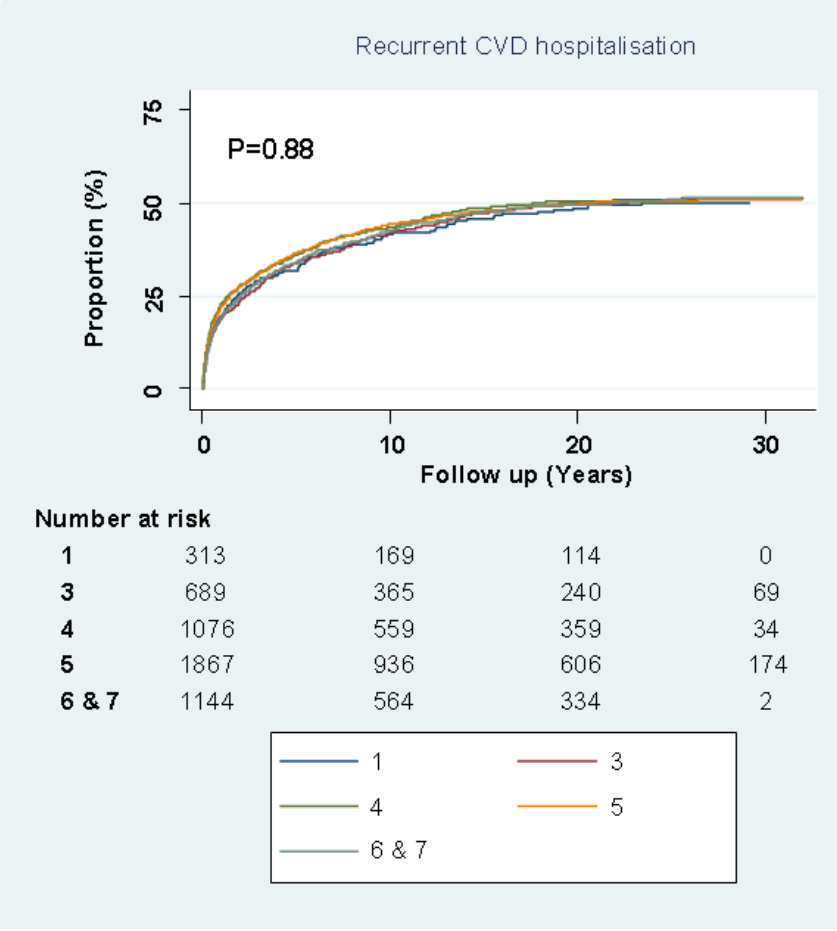
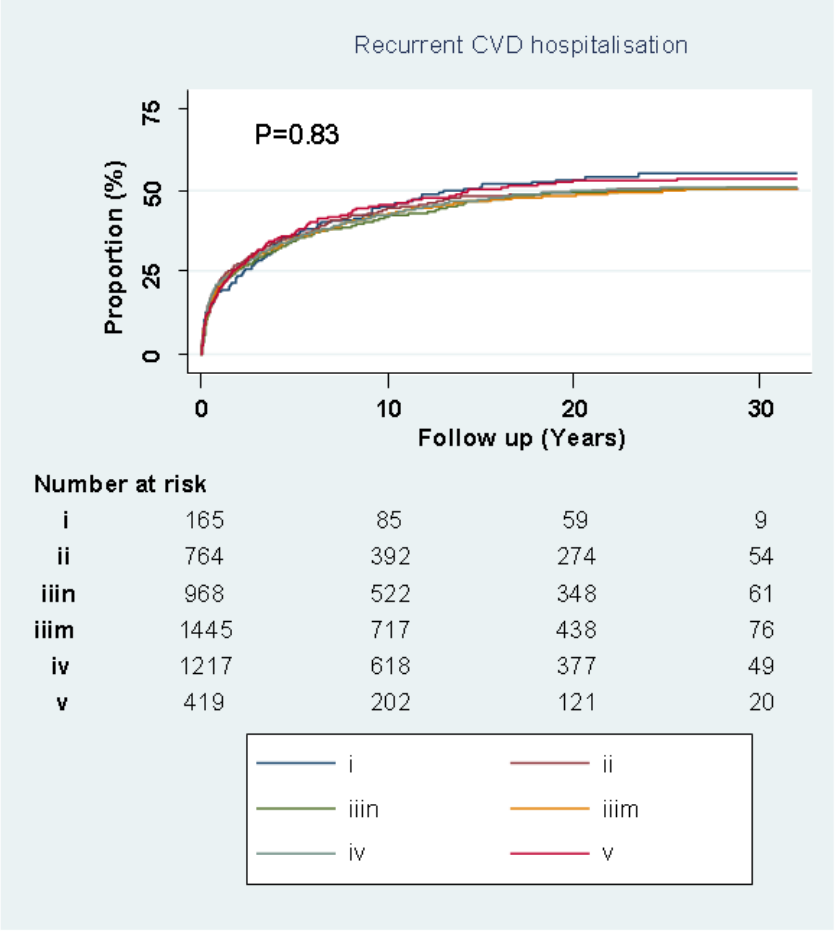


Figure 26 Kaplan Meier analysis of recurrent cardiovascular hospitalisation over follow up according to Carstairs Morris index



Number at risk				
1	313	169	114	0
3	689	365	240	69
4	1076	559	359	34
5	1867	936	606	174
6 & 7	1144	564	334	2

Figure 27 Kaplan Meier analysis of recurrent cardiovascular hospitalisation over follow up according to social class



Number at risk				
i	165	85	59	9
ii	764	392	274	54
iiin	968	522	348	61
iiim	1445	717	438	76
iv	1217	618	377	49
v	419	202	121	20

Figure 28 Kaplan Meier analysis of a recurrent coronary heart disease hospitalisation over up according to Carstairs Morris index

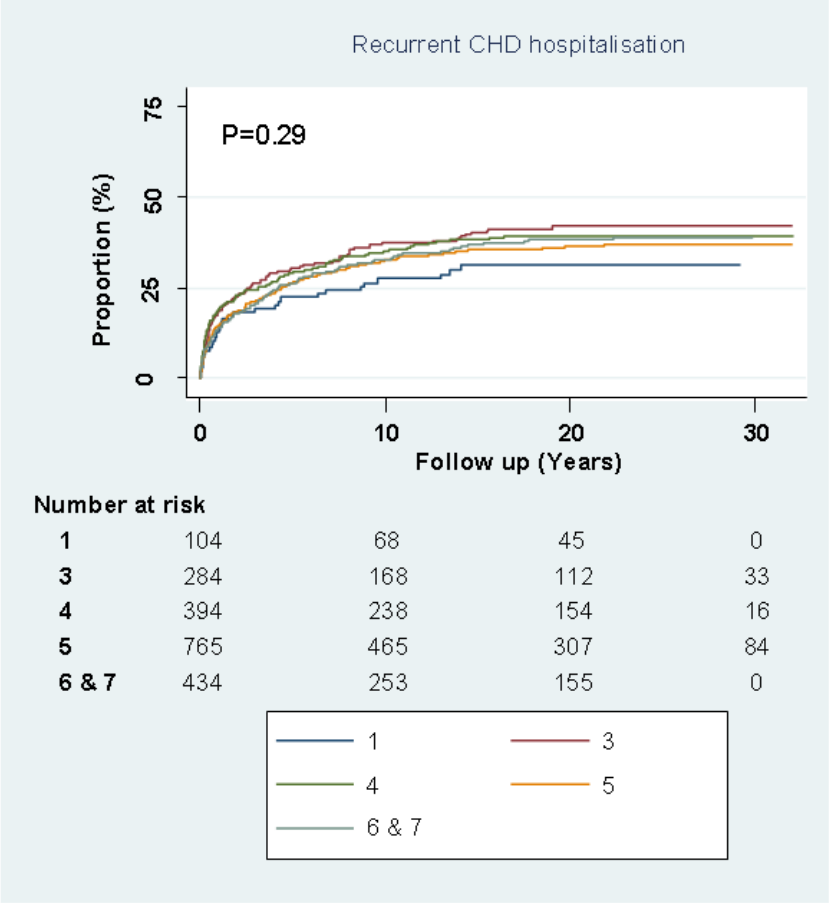


Figure 29 Kaplan Meier analysis of a recurrent coronary heart disease hospitalisation over follow up according to social class

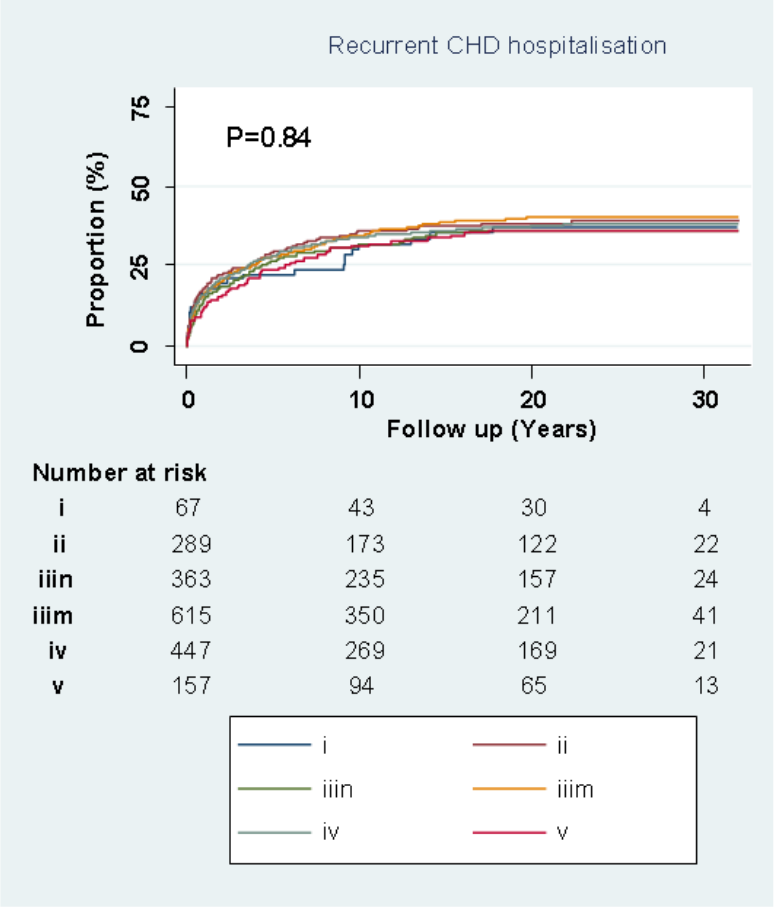
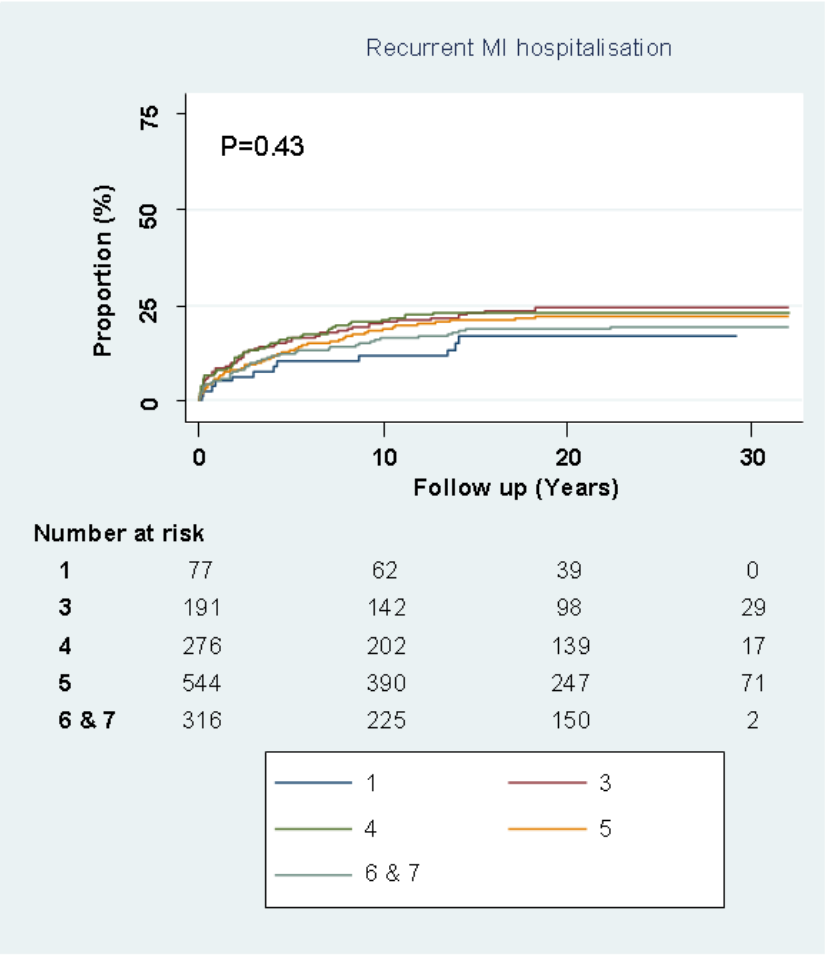
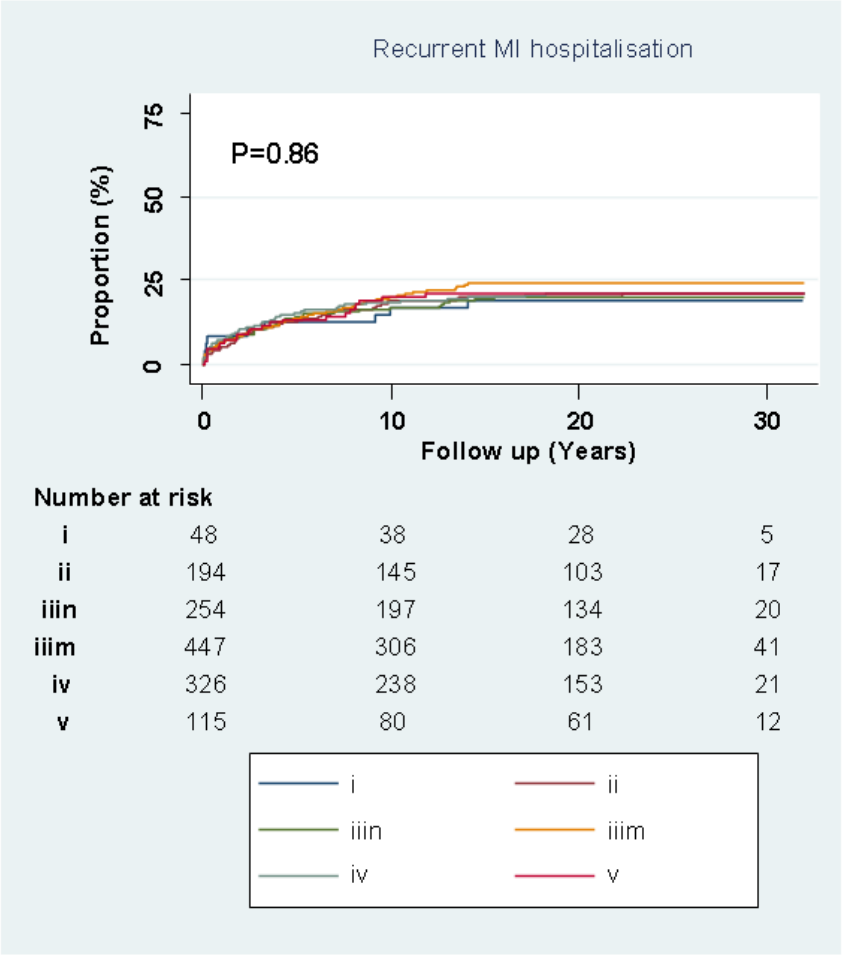


Figure 30 Kaplan Meier analysis of recurrent myocardial infarction hospitalisation over follow up according to Carstairs Morris index



Number at risk				
1	77	62	39	0
3	191	142	98	29
4	276	202	139	17
5	544	390	247	71
6 & 7	316	225	150	2

Figure 31 Kaplan Meier analysis of recurrent myocardial infarction hospitalisation over follow up according to social class



Number at risk				
i	48	38	28	5
ii	194	145	103	17
iiin	254	197	134	20
iiim	447	306	183	41
iv	326	238	153	21
v	115	80	61	12

Figure 32 Kaplan Meier analysis of recurrent stroke hospitalisation over follow up according to Carstairs Morris index

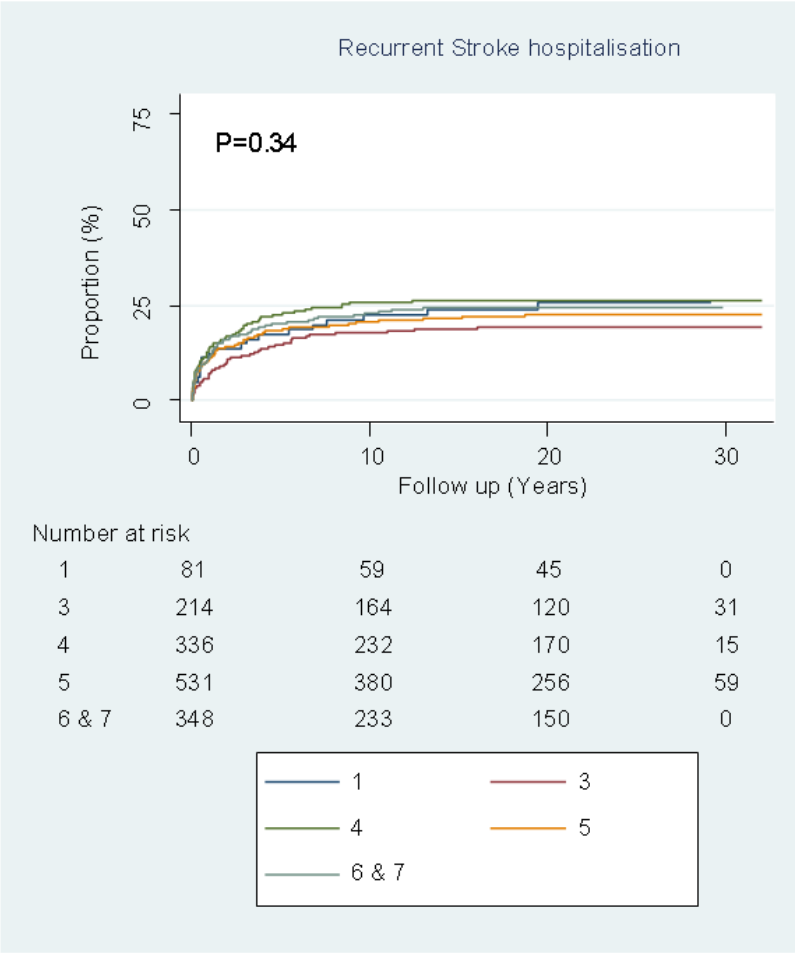


Figure 33 Kaplan Meier analysis of recurrent stroke hospitalisation over follow up according to social class

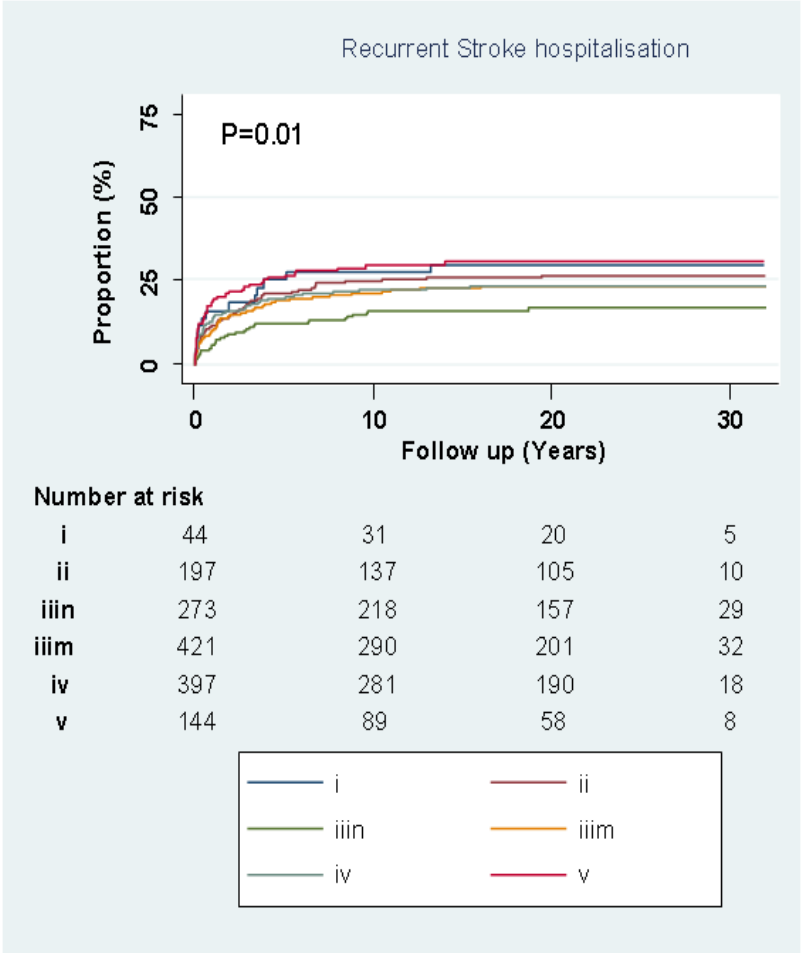


Figure 34 Kaplan Meier analysis of recurrent heart failure hospitalisation over follow up according to Carstairs Morris index

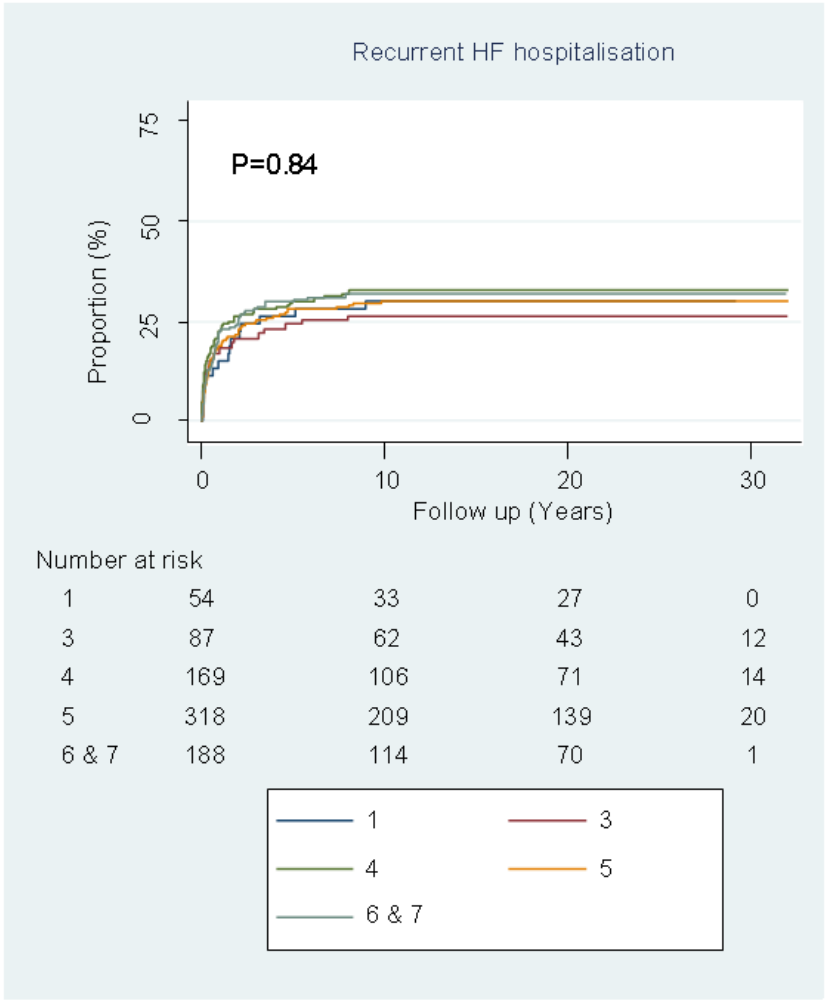
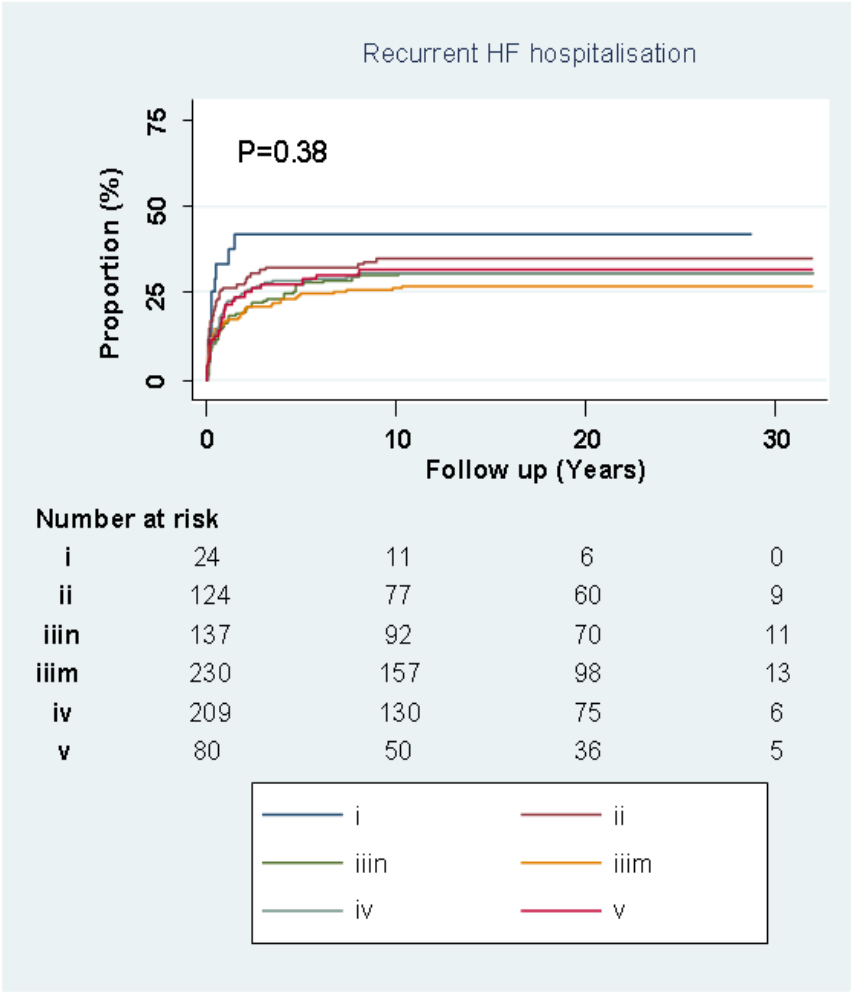


Figure 35 Kaplan Meier analysis of recurrent heart failure hospitalisation over follow up according to social class



Adjusted survival to a recurrent hospitalisation

In a regression model the association between SED and recurrent events was examined (Tables 49 and 50). In both unadjusted and adjusted analyses the risk of a second recurrent event was not associated with SED. The removal of smoking from the multivariable model made no discernable difference to the results only altering the hazard ratios at the 4th or smaller decimal place. Therefore, smoking was retained in the model.

Table 49 Hazard of recurrent hospitalisation of the same type in the most versus least deprived as measured by the Carstairs Morris index.

	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
CVD	1.02	0.85	1.23	0.797	0.99	0.83	1.19	0.928	1.00	0.83	1.19	0.967	0.97	0.81	1.17	0.761
CHD	1.28	0.87	1.88	0.205	1.21	0.82	1.77	0.34	1.22	0.83	1.79	0.321	1.27	0.85	1.88	0.239
MI	1.22	0.65	2.26	0.539	1.16	0.62	2.16	0.647	1.15	0.61	2.14	0.668	1.19	0.62	2.28	0.611
Stroke	0.99	0.61	1.62	0.972	0.97	0.60	1.58	0.905	0.99	0.60	1.61	0.956	0.98	0.60	1.61	0.935
HF	1.10	0.64	1.91	0.728	1.04	0.60	1.81	0.894	1.06	0.61	1.84	0.848	1.02	0.58	1.81	0.936

Table 50 Hazard of recurrent hospitalisation of the same type in the most versus least deprived as measured by social class.

	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
CVD	0.99	0.77	1.28	0.944	1.03	0.79	1.33	0.833	1.03	0.80	1.34	0.807	1.03	0.79	1.35	0.811
CHD	0.96	0.59	1.56	0.874	0.96	0.59	1.56	0.868	1.02	0.63	1.66	0.936	1.11	0.66	1.84	0.7
MI	1.30	0.61	2.78	0.494	1.49	0.69	3.22	0.308	1.37	0.63	2.95	0.428	1.52	0.68	3.43	0.31
Stroke	0.97	0.50	1.86	0.927	0.94	0.49	1.82	0.86	0.92	0.48	1.79	0.814	1.07	0.54	2.13	0.849
HF	0.63	0.29	1.36	0.24	0.65	0.30	1.42	0.283	0.66	0.30	1.43	0.289	0.60	0.27	1.32	0.206

*Unadjusted

**Adjusted for age at first hospitalisation and sex

† Adjusted for age at first hospitalisation, sex, diabetes, cholesterol, systolic blood pressure, smoking and year of first hospitalisation

‡ Adjusted for age at first hospitalisation, sex, diabetes, cholesterol, systolic blood pressure, smoking, year of first hospitalisation, body mass index, FEV1, cardiomegaly

Death following a cardiovascular hospitalisation

Crude rates

The numbers of individuals who died following a particular cardiovascular hospitalisation are outlined in Tables 51 and 52. The rate of death following a non-fatal cardiovascular hospitalisation did show evidence of a gradient by SED (Figure 36 and 37). Following any CVD hospitalisation the rate ratio for the rate of death in the most versus least deprived was 1.33 (95%CI 1.14-1.56), p=0.0003 (Table 53). Similar trends were observed following a CHD hospitalisation 1.21 (0.921-1.59), p=0.1689, MI 1.29(0.95-1.75),p=0.11, stroke 1.23 (0.93-1.62), p=0.148 and HF 1.20 (0.84-1.69), p=0.314. As with Carstairs Morris index, only the rate ratio for death following a CVD hospitalisation was significant when social class was used to measure SED (Table 54). Overall rates of death were highest following a stroke or heart failure.

Table 51 Number of Deaths by type of first hospitalisation and socioeconomic deprivation measured by Carstairs Morris index

1st hospitalisation	Outcome	1	3	4	5	6 & 7
CVD	Death	192	468	738	1321	867
CHD	Death	62	190	265	525	317
MI	Death	49	144	198	411	249
Stroke	Death	61	163	262	433	290
HF	Death	40	70	138	277	167

Table 52 Number of Deaths by type of first hospitalisation and socioeconomic deprivation measured by social class

1st hospitalisation	Outcome	I	II	IIIN	IIIM	IV	V
CVD	Death	99	500	641	1063	884	320
CHD	Death	42	181	243	433	326	110
MI	Death	31	133	196	338	255	85
Stroke	Death	33	158	203	341	321	124
HF	Death	21	99	109	204	182	69

Table 53 Rate ratio of most versus least deprived (measured by Carstairs Morris index) for death following a first cardiovascular hospitalisation

Initial hospitalisation	Subsequent Event	RR	95% CI		P
CVD	Death	1.34	1.14	1.53	0.0003
CHD	Death	1.21	0.92	1.59	0.17
MI	Death	1.29	0.95	1.75	0.12
Stroke	Death	1.23	0.93	1.62	0.15
HF	Death	1.19	0.84	1.69	0.31

Table 54 Rate ratio of most versus least deprived (measured by social class) for death following a first cardiovascular hospitalisation

Initial hospitalisation	Subsequent Event	RR	95% CI		P
CVD	Death	1.36	1.09	1.71	0.007
CHD	Death	1.14	0.79	1.63	0.48
MI	Death	1.24	0.80	1.84	0.36
Stroke	Death	1.19	0.81	1.75	0.37
HF	Death	0.97	0.41	1.11	0.12

Figure 36 Rate of death following a first cardiovascular hospitalisation according to Carstairs Morris index

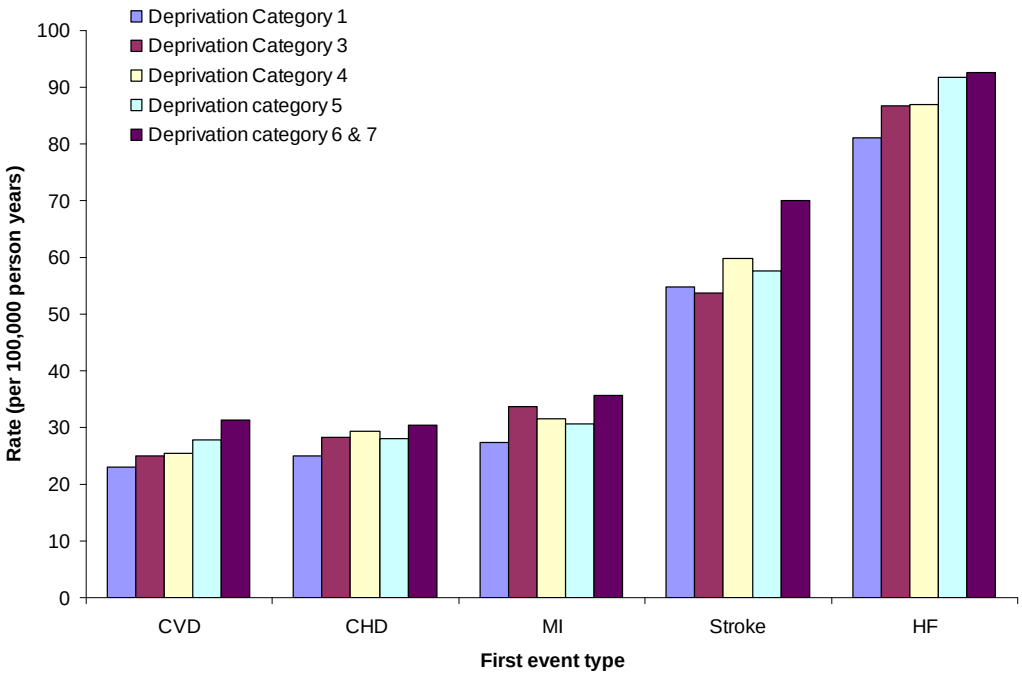
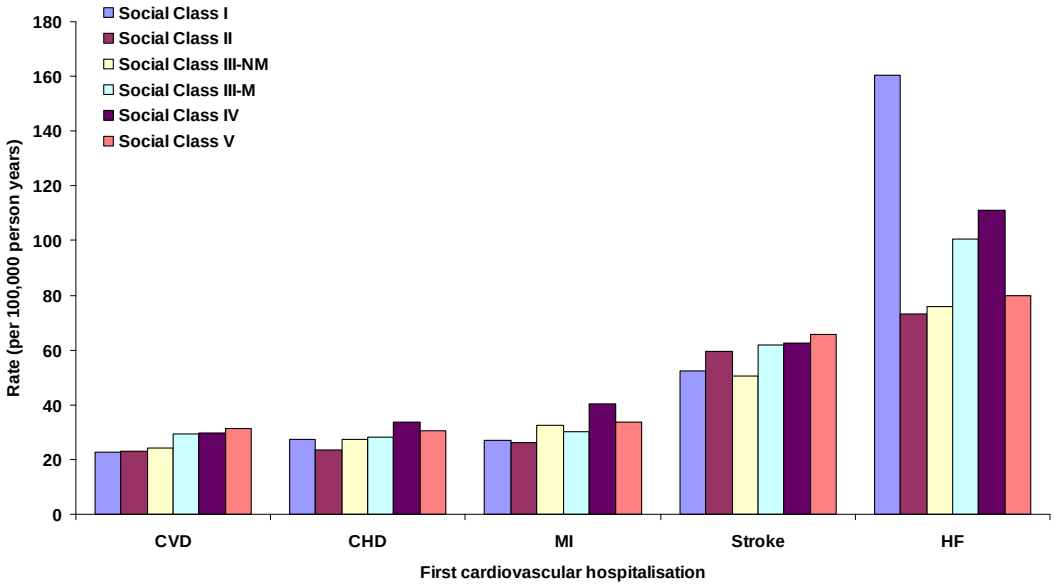


Figure 37 Rate of death following a first cardiovascular hospitalisation according to social class



Kaplan Meier Analysis

Following a cardiovascular hospitalisation the risk of death was higher in the most deprived during the remaining follow up (log rank p=0.0001) (Figures 38 and 39). A trend towards a similar association was seen with each of the other cardiovascular events though did not reach statistical significance (Figures 40-47).

Figure 38 Kaplan Meier analysis of death following a cardiovascular hospitalisation over follow up according to Carstairs Morris index

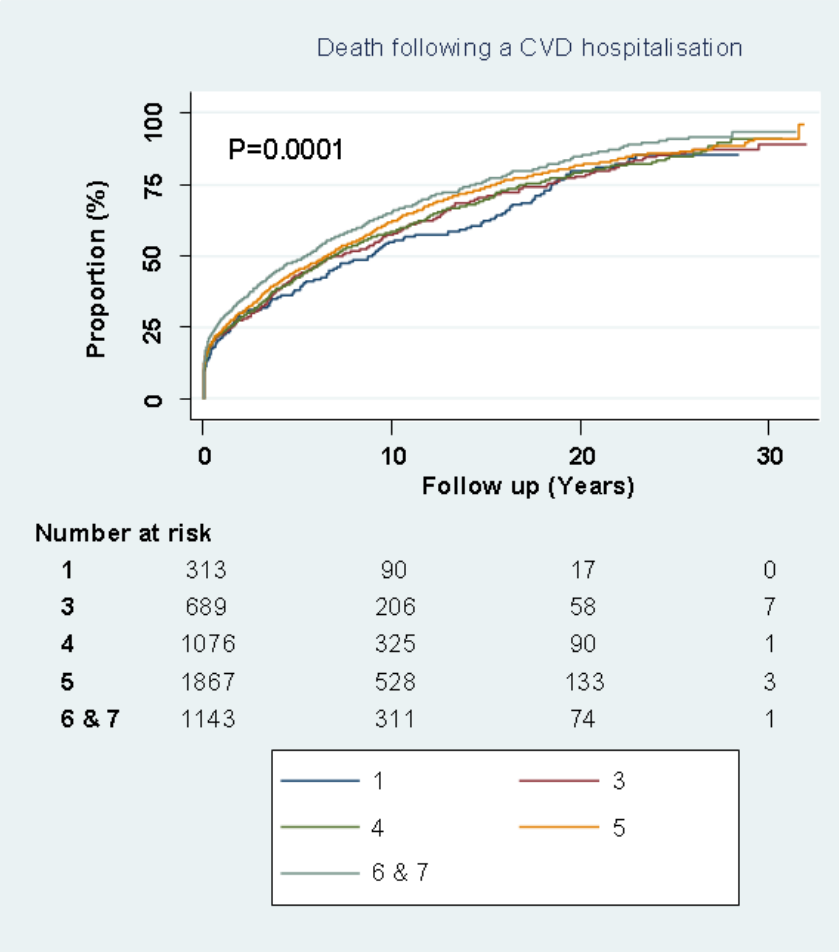


Figure 39 Kaplan Meier analysis of death following a cardiovascular hospitalisation over follow up according to social class

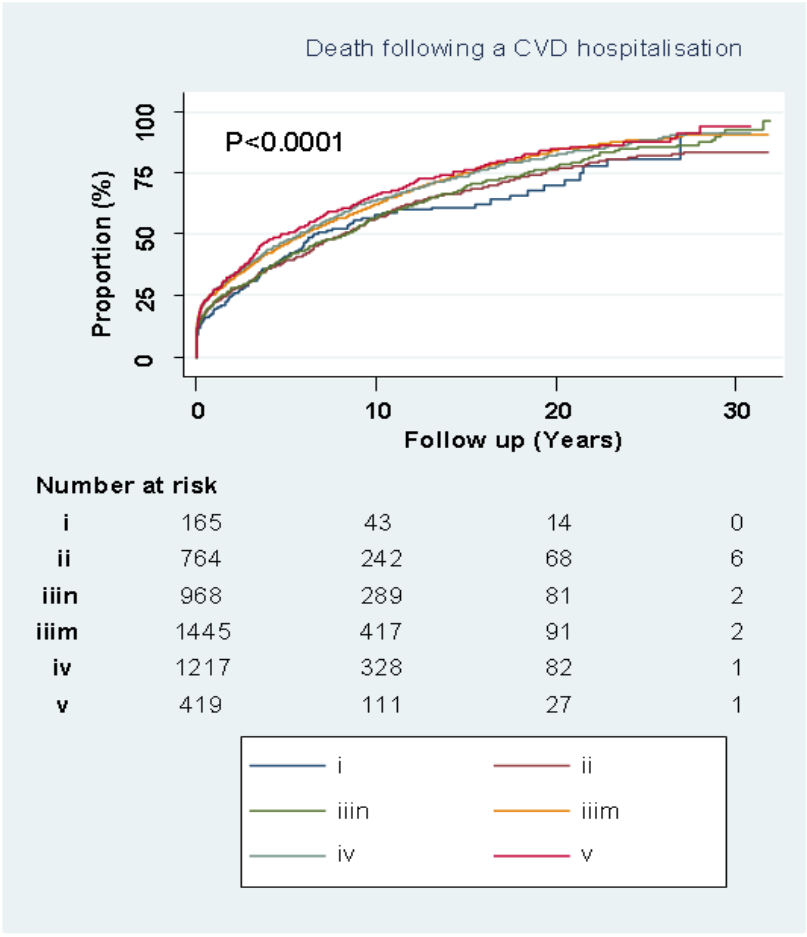


Figure 40 Kaplan Meier analysis of death following a coronary heart disease hospitalisation over follow up according to Carstairs Morris index

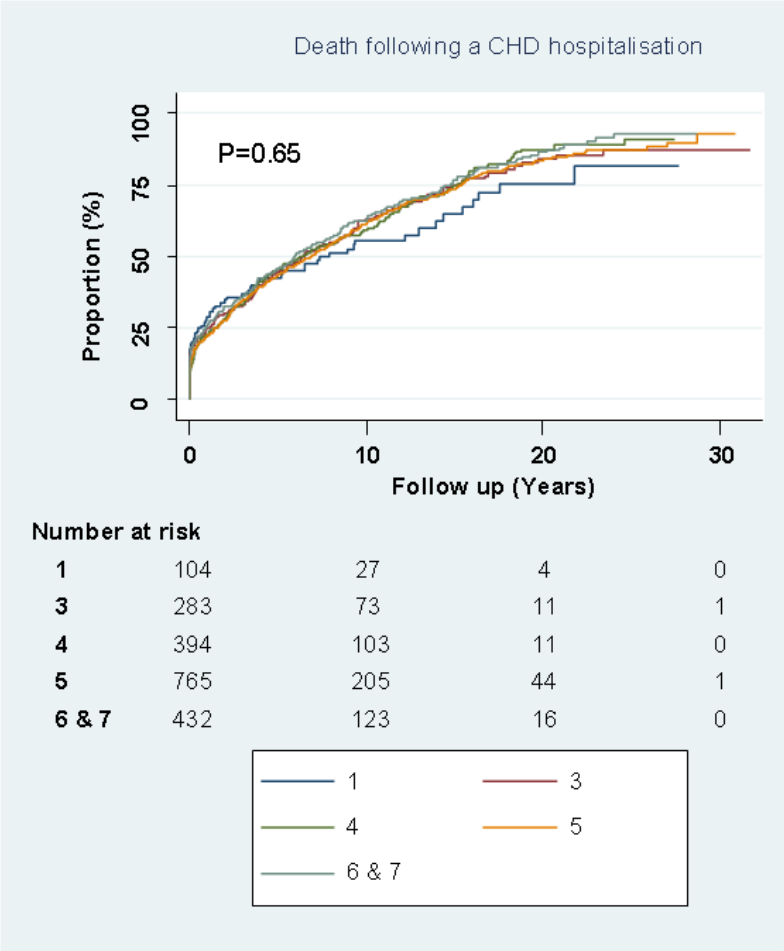


Figure 41 Kaplan Meier analysis of death following a coronary heart disease hospitalisation over follow up according to social class

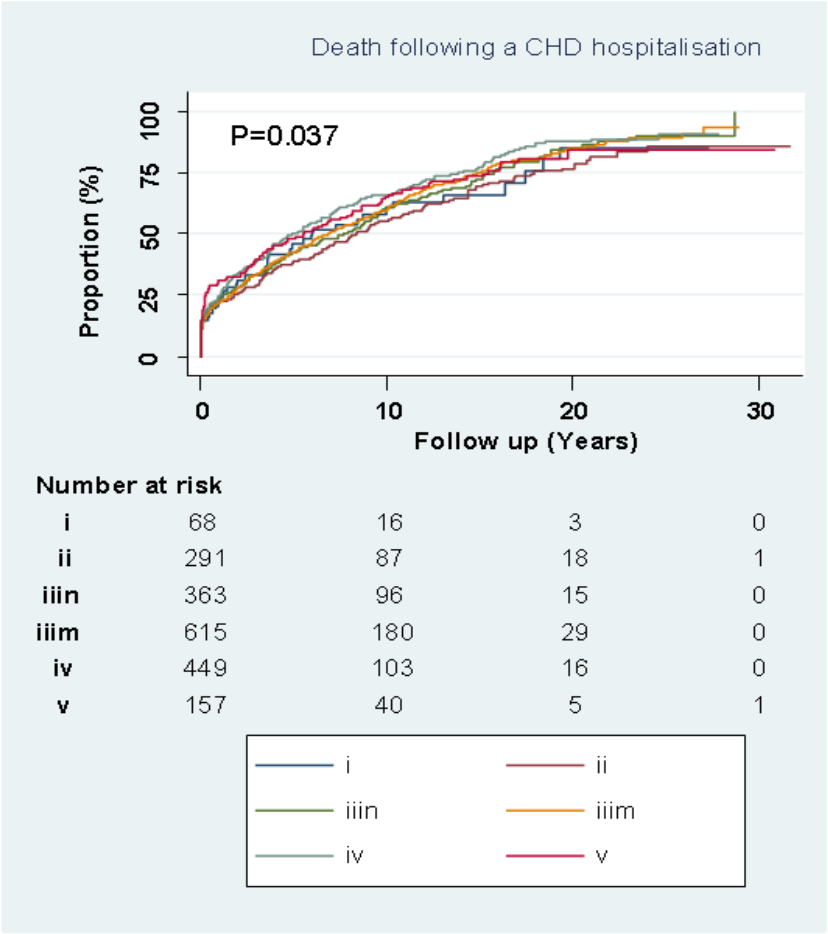


Figure 42 Kaplan Meier analysis of death following a myocardial infarction hospitalisation over follow up according to Carstairs Morris index

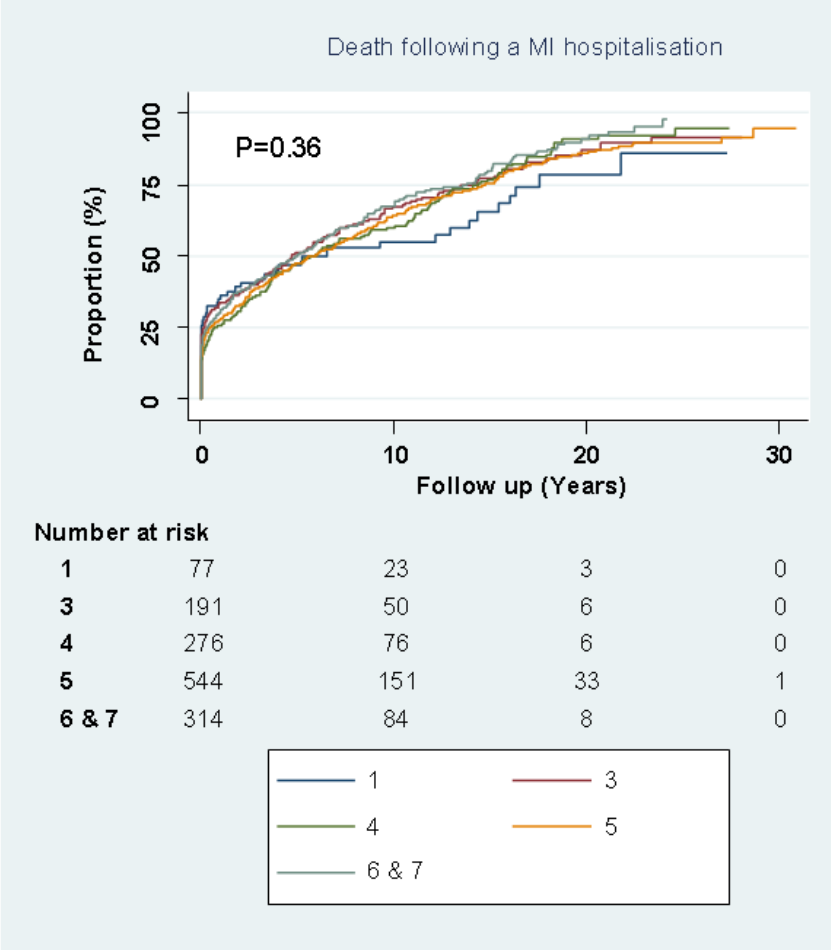


Figure 43 Kaplan Meier analysis of death following a myocardial infarction hospitalisation over follow up according to social class

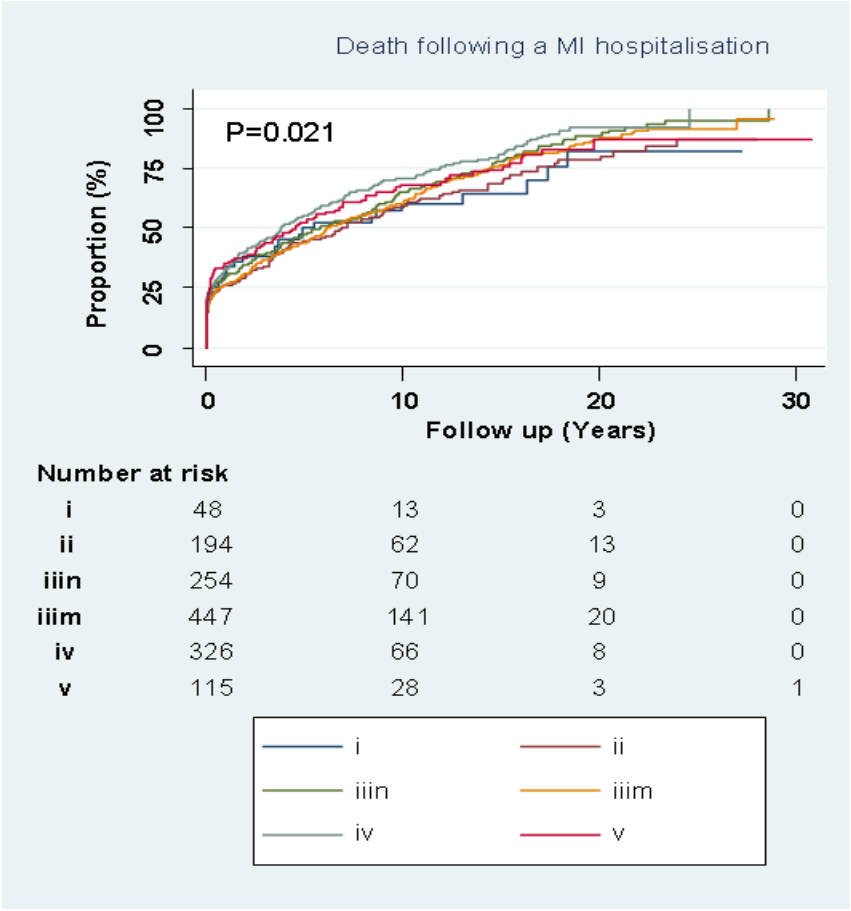


Figure 44 Kaplan Meier analysis of death following a stroke hospitalisation over follow up according to Carstairs Morris index

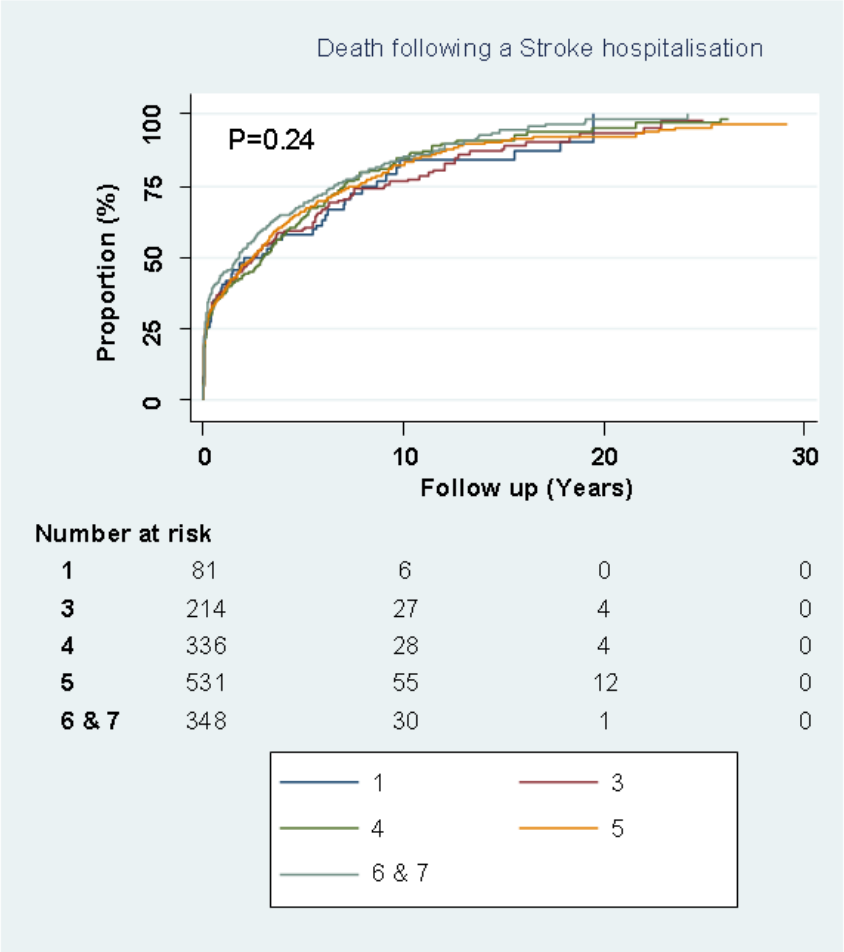


Figure 45 Kaplan Meier analysis of death following a stroke hospitalisation over follow up according to social class

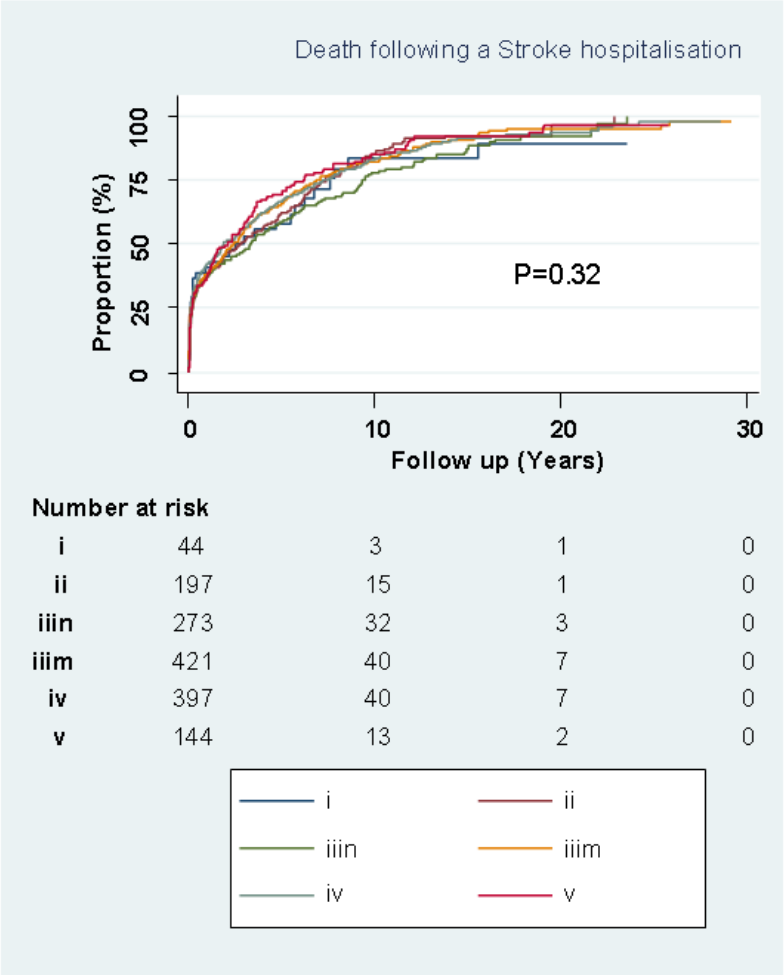


Figure 46 Kaplan Meier analysis of death following a heart failure hospitalisation over follow up according to Carstairs Morris index

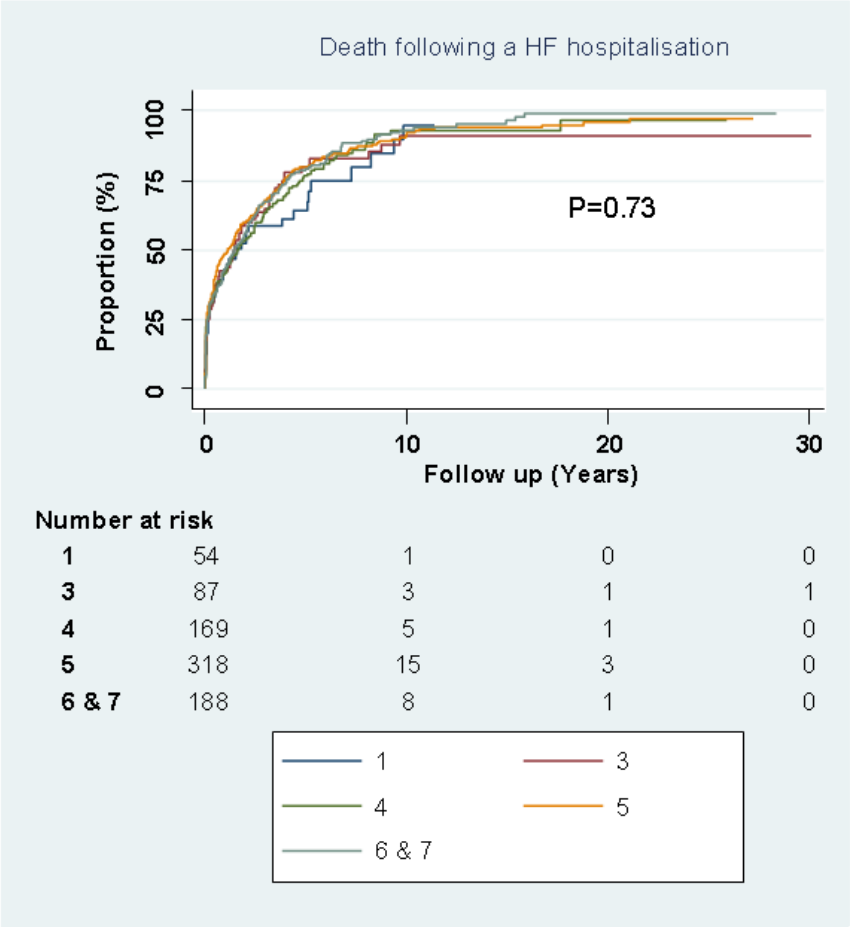
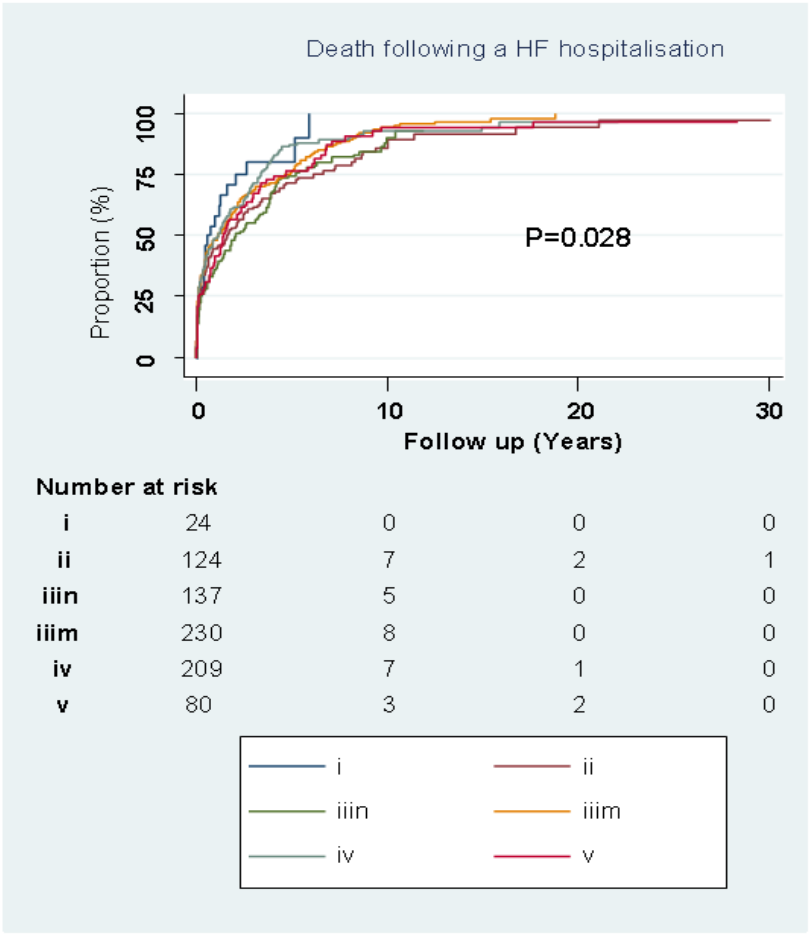


Figure 47 Kaplan Meier analysis of death following a heart failure hospitalisation over follow up according to social class



Adjusted survival

In a regression model the association between SED (measured by Carstairs Morris index) and death following an initial hospitalisation was examined (Table 55). In unadjusted analyses there was no association with SED. After adjustment for age at event and sex, a significantly higher risk of death following a hospitalisation for CVD, HR1.53 (1.31-1.79), CHD 1.38(1.05-1.81), and MI 1.37(1.01-1.87) was observed. After adjustment for the traditional risk factors (diabetes, cholesterol, systolic blood pressure) and the year of the initial event, these associations between SED and death following a CVD, CHD and MI event persisted. After further adjustment for BMI, FEV1 and cardiomegaly only the relationship between SED and death following a CVD hospitalisation remained significant. Whilst the risk of death following a stroke or HF hospitalisation did not reach statistical significance a trend towards an increased risk was observed. When social class was used to measure SED only recurrent CVD hospitalisations showed a statistically significant association with SED after adjustment for traditional risk factors (Table 56).

Table 55 Hazard of death following a first cardiovascular hospitalisation in the most versus least deprived as measured by Carstairs Morris index

	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
CVD	1.34	1.15	1.57	<0.001	1.53	1.31	1.79	<0.001	1.53	1.31	1.79	<0.001	1.38	1.18	1.63	<0.001
CHD	1.21	0.92	1.59	0.175	1.38	1.05	1.81	0.021	1.41	1.07	1.85	0.014	1.29	0.97	1.71	0.075
MI	1.28	0.94	1.73	0.119	1.37	1.01	1.87	0.044	1.42	1.04	1.93	0.026	1.31	0.95	1.80	0.099
Stroke	1.21	0.91	1.59	0.184	1.24	0.94	1.63	0.133	1.19	0.90	1.57	0.226	1.13	0.85	1.51	0.386
HF	1.21	0.86	1.71	0.272	1.39	0.98	1.97	0.065	1.36	0.96	1.93	0.085	1.34	0.93	1.92	0.115

Table 56 Hazard of death following a first cardiovascular hospitalisation in the most versus least deprived as measured by social class

	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
CVD	1.36	1.09	1.71	0.007	1.47	1.17	1.84	0.001	1.31	1.04	1.64	0.021	1.18	0.93	1.49	0.165
CHD	1.12	0.79	1.60	0.519	1.07	0.75	1.54	0.699	0.94	0.65	1.35	0.733	0.92	0.63	1.34	0.668
MI	1.22	0.81	1.84	0.349	1.24	0.85	1.80	0.267	0.89	0.59	1.35	0.584	0.91	0.59	1.40	0.664
Stroke	1.19	0.81	1.74	0.381	1.26	0.86	1.85	0.244	1.13	0.77	1.66	0.537	1.05	0.71	1.56	0.793
HF	0.72	0.44	1.17	0.187	0.71	0.43	1.16	0.174	0.64	0.39	1.06	0.083	0.63	0.37	1.07	0.086

*Unadjusted

**Adjusted for age at first hospitalisation and sex

† Adjusted for age at first hospitalisation, sex, diabetes, cholesterol, systolic blood pressure, smoking and year of first hospitalisation

‡ Adjusted for age at first hospitalisation, sex, diabetes, cholesterol, systolic blood pressure, smoking, year of first hospitalisation, body mass index, FEV1, cardiomegaly

Crude rate of death or subsequent recurrent hospitalisation

The numbers of each of the outcome of death or recurrent hospitalisation are shown in Tables 57 and 58. With the exception of cardiovascular disease and coronary heart disease there is an imbalance in the numbers of deaths as compared to recurrent myocardial infarction, stroke and heart failure hospitalisations.

Table 57 Number of deaths or recurrent hospitalisation according to first cardiovascular event and Carstairs Morris index

1st hospitalisation	Outcome	1	3	4	5	6 & 7
CVD	Death/CVD	96/149	242/335	386/533	669/908	449/547
CHD	Death/CHD	46/31	116/116	177/152	350/271	210/159
MI	Death/MI	41/12	110/45	152/63	321/113	199/57
Stroke	Death/Stroke	46/20	128/41	192/87	334/116	221/83
HF	Death/HF	27/16	49/23	91/55	194/95	112/60

Table 58 Number of deaths or recurrent hospitalisation according to first cardiovascular event and social class

1st hospitalisation	Outcome	I	II	IIIN	IIIM	IV	V
CVD	Death/ CVD	47/88	252/374	324/471	573/683	453/587	154/213
CHD	Death/ CHD	32/25	116/111	164/129	281/235	215/164	74/54
MI	Death/ MI	27/9	105/39	154/49	258/102	202/66	66/23
Stroke	Death/ Stroke	24/13	114/51	169/44	264/95	246/90	85/43
HF	Death/ HF	13/10	65/43	72/42	146/61	126/64	46/25

The rate of death or subsequent recurrent hospitalisation was examined. A clear gradient of risk emerged in the risk of recurrent hospitalisation when death was included in the composite endpoint when SED was measured by Carstairs Morris index. The relationship

was not as clear with social class as the measure of SED. The rate ratios are given below in Table 59 and 60 and the rates displayed in Figures 48 and 49.

Table 59 Rate ratio for death or recurrent hospitalisation according in the most versus least deprived as measured by Carstairs Morris index

Initial hospitalisation	Subsequent hospitalisation	RR	95% CI		P
CVD	Death/CVD	1.24	1.08	1.43	0.0025
CHD	Death/CHD	1.36	1.07	1.74	0.0135
MI	Death/MI	1.35	1.01	1.82	0.0447
Stroke	Death/Stroke	1.26	0.96	1.64	0.0964
HF	Death/HF	1.47	1.05	2.06	0.0239

Table 60 Rate ratio for death or recurrent hospitalisation according in the most versus least deprived as measured by social class

Initial hospitalisation	Subsequent hospitalisation	RR	95% CI		P
CVD	Death/CVD	1.18	0.97	1.44	0.09
CHD	Death/CHD	0.96	0.70	1.31	0.78
MI	Death/MI	1.10	0.74	1.63	0.64
Stroke	Death/Stroke	1.23	0.85	1.78	0.28
HF	Death/HF	0.63	0.39	1.02	0.055

Figure 48. Rate of death or recurrent hospitalisation according to first cardiovascular event type and Carstairs Morris index

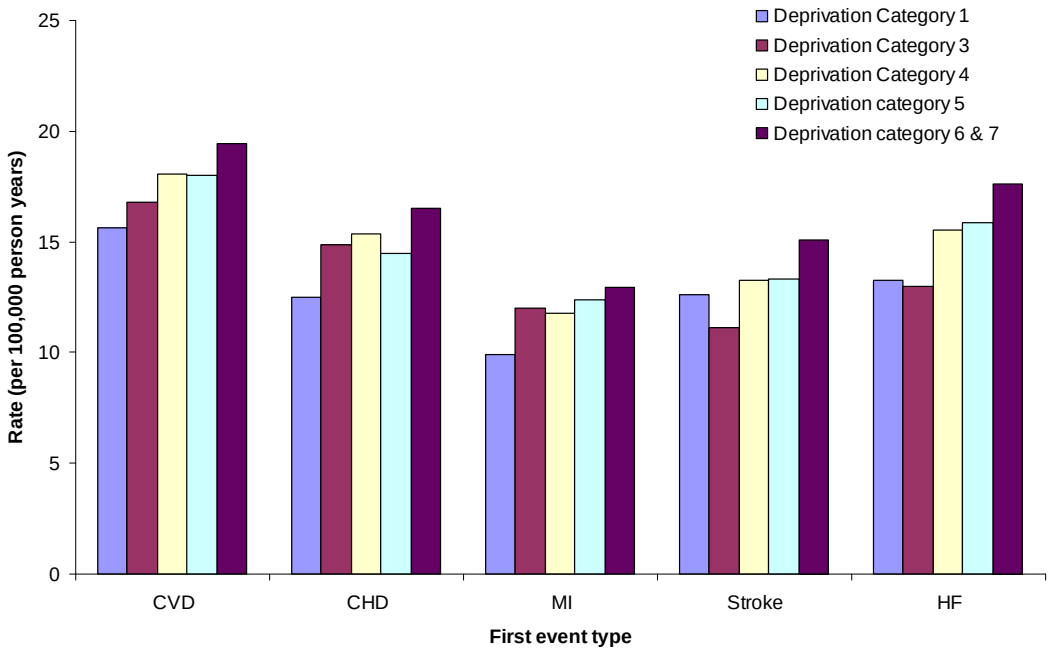
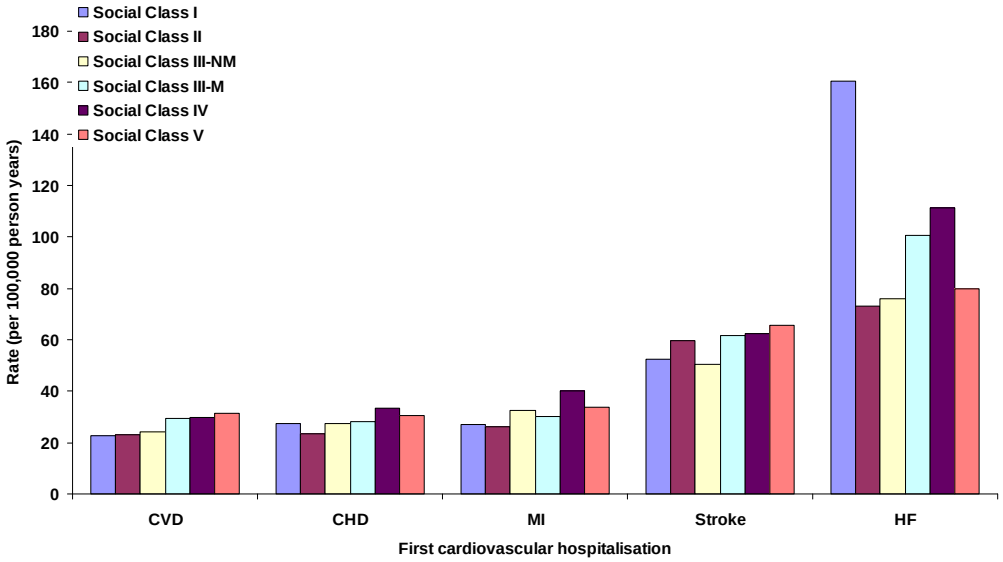


Figure 49 Rate of death or recurrent hospitalisation according to first cardiovascular event type and social class



Kaplan Meier analysis of the risk of death or recurrent cardiovascular hospitalisation

Kaplan Meier analysis of the association between SED and the composite outcome of death or recurrent hospitalisation illustrated the higher risk experienced by the most deprived versus the least deprived (Figures 50-59). Whilst the association was not statistically significant for those who had experienced a coronary hospitalisation or myocardial infarction, the higher risk was still evident in the most deprived.

Adjusted rates

The hazard of recurrent hospitalisation or death varied according to socioeconomic deprivation when measured by Carstairs Morris index (Table 61). This association was statistically significant for CVD and subsequent death or CVD, CHD and subsequent death or CHD even after adjustment for traditional risk factors. The risk of death or recurrent MI was associated with SED in the unadjusted and adjusted analyses although just failed to reach statistical significance. There was no clear association with social class (Table 62).

Figure 50 Kaplan Meier analysis of death or recurrent cardiovascular hospitalisation following a cardiovascular hospitalisation over follow up according to Carstairs Morris index

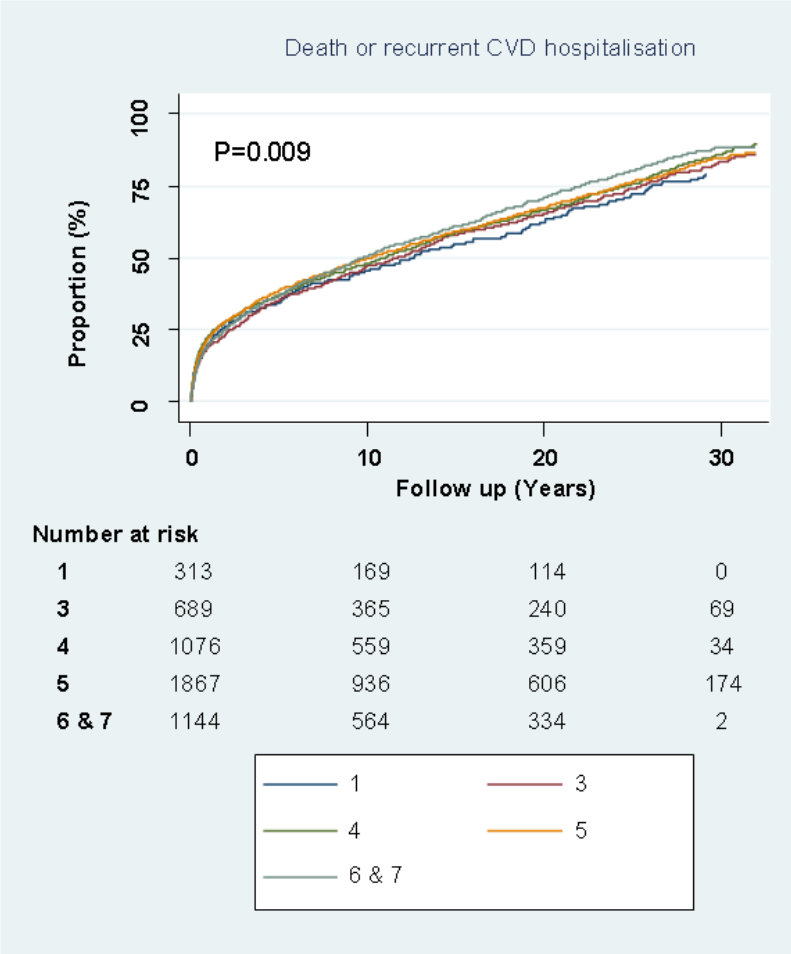


Figure 51 Kaplan Meier analysis of death or recurrent cardiovascular hospitalisation following a cardiovascular hospitalisation over follow up according to social class

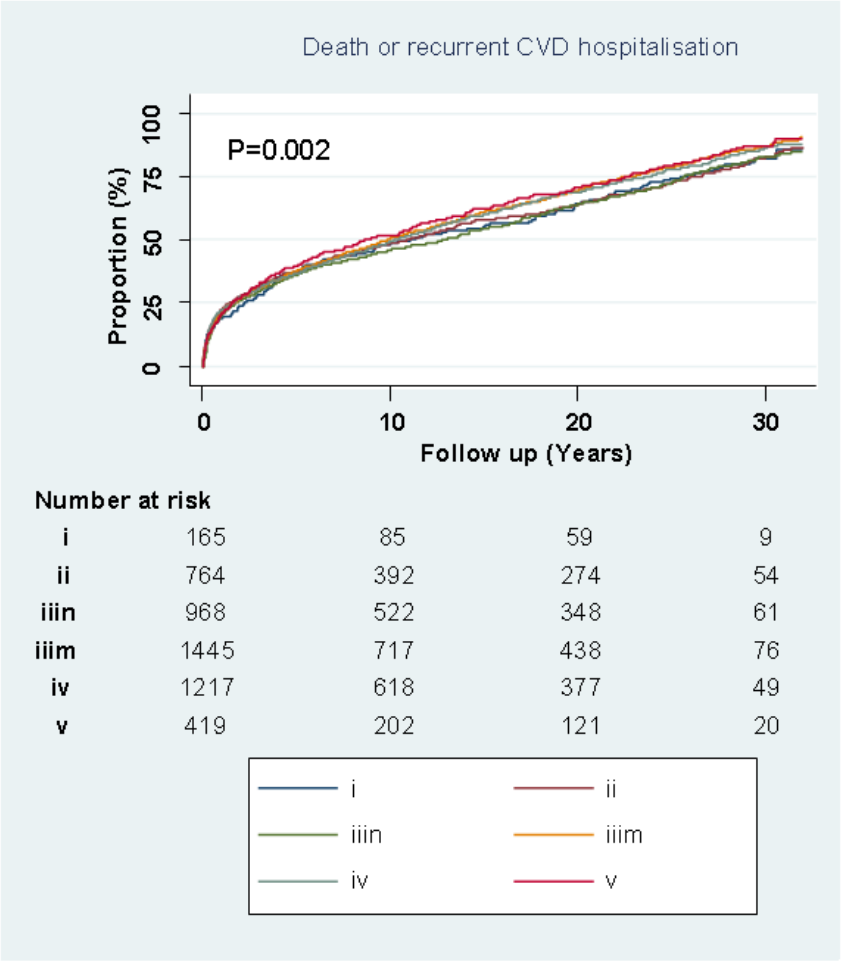


Figure 52 Kaplan Meier analysis of death or recurrent coronary hospitalisation disease event following a coronary heart disease hospitalisation over follow up according to Carstairs Morris index

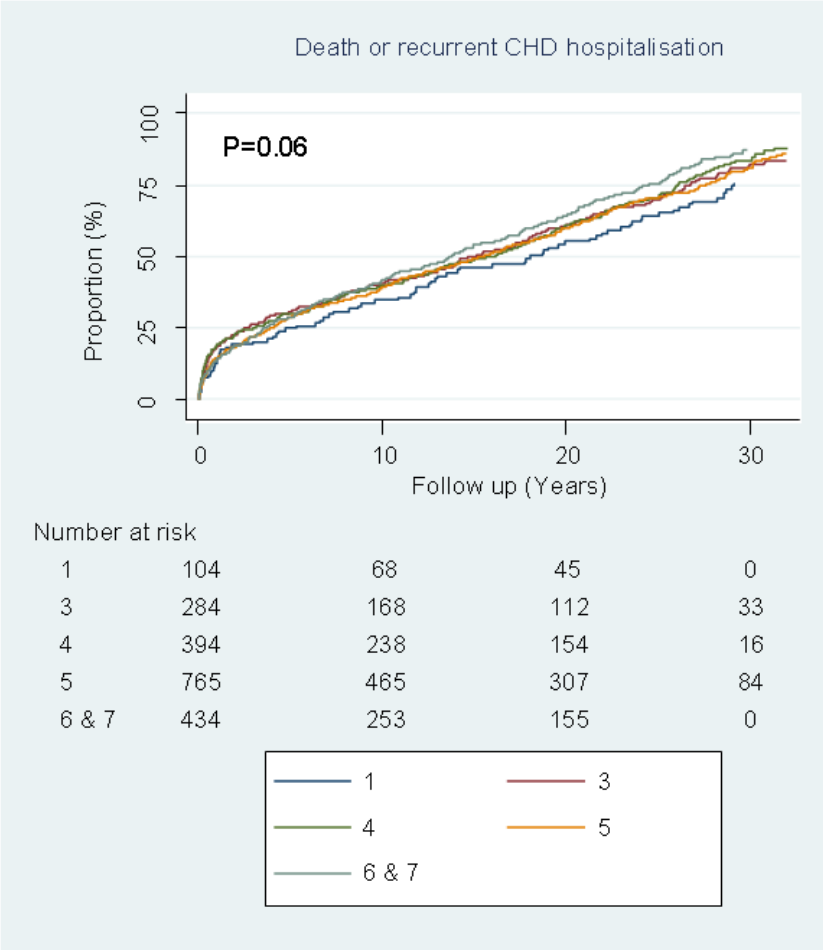


Figure 53 Kaplan Meier analysis of death or recurrent coronary heart disease hospitalisation following a coronary heart disease hospitalisation over follow up according to social class

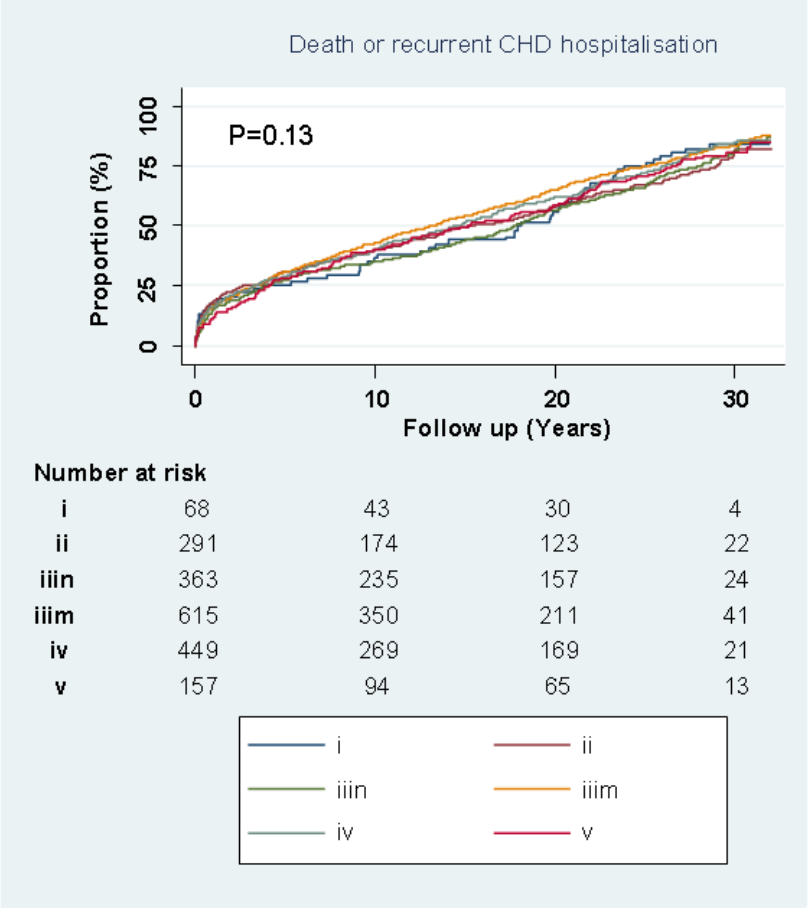
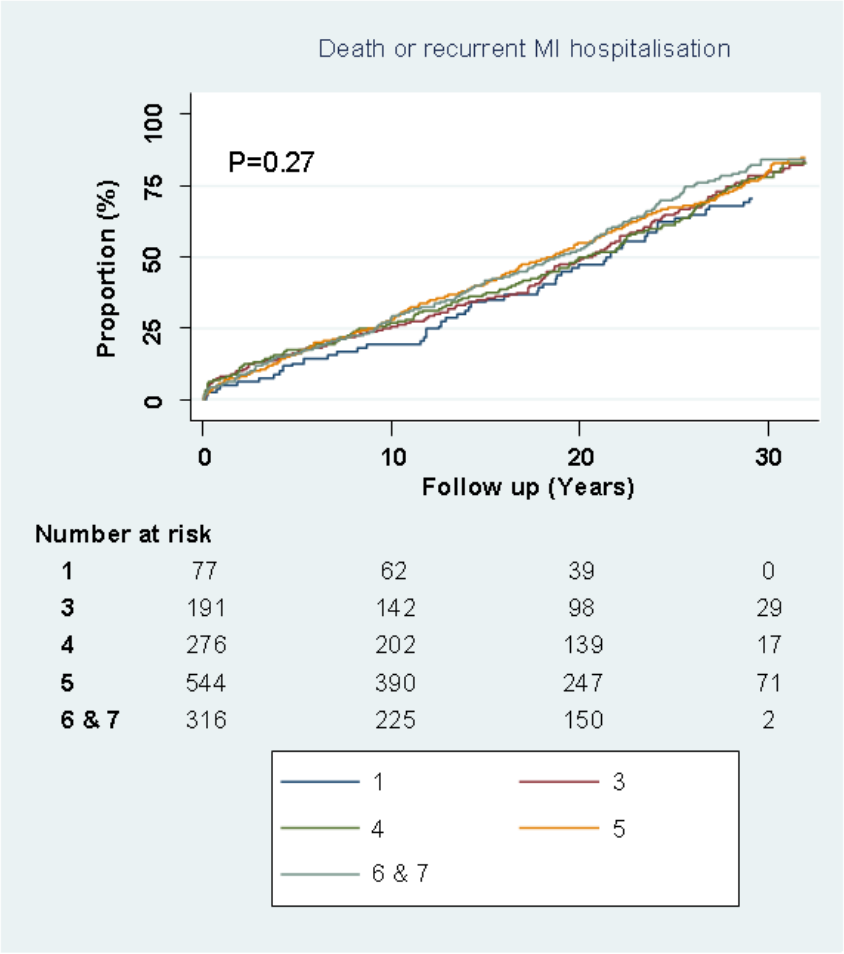
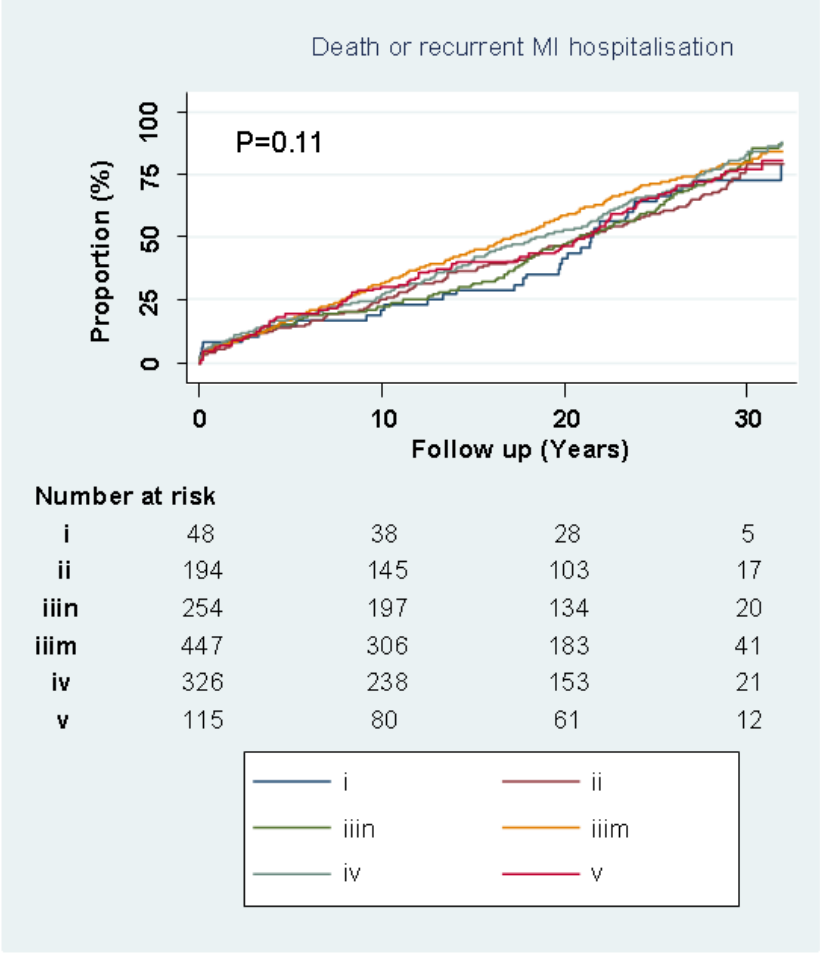


Figure 54 Kaplan Meier analysis of death or recurrent myocardial infarction hospitalisation following a myocardial infarction hospitalisation over follow up according to Carstairs Morris index



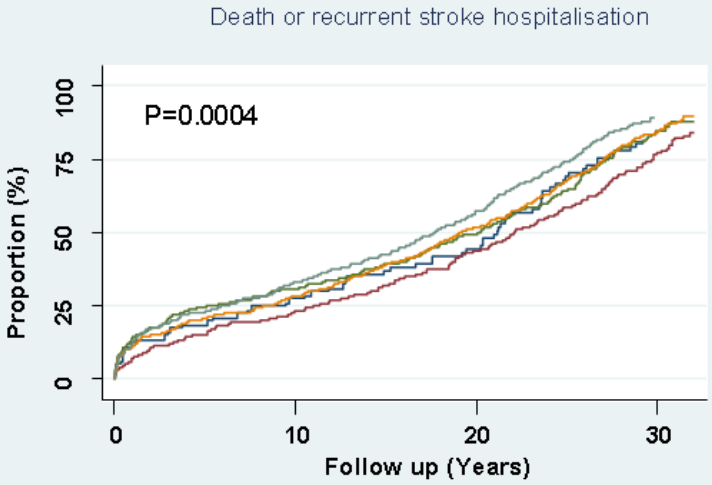
Number at risk				
1	77	62	39	0
3	191	142	98	29
4	276	202	139	17
5	544	390	247	71
6 & 7	316	225	150	2

Figure 55 Kaplan Meier analysis of death or recurrent myocardial infarction hospitalisation following a myocardial infarction hospitalisation over follow up according to social class



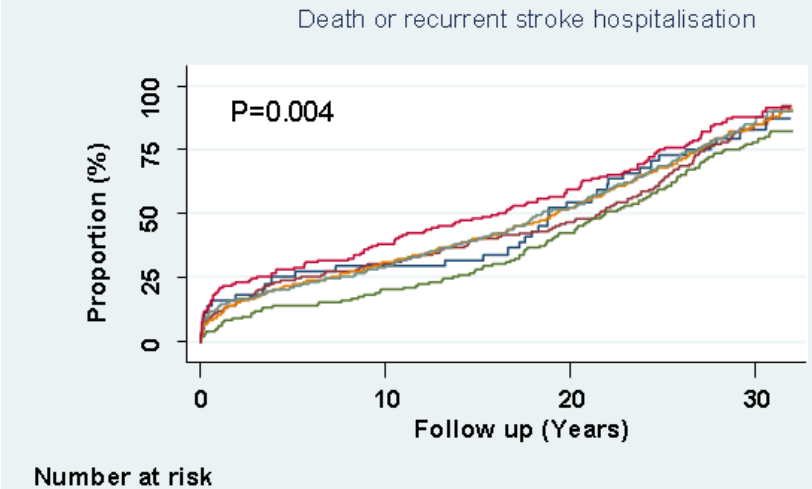
Number at risk				
i	48	38	28	5
ii	194	145	103	17
iiin	254	197	134	20
iiim	447	306	183	41
iv	326	238	153	21
v	115	80	61	12

Figure 56 Kaplan Meier analysis of death or recurrent stroke hospitalisation following a stroke over follow up according to Carstairs Morris index



Number at risk				
1	81	59	45	0
3	214	164	120	31
4	336	232	170	15
5	531	380	256	59
6 & 7	348	233	150	0

Figure 57 Kaplan Meier analysis of death or recurrent stroke hospitalisation following a stroke over follow up according to social class



Number at risk				
i	44	31	20	5
ii	197	137	105	10
iiin	273	218	157	29
iiim	421	290	201	32
iv	397	281	190	18
v	144	89	58	8

Figure 58 Kaplan Meier analysis of death or recurrent heart failure hospitalisation following a heart failure hospitalisation over follow up according to Carstairs Morris index

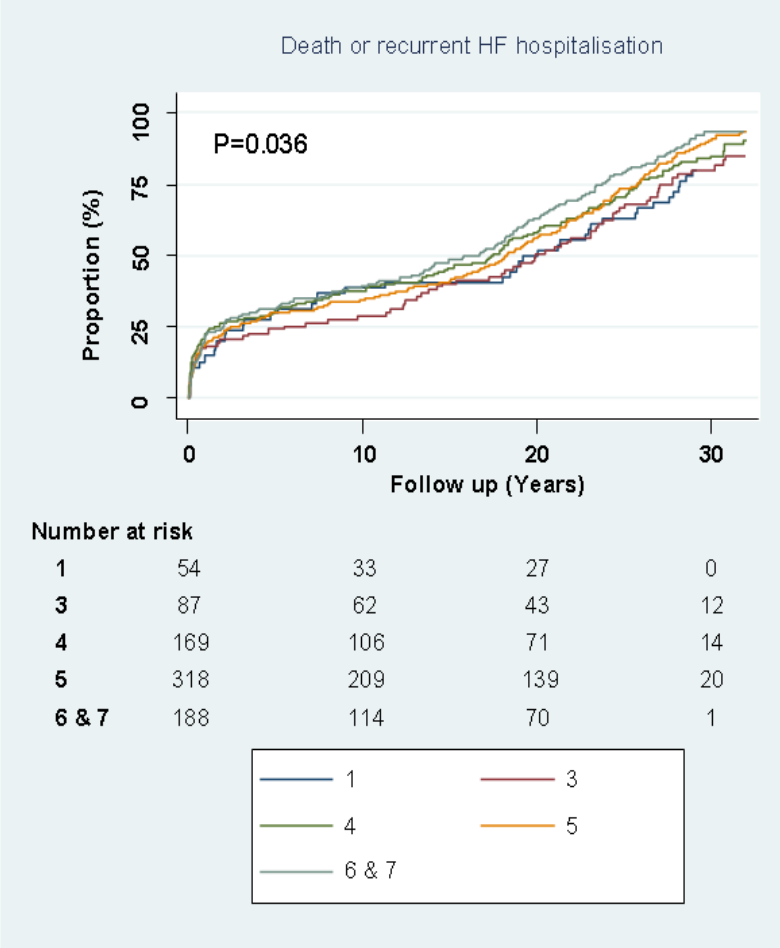


Figure 59 Kaplan Meier analysis of death or recurrent heart failure hospitalisation over follow up according to social class

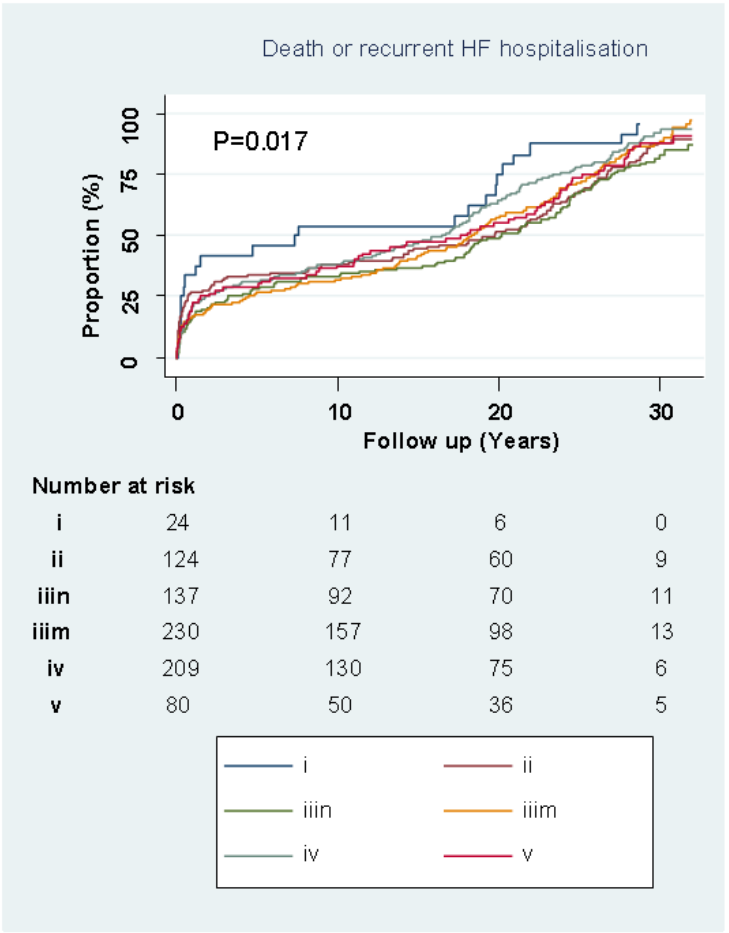


Table 61 Hazard of death or recurrent cardiovascular hospitalisation in the most versus least deprived as measured by Carstairs Morris index.

Initial hospitalisation	Subsequent Event	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
CVD	Death/CVD	1.23	1.07	1.42	0.004	1.21	1.05	1.40	0.007	1.22	1.06	1.41	0.005	1.14	0.98	1.31	0.08
CHD	Death/CHD	1.35	1.05	1.72	0.017	1.31	1.02	1.67	0.033	1.35	1.06	1.73	0.017	1.30	1.01	1.67	0.044
MI	Death/MI	1.34	1.00	1.80	0.054	1.34	1.00	1.81	0.051	1.34	1.00	1.81	0.052	1.25	0.92	1.70	0.147
Stroke	Death/Stroke	1.25	0.95	1.63	0.106	1.23	0.94	1.60	0.133	1.18	0.90	1.54	0.233	1.15	0.87	1.50	0.328
HF	Death/HF	1.46	1.04	2.04	0.027	1.24	0.88	1.73	0.218	1.21	0.86	1.70	0.269	1.12	0.79	1.59	0.532

Table 62 Hazard of death or recurrent cardiovascular hospitalisation in the most versus least deprived as measured by social class

Initial hospitalisation	Subsequent Event	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
CVD	Death/CVD	1.18	0.97	1.44	0.098	1.29	1.06	1.57	0.012	1.13	0.92	1.37	0.242	1.08	0.88	1.33	0.458
CHD	Death/CHD	0.95	0.70	1.30	0.758	1.01	0.73	1.38	0.971	0.82	0.59	1.13	0.217	0.83	0.59	1.15	0.257
MI	Death/MI	1.15	0.78	1.67	0.481	1.31	0.89	1.92	0.169	0.93	0.64	1.37	0.726	0.94	0.63	1.41	0.776
Stroke	Death/Stroke	1.13	0.79	1.61	0.511	1.16	0.81	1.66	0.429	0.93	0.65	1.33	0.685	0.95	0.65	1.38	0.778
HF	Death/HF	0.63	0.39	1.01	0.055	0.63	0.39	1.01	0.057	0.63	0.39	1.02	0.06	0.57	0.35	0.94	0.026

*Unadjusted

**Adjusted for age at first hospitalisation and sex

† Adjusted for age at first hospitalisation, sex, diabetes, cholesterol, systolic blood pressure, smoking and year of first hospitalisation

‡ Adjusted for age at first hospitalisation, sex, diabetes, cholesterol, systolic blood pressure, smoking, year of first hospitalisation, body mass index, FEV1, cardiomegaly

Discussion

As described earlier in the first chapter, SED is related to the first occurrence of a cardiovascular event after adjustment for multiple cardiovascular risk factors. However, little evidence is available from the literature to suggest that SED is related to the risk of a recurrent cardiovascular hospitalisation.[92,105] The analyses presented here indicate that SED is not associated with a higher risk of a recurrent cardiovascular hospitalisation but is associated with a higher risk of death. A composite outcome of death or recurrent hospitalisation revealed similar trends, mainly driven by the association with death.

Risk of a recurrent hospitalisation

It is somewhat surprising that the risk of recurrent hospitalisation was not related to SED. It has been reported that the most deprived individuals receive less intensive therapy for their cardiovascular disease. For example, the most deprived are less likely to receive aspirin, beta-blockers and thrombolysis for myocardial infarction[230] and rehabilitation following a stroke[118]. Those with ischaemic heart disease as less likely to be referred for surgical (coronary artery bypass grafting[79]) or percutaneous (coronary angioplasty[79,231,232]) revascularisation with possibly detrimental effects on subsequent mortality[93]. For those who experience a stroke, rates of carotid endarterectomy were not different according to SED but waiting times were longer in the most deprived in one study from Canada [118]. Furthermore, more deprived individuals are less likely to adhere to preventative medications[233] and attend rehabilitation classes[234,235] and then to complete them[235]. Finally, lifestyle modification is recommended following the development of cardiovascular disease but in a cohort of survivors of a myocardial infarction, the most deprived were less likely to reduce their alcohol intake, exercise and adopt a healthier diet.[236] As many of these therapies and interventions potentially reduce morbidity as well as mortality we may expect that the rates of recurrent cardiovascular events would be higher amongst the most deprived who do not receive these treatments or make such changes. However, the lack of such treatments may predispose the most deprived to a greater risk of death following their cardiovascular hospitalisation and this was evident in this cohort. As a consequence it may be that the most deprived simply die before they can experience a recurrent cardiovascular hospitalisation. In analyses where a composite of death or recurrent cardiovascular event were performed the most deprived were at higher risk. However, from these results I can only hypothesise that this is the case for all recurrent CVD hospitalisations as the composite was balanced in terms of numbers of events for the fatal and non-fatal parts of

the outcome. For all the other composite outcomes, death with CHD, MI, stroke or HF, the composite outcome mainly consisted of deaths.

After experiencing and surviving a cardiovascular event, it is perhaps unsurprising that SED, as measured by an area based measure, would continue to confer an excess risk of death or recurrence of cardiovascular disease. After discharge it is highly likely that the individual will return to their home and their neighbourhood. Therefore, all the potential causal mechanisms associated with living in a deprived area will still be present, e.g. higher crime, damp housing, poor access to health services, lack of leisure activity etc. These will therefore continue to exert a potentially detrimental effect on health.

Following a cardiovascular event it is possible that individuals may become too ill to continue to work. One confounding issue that I was not able to address was the potential bias that following a cardiovascular event an individual's social status may change. Due to continuing ill health an individual may not return to work. This would then lower their socioeconomic status, thus, possibly increasing their risk of a subsequent mortality and possibly cardiovascular events. Indeed, there is evidence that following a myocardial infarction recovery of functional status is poorer in the most deprived as compared to least deprived in one study of men[237], and, that following a stroke, greater levels of disability are experienced by the most deprived[238], both factors which could lead to a loss of employment.

A number of studies have reported that more deprived individuals present with more severe disease during their first event. This may explain the higher risk of death and trend toward a higher risk of recurrent hospitalisations amongst the most deprived. There is no more severe a presentation than death and a number of studies of coronary heart disease have reported that more deprived individuals are less likely to reach hospital alive when presenting with CHD. In the MONICA studies individuals with a first myocardial infarction were less likely to reach hospital alive if they were deprived.[61] In another study of coronary deaths in Scotland, the most deprived were more likely to die out of hospital with a first coronary event.[64] In a study of patients with MI admitted to a coronary care unit more individuals in the deprived cohort presented with heart failure.[133] A number of studies have reported that stroke severity is higher in the most deprived as compared to the least deprived.[115,117] In one study, the most deprived were more likely to be dependant for their activities of daily living at 28 days following a stroke.[99] It has also been reported that stroke longer term disability and handicap are higher in the most deprived.[238] Again we may expect that the greater severity of disease in the most deprived would increase rates of

recurrent events, but it may simply serve to increase case fatality and mortality, reducing the chances of a deprived individual to experience further non-fatal outcomes.

It is not only the presentation that is more severe in patients with CVD. Following a cardiovascular event, multiple studies have demonstrated that access to health care professionals is lower during or after an event. In individuals with HF[129], stroke[119] and coronary disease, the most deprived were less likely to be treated by a specialist, attend a high volume i.e. expert hospital, and receive appropriate investigations or further interventions[113]. All of these factors may explain the higher rates of death and possibly recurrence. Indeed, when discharged following a cardiovascular hospitalisation a deprived individual may be less likely to have contact with their general practitioner. In a study from primary care practices from Scotland those deprived individual with a diagnosis of HF were less likely to see their general practitioner each year than the least deprived individuals with the diagnosis of HF.[121]

In general deprived individuals tend to exhibit a higher burden of other diseases too. Prior studies have documented a higher prevalence in the deprived of comorbidities that increase the risk of death following a cardiovascular event such as diabetes, chronic obstructive airways disease, cancer and renal impairment.[77,92] This differential distribution of comorbidities may partly explain why more deprived individuals are more likely to die following a cardiovascular event.

Limitations

In these analyses the adjustment was made for risk factors that were measured prior to the first hospitalisation an individual experienced. This may bias the result, as risk factors may have changed subsequent to experiencing a first cardiovascular hospitalisation.[236] It is unlikely that factors such as cholesterol and blood pressure changed substantially as it has only been possible to modify these risk factors adequately through pharmacotherapy in the latter period of follow up.

The choice of adjusting variables may also have been incorrect. Whist the risk factors of smoking, blood pressure, diabetes and cholesterol may have a deleterious effect on the risk of a first cardiovascular event[67], other factors related to the form of cardiovascular event experienced, e.g. disability following stroke[117], heart failure after a myocardial infarction[77,92], may be more important mediators of subsequent risk following a

cardiovascular event. However, for risk factors such as diabetes, the risk associated with them persists following a first cardiovascular hospitalisation such as heart failure.[239]

Summary

The risk of death or a recurrent cardiovascular hospitalisation is higher in the most deprived as compared to the least deprived. This is mainly driven by the higher rates of death amongst the most deprived. The risk of recurrent hospitalisations displays a trend towards higher rates in the deprived though this was not consistent or statistically significant. This may be due to the fact that socioeconomic status changes following a cardiovascular hospitalisation or that other factors are more important once cardiovascular disease has led to a hospitalisation in an individual.

In the next chapter I will explore how SED is related to the total hospital burden of CVD. On the basis of the last chapter where was associated with a higher risk of subsequent mortality but not recurrent cardiovascular hospitalisations, and the chapter before where SED was associated with a greater risk of a first hospitalisations for CVD, it remains to be seen what the total burden by SED is.

The Burden of Cardiovascular Disease and Death

In this section I will examine the burden of disease in relation to SED. Firstly the rate of death and premature deaths will be determined, including cardiovascular deaths. The numbers of hospitalisations according to SED for each cardiovascular disease type will be described. The costs associated with CVD hospitalisations will be calculated by SED. The population attributable fraction of SED in relation to a number of cardiovascular disease types will be calculated.

Methods

Burden of cardiovascular disease

Hospital burden

Using the linked Scottish Morbidity Record data the number of discharges for a particular cardiovascular disease type was calculated. The length of stay in hospital for the entire stay pertaining to that admission was calculated. Mean length of stay for each cardiovascular cause was calculated. The total time a person spent out of hospital before their first cardiovascular event was calculated from the time on enrolment to the first admission with that cardiovascular disease type. Time spent in hospital was computed over the length of follow up and the time free from hospital also calculated. Analyses were stratified by SED.

Burden of death

Using the linked General Registrar Office data on deaths, the number of deaths in each socioeconomic group was calculated. The number of days from enrolment to the end of study or death was calculated according to SED and the number of days until death was calculated. Deaths occurring before a specific age were also calculated. At the start of the study the life expectancy of the cohort was until the age of 75 years approximately (71 years for men and 76 years for women). This figure was obtained from the General Register Office records of life expectancy from the 1970-1972 census for individuals aged 45-64 years of age at that time (personal communication, General Register Office, 2008). All analyses of deaths have examined deaths at end of follow up of the cohort. In addition to ascertain if SED had an effect on premature deaths, deaths at age 65 and 70 years, and 75 (life expectancy) were calculated. These were stratified by SED.

Adjusted risk of death

The adjusted risk of death was calculated using Cox regression. The effect of SED was tested in unadjusted and age and sex adjusted models. Models were then additionally adjusted for traditional cardiovascular risk factors (diabetes, smoking, cholesterol and systolic blood pressure). Finally, other factors known to influence cardiovascular and all cause mortality were added to the model (body mass index, FEV1, cardiomegaly).

Population attributable fraction

The contribution of a risk factor to a disease or a death can be quantified using the population attributable fraction (PAF). The PAF is the proportional reduction in population disease or mortality that we would expect to occur if exposure to that risk factor were reduced to an alternative ideal exposure scenario (e.g. reduction of smoking levels to nil). As with cardiovascular disease, many diseases are caused by multiple risk factors, therefore, individual risk factors may interact in their impact on overall risk of disease. Consequently, PAFs for individual risk factors often overlap and add up to more than 100 percent.

The PAF can be calculated using the formula below:

$$\mathrm{AF} = \Pr(\mathrm{exposed}|\mathrm{disease})\left(1 - \frac{1}{\mathrm{RR}}\right)$$

Where:

Pr = proportion of population at exposure level with the outcome

RR = relative risk

For risk factors with continuous rather than discrete exposure levels there is an analogous formula for PAF involving integration of the exposure level distribution.

However, as noted, calculation of the population attributable fraction can in theory lead to all percentages adding to over 100%. This is of course counterintuitive. Furthermore, the method above makes no allowance for the potential confounders of the outcome. By failing

to adjust for confounders the potential attributable fraction will be overestimated. A number of methods are available to adjust for this concern. The commonest approach is to use the Levin formula:

$$AF_{Levin} = \frac{p \cdot (RR-1)}{1+p \cdot (RR-1)}$$

Where p = the prevalence of the risk factor and RR = the relative risk estimate.

This method requires the assumption that the number of cases in the exposed is the same as the unexposed. An assumption that would be violated in this setting. Furthermore, this approach can also yield results that add to over 100%. Adjusted risk estimates can also be used in this formula. However this method yields inconsistent and biased results.

The calculation of the average attributable fraction overcomes these limitations by producing an estimate of the attributable fraction from a multivariable model adjusted for other factors.[240] It uses a logistic regression model to calculate the attributable fraction using the following method:

1. The risk factor is coded into a dichotomous variable.

2. Predicted probabilities for each individual are calculated using the following formula:

$$pp_i = \frac{1}{1+\exp(-(\alpha+\beta' x_i))}$$

   Where alpha = the estimate of the intercept for the regression model, beta = the parameter vector for the covariate in the model and x_i = the observations of the covariates for each individual with the removed variable set to zero for all individuals

3. The sum of the predicted probabilities is the adjusted number of cases that would be expected if the risk factor was removed from the population

4. The average attributable fraction is calculated by subtracting the expected cases calculated above from the observed number of cases and then dividing by the observed number of cases.

Using this method more meaningful results and unbiased results of the proportion of disease attributable to a risk factor in a population can be obtained. In these analyses both the simple formula for attributable fraction and the average attributable fraction are used. As the average attributable fraction requires that variables be dichotomous, age was split in to age 45-54 years and 55-64 years, blood pressure into groups <140mmHg and ≥140mmHg, cholesterol into groups <5 mmol/l and ≥5 mmol/l and SED into Carstairs Morris index categories 1,3 and 4 (the least deprived) and 5,6 and 7(the most deprived) and social class into I,II, III-NM and III-M, IV and V.

Economic costs

The cost associated with a cardiovascular admission was calculated for each socioeconomic group. The cost associated with each type of cardiovascular disease type was also calculated. The costs pertaining to the admission type were calculated using the NHS Greater Glasgow and Clyde costs for 2007 from the NHS cost book.[241] The health board costs for a particular type of admission are collated by the Information Services Division of NHS Scotland and updated every year. The summary costs for the whole health board were used to try and ensure that a representative figure was used that captured the possibility that individuals may have been admitted to hospitals across the Glasgow area during their lifetime.

Inflation

To account for inflation over time the costs for admissions in NHS Greater Glasgow and Clyde from 2007 were taken and discounted back by 5% per annum. In a sensitivity analysis the historical rates of inflation were obtained from the Office of National Statistics.[242] These inflation rates are based on the consumer price inflation index. These rates were then used to calculate the equivalent historical costs associated with admissions. As no discernable difference was observed using either method a consistent 5% deflation was used.

Cost

The cost associated with a particular type of stay in an acute hospital was obtained. A cost per day from the NHS cost book was calculated and multiplied by the actual number of days spent in hospital for an admission by an individual. For example, to calculate the cost per day of a stroke admission from the NHS cost book, an admission for stroke was presumed to have occurred in a general medical ward as stroke units have only recently been introduced. The cost per day on a general medical ward was then multiplied by the number of days actually spent by an individual in hospital during a hospitalisation for stroke during follow up. A myocardial infarction was on average assumed to last 7 days of which 2 days would be spent in a coronary care unit. All other cardiovascular, coronary heart disease and chronic heart failure admissions were assumed to occur in a cardiology ward. The costs per day for an admission to each type of these wards was calculated using Greater Glasgow and Clyde data in the NHS cost book. These costs were then totalled according to the assumptions above. For example the cost of a myocardial infarction admission was calculated as thus:

Step 1: Calculate average cost per day

Total cost of myocardial infarction stay = (Cost of stay in coronary care unit/ average length of stay in NHS cost book) * 2 + (cost of stay in cardiology ward/ average length of stay in cost book)*5

This was then divided by 7 to give a cost per day.

Step 2: Calculate the cost for a hospitalisation

Multiply the actual number of days in hospital during a myocardial infarction hospitalisation by the cost per day calculated in step 1.

Step 3: Deflation

This cost was then deflated as outlined above.

Outpatient and pharmacotherapy costs

The costs of outpatient attendance were not calculated in these analyses. It has been reported that attendance at out patient clinics varies by socioeconomic status in one study

[243], though not in another[244]. The most deprived may attend outpatients clinics more often than the least deprived members of society.[243] Due to the uncertainty surrounding the direction of effect of socioeconomic status on out patient attendances and the lack of data on outpatient attendances in the dataset an average number of visits per admission type would have to be applied to all socioeconomic groups, lessening the ability to detect between group differences.

Similarly, the costs of pharmacotherapy were not included. These were not calculated as two large assumptions would have to be made thus reducing the validity of such analyses. Firstly, assumptions regarding which pharmacotherapies may have been prescribed at which time points would have to be made. Over the study period effective pharmacotherapies for cardiovascular disease were established. There is no record of pharmacotherapies in the Renfrew/Paisley dataset therefore multiple assumptions would have to be made in determining which therapies were prescribed. Secondly, the prescription of pharmacotherapies differs by socioeconomic status.[155,165,245] Some studies have reported no difference[246] and others do not agree on the direction of effect.[165,247] Therefore, again an assumption around the direction and size of effect of socioeconomic deprivation and rates pharmacotherapy prescription would have to be made on top of the assumption made previously regarding when certain pharmacotherapies would have been likely to have been prescribed over time. This was deemed to introduce an unacceptable degree of uncertainty. Therefore, only costs associated with inpatient care were studied so that the size and direction of effect associated with socioeconomic deprivation could be measured with a degree of certainty. Indirect costs, such as loss of earnings were similarly not calculated due to insufficient evidence in the published literature to determine possible directions of effect.

Results

All cause mortality

The number of deaths according to deprivation category are outlined in Table 63.The absolute numbers in the most deprived groups are higher than in the least deprived and this is reflected in the fact that by the end of follow up nearly 72% of the most deprived were dead from all causes as compared to only 58% of the least deprived. This gradient was evident when deaths prior to the age of 65 years, 70 years and finally 75 years were examined. At the age of life expectancy, 75 years, 46% of the most deprived members of

the cohort had died as opposed to 31% of the least deprived with a gradient in the proportion dead in between.

Table 63 Number of deaths and proportions of deaths at end of follow up and before 65 years, 70 years and 75 years of age according to Carstairs Morris index.

	N	All deaths	%	65 years	%	70 years	%	75 years	%
1	990	578	58.38	108	10.91	197	19.90	307	31.01
3	2084	1,337	64.16	272	13.05	491	23.56	769	36.90
4	3347	2,169	64.80	440	13.15	809	24.17	1,288	38.48
5	5534	3,742	67.62	871	15.74	1,532	27.68	2,355	42.56
6&7	3389	2,437	71.91	606	17.88	1,031	30.42	1,548	45.68
Total	15344	10,263	66.89	2,297	14.97	4,060	26.46	6,267	40.84

The number of deaths occurring during follow up by social class is outlined in Table 64. As with Carstairs Morris index a gradient in the numbers and proportions on individuals dying was seen for all cause mortality at the end of follow up. The gradient in proportion of all cause deaths was as clear according to social class for deaths when compared to Carstairs Morris index, though the deprived experienced a greater number of deaths.

Table 64 Number of deaths and proportions of deaths at end of follow up and before 65 years, 70 years and 75 years of age in each social class.

	N	All deaths	%	65 years	%	70 years	%	75 years	%
I	545	315	57.80	69	12.66	121	22.20	191	35.05
II	2,235	1,330	59.51	268	11.99	488	21.83	760	34.00
III-NM	2,804	1,698	60.56	342	12.20	601	21.43	961	34.27
III-M	4,299	3,114	72.44	785	18.26	1,316	30.61	2,026	47.13
IV	3,771	2,575	68.28	573	15.19	1,047	27.76	1,589	42.14
V	1,301	949	72.94	202	15.53	384	29.52	575	44.20
	14,955	9,981	66.74	2,239	14.97	3,957	26.46	6,102	40.80

Years of life lived until death

The number of years a person lived between enrolment and death was examined according to SED (Table 65). On average an individual in the most deprived group lived approximately 2 ½ years less than an individual in the least deprived group.

Table 65 Number of years between enrolment and death or censoring according to Carstairs Morris index.

	N	total	95% CI		mean	95% CI	
1	990	21838	21324	22352	22.06	21.54	22.58
3	2084	46430	45630	47230	22.28	21.90	22.66
4	3347	72167	71177	73157	21.56	21.27	21.86
5	5534	116802	115475	118129	21.11	20.87	21.35
6&7	3389	66633	65623	67643	19.66	19.36	19.96
	15344	323870	319229	328511	21.33	20.99	21.68

A similar pattern was observed when social class was used as the measure of SED (Table 66). The least deprived survived on average just over 2 ½ years longer than the most deprived members of the cohort.

Table 66. Number of years between enrolment and death or censoring according to social class.

	N	total	95% CI		mean	95% CI	
I	545	12401	12016	12786	22.75	22.05	23.46
II	2,235	50281	49499	51063	22.50	22.15	22.85
III-NM	2,804	62943	62059	63827	22.45	22.13	22.76
III-M	4,299	85917	84736	87098	19.99	19.71	20.26
IV	3,771	78130	77061	79199	20.72	20.44	21.00
V	1,301	26085	25436	26734	20.05	19.55	20.55
	14,955	315757	310807	320707	21.41	21.00	21.81

Adjusted risk of death

The risk of death from all causes was modelled in a multivariable Cox regression model (Table 67) to allow adjustment for multiple cardiorespiratory risk factors. In unadjusted analyses the risk of all cause death was highest in the most deprived, approximately 50% higher than the least deprived. After adjustment this association persisted. A similar pattern of risk was observed when social class was used as the measure of SED (Table 68).

The risk of death by the age of 65 years, 70 years and 75 years was also modelled. As was observed in the proportions of deaths in each SED group above, there was evidence that after age and sex adjustment the risk of death associated with SED was higher in the most deprived versus the least deprived (Tables 69-74). After adjustment for further cardiorespiratory risk factors the risk of death at 65, 70 and 75 years of age were similar to that of the risk of death at the end of follow up.

Table 67 Hazard of all cause death during complete follow up by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	1.09	0.98	1.20	0.101	1.20	1.09	1.32	<0.001	1.19	1.08	1.32	<0.001	1.15	1.04	1.27	0.008
4	3347	1.18	1.07	1.29	<0.001	1.27	1.15	1.39	<0.001	1.26	1.15	1.38	<0.001	1.19	1.08	1.31	<0.001
5	5534	1.22	1.12	1.33	<0.001	1.36	1.24	1.48	<0.001	1.30	1.19	1.42	<0.001	1.21	1.10	1.32	<0.001
6&7	3389	1.49	1.36	1.63	<0.001	1.58	1.44	1.73	<0.001	1.53	1.39	1.67	<0.001	1.39	1.27	1.53	<0.001

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 68 Hazard of all cause death during complete follow up by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	1.06	0.93	1.19	0.386	1.07	0.95	1.22	0.251	1.05	0.93	1.19	0.405	1.03	0.91	1.17	0.631
III-NM	3,894	1.07	0.95	1.21	0.265	1.17	1.04	1.32	0.011	1.14	1.01	1.29	0.034	1.09	0.96	1.23	0.177
III-M	6,710	1.52	1.35	1.70	<0.001	1.39	1.24	1.57	<0.001	1.33	1.19	1.50	<0.001	1.25	1.11	1.40	<0.001
IV	5,815	1.37	1.22	1.54	<0.001	1.39	1.24	1.56	<0.001	1.33	1.18	1.50	<0.001	1.20	1.07	1.36	0.003
V	2,112	1.52	1.34	1.73	<0.001	1.56	1.38	1.78	<0.001	1.45	1.27	1.65	<0.001	1.29	1.13	1.47	<0.001

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 69 Hazard of all cause death prior to the age of 65 years by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	1.06	0.85	1.33	0.582	1.12	0.90	1.40	0.314	1.09	0.87	1.36	0.472	1.03	0.82	1.30	0.776
4	3347	1.13	0.92	1.40	0.249	1.17	0.95	1.45	0.135	1.13	0.92	1.40	0.241	1.03	0.83	1.27	0.808
5	5534	1.30	1.07	1.59	0.01	1.38	1.13	1.69	0.001	1.26	1.03	1.54	0.023	1.13	0.92	1.39	0.25
6&7	3389	1.66	1.35	2.03	<0.001	1.71	1.39	2.10	<0.001	1.59	1.29	1.95	<0.001	1.38	1.12	1.70	0.003

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 70 Hazard of all cause death prior to the age of 65 years by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	1.03	0.79	1.34	0.849	1.10	0.84	1.43	0.481	1.06	0.81	1.38	0.681	1.08	0.82	1.43	0.576
III-NM	3,894	1.05	0.81	1.37	0.687	1.25	0.97	1.63	0.089	1.20	0.92	1.55	0.177	1.11	0.84	1.46	0.456
III-M	6,710	1.69	1.32	2.16	<0.001	1.57	1.23	2.01	<0.001	1.45	1.13	1.85	0.003	1.31	1.01	1.69	0.044
IV	5,815	1.41	1.10	1.80	0.008	1.50	1.17	1.93	0.001	1.39	1.08	1.79	0.01	1.25	0.96	1.63	0.094
V	2,112	1.55	1.18	2.04	0.002	1.69	1.29	2.23	<0.001	1.49	1.13	1.97	0.004	1.30	0.98	1.74	0.074

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 71 Hazard of all cause death prior to the age of 70 years by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	1.10	0.94	1.30	0.239	1.17	0.99	1.38	0.067	1.15	0.97	1.35	0.11	1.08	0.91	1.28	0.365
4	3347	1.19	1.02	1.39	0.029	1.24	1.06	1.45	0.008	1.21	1.04	1.42	0.015	1.10	0.93	1.29	0.265
5	5534	1.33	1.15	1.55	<0.001	1.42	1.23	1.65	<0.001	1.32	1.14	1.53	<0.001	1.19	1.02	1.38	0.028
6&7	3389	1.62	1.39	1.89	<0.001	1.67	1.44	1.95	<0.001	1.58	1.35	1.84	<0.001	1.37	1.17	1.61	<0.001

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 72 Hazard of all cause death prior to the age of 70 years by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	1.05	0.86	1.28	0.623	1.13	0.93	1.38	0.23	1.10	0.90	1.34	0.367	1.11	0.91	1.37	0.309
III-NM	3,894	1.04	0.85	1.26	0.702	1.23	1.01	1.50	0.038	1.19	0.97	1.44	0.09	1.12	0.91	1.37	0.278
III-M	6,710	1.62	1.34	1.95	<0.001	1.50	1.25	1.81	<0.001	1.40	1.16	1.69	<0.001	1.29	1.06	1.56	0.011
IV	5,815	1.45	1.20	1.75	<0.001	1.55	1.28	1.87	<0.001	1.45	1.20	1.75	<0.001	1.30	1.06	1.58	0.01
V	2,112	1.63	1.33	2.00	<0.001	1.79	1.45	2.20	<0.001	1.60	1.30	1.97	<0.001	1.41	1.14	1.75	0.002

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 73 Hazard of all cause death prior to the age of 75 years by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	1.13	0.99	1.29	0.075	1.20	1.05	1.37	0.006	1.18	1.03	1.35	0.015	1.13	0.99	1.29	0.079
4	3347	1.23	1.09	1.40	0.001	1.29	1.14	1.47	<0.001	1.27	1.12	1.44	<0.001	1.18	1.04	1.34	0.011
5	5534	1.35	1.20	1.52	<0.001	1.46	1.30	1.65	<0.001	1.36	1.21	1.53	<0.001	1.24	1.10	1.41	<0.001
6&7	3389	1.61	1.43	1.82	<0.001	1.67	1.47	1.88	<0.001	1.57	1.39	1.78	<0.001	1.40	1.24	1.59	<0.001

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 74 Hazard of all cause death prior to the age of 75 years by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	1.03	0.88	1.20	0.755	1.09	0.93	1.28	0.299	1.06	0.90	1.24	0.475	1.06	0.90	1.25	0.46
III-NM	3,894	1.04	0.89	1.22	0.616	1.21	1.03	1.41	0.018	1.17	1.00	1.37	0.052	1.11	0.95	1.31	0.194
III-M	6,710	1.60	1.38	1.86	0	1.48	1.27	1.72	0	1.39	1.20	1.61	0	1.29	1.11	1.51	0.001
IV	5,815	1.40	1.20	1.62	0	1.47	1.27	1.71	0	1.39	1.19	1.62	0	1.25	1.07	1.47	0.005
V	2,112	1.55	1.32	1.83	0	1.68	1.42	1.98	0	1.52	1.29	1.80	0	1.35	1.14	1.61	0.001

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Death due to cardiovascular disease

The numbers of deaths due to cardiovascular causes are outlined in Table 75 according to Carstairs Morris index. Most cardiovascular deaths occurred in the most deprived. As with all cause deaths, a greater proportion of the most deprived individuals suffered a cardiovascular death than the least deprived. At the end of follow up 36% of the most deprived group had died due to cardiovascular causes, the respective figure was only 29% of the least deprived group. This gradient was evident for cardiovascular deaths before the age of 65 years and 70 years. At the age of 75 years (life expectancy) 22% of the deprived individuals had died of cardiovascular diseases whereas only 17% of the least deprived group had died due to cardiovascular disease.

Table 75 Number of cardiovascular deaths and proportions of cardiovascular deaths at end of follow up and before 65 years, 70 years and 75 years of age according to Carstairs Morris index .

	N	CVD Deaths	%	65 years	%	70 years	%	75 years	%
1	990	288	29.09	61	6.16	103	10.40	166	16.77
3	2084	674	32.34	124	5.95	238	11.42	378	18.14
4	3347	1,074	32.09	217	6.48	407	12.16	652	19.48
5	5534	1,849	33.41	417	7.54	761	13.75	1,183	21.38
6&7	3389	1,232	36.35	291	8.59	507	14.96	741	21.86
	15344	5,117	33.35	1,110	7.23	2,016	13.14	3,120	20.33

When SED was measured using social class the same gradients in cardiovascular deaths was observed as with Carstairs Morris index (Table 76). In the most deprived group 37% of individuals had died of cardiovascular causes over the course of follow up whilst only 29% of the least deprived had died of cardiovascular disease.

Table 76. Number of cardiovascular deaths and proportions of deaths at end of follow up and before 65 years, 70 years and 75 years of age in each social class.

	N	CVD Deaths	%	65 years	%	70 years	%	75 years	%
I	545	159	29.17	37	6.79	63	11.56	101	18.53
II	2,235	670	29.98	120	5.37	240	10.74	387	17.32
III-NM	2,804	818	29.17	161	5.74	283	10.09	451	16.08
III-M	4,299	1,568	36.47	403	9.37	675	15.70	1,019	23.70
IV	3,771	1,283	34.02	276	7.32	530	14.05	802	21.27
V	1,301	481	36.97	87	6.69	180	13.84	287	22.06
	14,955	4,979	33.29	1,084	7.25	1,971	13.18	3,047	20.37

Adjusted risk of cardiovascular death

The risk of a cardiovascular death varied according to socioeconomic status. The risk of suffering a cardiovascular death at the end of follow up was 60% higher in the most deprived versus the least deprived after adjustment for age and sex (Table 77). This excess risk persisted after adjustment for multiple cardiovascular risk factors. These relationships were evident when social class was used as the marker of socioeconomic deprivation (Table 78).

Cardiovascular deaths prior to the age of 65, 70 and 75 years were also modelled (Tables 79-84). The age and sex adjusted risk of a cardiovascular death in the most versus the least deprived was 40% higher by the age of 65 years (Table 79). The risk of dying from cardiovascular disease by the age of 70 years was 50% higher after adjustment for age and sex, which was attenuated to a 40% higher risk after adjustment for traditional cardiovascular risk factors (Table 81). The risk of cardiovascular death by the age of 75 was approximately 30% higher in the most deprived versus the least deprived (Table 83). The same association between social class and cardiovascular death was observed for deaths at each age (Tables 80, 82 and 84).

Table 77 Hazard of cardiovascular death by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	1.11	0.96	1.27	0.152	1.24	1.08	1.42	0.003	1.19	1.03	1.36	0.015	1.15	1.00	1.33	0.049
4	3347	1.17	1.03	1.34	0.017	1.27	1.12	1.45	<0.001	1.27	1.11	1.44	<0.001	1.22	1.07	1.40	0.003
5	5534	1.22	1.07	1.38	0.002	1.37	1.21	1.55	<0.001	1.27	1.12	1.44	<0.001	1.21	1.06	1.38	0.003
6&7	3389	1.51	1.33	1.72	<0.001	1.61	1.41	1.83	<0.001	1.55	1.36	1.76	<0.001	1.43	1.25	1.63	<0.001

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 78 Hazard of cardiovascular death by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	1.05	0.89	1.25	0.561	1.07	0.90	1.27	0.46	1.06	0.89	1.26	0.512	1.06	0.89	1.27	0.531
III-NM	3,894	1.02	0.86	1.21	0.81	1.11	0.94	1.32	0.227	1.11	0.93	1.31	0.245	1.09	0.92	1.31	0.316
III-M	6,710	1.51	1.28	1.78	<0.001	1.37	1.17	1.62	<0.001	1.33	1.13	1.56	0.001	1.28	1.08	1.51	0.005
IV	5,815	1.34	1.14	1.59	<0.001	1.36	1.15	1.60	<0.001	1.33	1.12	1.57	0.001	1.25	1.05	1.48	0.011
V	2,112	1.52	1.27	1.82	<0.001	1.55	1.29	1.86	<0.001	1.46	1.22	1.75	<0.001	1.33	1.10	1.60	0.003

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 79 Hazard of cardiovascular death by the age of 65 years by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	0.85	0.63	1.16	0.307	0.89	0.65	1.21	0.454	0.84	0.62	1.14	0.259	0.82	0.60	1.12	0.204
4	3347	0.98	0.73	1.30	0.863	1.01	0.76	1.34	0.957	0.97	0.73	1.29	0.838	0.93	0.69	1.24	0.614
5	5534	1.09	0.83	1.43	0.53	1.15	0.88	1.50	0.31	1.01	0.77	1.33	0.932	0.93	0.71	1.23	0.62
6&7	3389	1.37	1.04	1.81	0.025	1.40	1.06	1.85	0.016	1.30	0.98	1.71	0.065	1.15	0.87	1.53	0.331

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 80 Hazard of cardiovascular death by the age of 65 years by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	0.85	0.59	1.23	0.381	0.96	0.66	1.38	0.809	0.92	0.63	1.33	0.643	0.95	0.65	1.41	0.807
III-NM	3,894	0.91	0.64	1.31	0.618	1.19	0.83	1.71	0.335	1.14	0.80	1.64	0.469	1.13	0.77	1.65	0.532
III-M	6,710	1.59	1.13	2.22	0.007	1.45	1.04	2.04	0.03	1.34	0.96	1.88	0.089	1.29	0.90	1.85	0.158
IV	5,815	1.24	0.88	1.74	0.226	1.39	0.98	1.96	0.063	1.29	0.92	1.83	0.143	1.24	0.86	1.78	0.252
V	2,112	1.22	0.83	1.79	0.315	1.42	0.96	2.09	0.077	1.26	0.86	1.87	0.236	1.15	0.76	1.73	0.503

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 81 Hazard of cardiovascular death by the age of 70 years by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	1.00	0.79	1.26	0.988	1.06	0.84	1.34	0.618	1.00	0.79	1.26	0.993	0.96	0.76	1.21	0.731
4	3347	1.11	0.90	1.38	0.326	1.16	0.93	1.44	0.181	1.13	0.91	1.41	0.256	1.07	0.85	1.33	0.572
5	5534	1.22	1.00	1.50	0.055	1.30	1.06	1.60	0.012	1.16	0.95	1.43	0.152	1.08	0.87	1.33	0.488
6&7	3389	1.44	1.17	1.78	0.001	1.48	1.20	1.83	0	1.40	1.13	1.73	0.002	1.24	0.99	1.54	0.056

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 82 Hazard of cardiovascular death by the age of 70 years by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	0.98	0.74	1.29	0.886	1.08	0.81	1.42	0.606	1.05	0.79	1.38	0.745	1.08	0.80	1.44	0.621
III-NM	3,894	0.93	0.71	1.22	0.588	1.14	0.86	1.50	0.357	1.11	0.84	1.46	0.451	1.10	0.82	1.47	0.516
III-M	6,710	1.53	1.19	1.99	0.001	1.41	1.09	1.82	0.01	1.32	1.02	1.71	0.036	1.29	0.98	1.69	0.07
IV	5,815	1.36	1.05	1.77	0.021	1.47	1.13	1.91	0.004	1.41	1.08	1.83	0.011	1.34	1.02	1.77	0.037
V	2,112	1.41	1.06	1.88	0.019	1.56	1.17	2.08	0.003	1.42	1.07	1.90	0.017	1.31	0.97	1.78	0.081

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 83 Hazard of cardiovascular death by the age of 75 years by Carstairs Morris index

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
1	990	1				1				1				1			
3	2084	1.01	0.84	1.21	0.952	1.08	0.90	1.29	0.429	1.02	0.85	1.22	0.831	1.00	0.83	1.20	0.989
4	3347	1.13	0.95	1.34	0.169	1.18	0.99	1.40	0.062	1.16	0.98	1.37	0.094	1.12	0.94	1.34	0.196
5	5534	1.22	1.03	1.43	0.019	1.30	1.11	1.53	0.001	1.18	1.00	1.38	0.051	1.12	0.95	1.32	0.182
6&7	3389	1.33	1.12	1.57	0.001	1.36	1.15	1.61	0	1.30	1.10	1.53	0.003	1.19	1.00	1.41	0.051

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

Table 84 Hazard of cardiovascular death by the age of 75 years by social class

	N	HR*	95% CI		P	HR**	95% CI		P	HR†	95% CI		P	HR‡	95% CI		P
I	744	1				1				1				1			
II	3,209	0.97	0.78	1.21	0.783	1.04	0.84	1.30	0.719	1.02	0.82	1.27	0.85	1.03	0.82	1.29	0.81
III-NM	3,894	0.91	0.73	1.12	0.367	1.06	0.85	1.32	0.591	1.05	0.84	1.30	0.672	1.05	0.84	1.32	0.671
III-M	6,710	1.43	1.17	1.75	0.001	1.31	1.07	1.61	0.01	1.24	1.01	1.53	0.037	1.22	0.99	1.52	0.064
IV	5,815	1.26	1.03	1.56	0.026	1.33	1.08	1.64	0.007	1.29	1.04	1.58	0.018	1.24	1.00	1.55	0.049
V	2,112	1.37	1.09	1.72	0.007	1.45	1.15	1.82	0.001	1.36	1.08	1.71	0.009	1.27	1.00	1.61	0.05

*Unadjusted, **Adjusted for age and sex , † Adjusted for age, sex, diabetes, smoking, cholesterol, systolic blood pressure, ‡ Adjusted for age at first event, sex, diabetes, smoking, cholesterol, systolic blood pressure, body mass index, FEV1, cardiomegaly

The burden of admissions

The number of hospital admissions for all cardiovascular causes is outlined in Table 85. The number of admissions per individual in each deprivation category is given. There was no clear trend in the number of admissions per person according to SED as measured by Carstairs Morris index.

Similarly no clear trend was observed when social class was used as the measure of socioeconomic deprivation (Table 86).

Table 85 Number of cardiovascular admissions and admissions per person for any cardiovascular cause according to Carstairs Morris index.

	N	CVD	N per person	CHD	N per person	MI	N per person	Stroke	N per person	HF	N per person
1	990	818	0.83	227	0.23	130	0.13	118	0.12	103	0.10
3	2084	2,011	0.96	734	0.35	341	0.16	336	0.16	159	0.08
4	3347	3,214	0.96	1,054	0.31	479	0.14	536	0.16	420	0.13
5	5534	5,362	0.97	1,927	0.35	897	0.16	846	0.15	604	0.11
6&7	3389	3,272	0.97	1,131	0.33	538	0.16	558	0.16	426	0.13
	15344	14,677	0.96	5,073	0.33	2,385	0.16	2,394	0.16	1,712	0.11

Table 86 Number of cardiovascular admissions and admissions per person for all cardiovascular admissions according to social class.

	N	CVD	N per person	CHD	N per person	MI	N per person	Stroke	N per person	HF	N per person
I	545	494	0.91	164	0.30	82	0.15	77	0.14	68	0.12
II	2,235	2,281	1.02	811	0.36	352	0.16	311	0.14	264	0.12
III-NM	2,804	2,566	0.92	804	0.29	401	0.14	398	0.14	262	0.09
III-M	4,299	4,133	0.96	1,566	0.36	759	0.18	686	0.16	460	0.11
IV	3,771	3,588	0.95	1,190	0.32	541	0.14	615	0.16	433	0.11
V	1,301	1,222	0.94	423	0.33	204	0.16	246	0.19	170	0.13
	14,955	14,284	0.96	4,958	0.33	2,339	0.16	2,333	0.16	1,657	0.11

Admissions according to age at admission

The number of admissions occurring before pre-defined ages was calculated. The number of cardiovascular admissions per person increased from the least to the most deprived when SED was measured using the Carstairs Morris Index when admissions prior to the age of 65 were examined (Table 87) . Similarly the number of coronary heart disease admissions also increased from the least to the most deprived. When admissions prior to the age of 70 and 74were examined the gradient of risk was attenuated. When social class was examined no clear gradation of risk was seen (Table 88).

Table 87 Number of admissions and number of admissions per person for each cardiovascular disease according to deprivation category.

		N	CVD	Number/ person	CHD	Number/ person	MI	Number/ person	Stroke	Number/ person	HF	Number/ person
Age less 65	1	990	185	0.19	62	0.06	45	0.05	10	0.01	8	0.01
	3	2084	517	0.25	189	0.09	112	0.05	48	0.02	16	0.01
	4	3347	781	0.23	249	0.07	139	0.04	61	0.02	38	0.01
	5	5534	1,446	0.26	556	0.10	337	0.06	157	0.03	91	0.02
	6&7	3389	978	0.29	375	0.11	216	0.06	78	0.02	71	0.02
		15344	3,907	0.25	1,431	0.09	849	0.06	354	0.02	224	0.01
Age less 70	1	990	329	0.33	102	0.10	73	0.07	22	0.02	22	0.02
	3	2084	880	0.42	340	0.16	182	0.09	97	0.05	39	0.02
	4	3347	1,407	0.42	482	0.14	248	0.07	149	0.04	106	0.03
	5	5534	2,548	0.46	947	0.17	532	0.10	325	0.06	184	0.03
	6&7	3389	1,649	0.49	615	0.18	329	0.10	174	0.05	162	0.05
		15344	6,813	0.44	2,486	0.16	1,364	0.09	767	0.05	513	0.03
Age less 75	1	990	515	0.52	155	0.16	98	0.10	56	0.06	41	0.04
	3	2084	1,338	0.64	527	0.25	255	0.12	177	0.08	85	0.04
	4	3347	2,206	0.66	750	0.22	371	0.11	283	0.08	231	0.07
	5	5534	3,813	0.69	1,408	0.25	704	0.13	544	0.10	375	0.07
	6&7	3389	2,323	0.69	832	0.25	423	0.12	338	0.10	252	0.07
		15344	10,195	0.66	3,672	0.24	1,851	0.12	1,398	0.09	984	0.06

Table 88 Number of admissions and number of admissions per person for each cardiovascular disease according to social class.

		N	CVD	Number/ person	CHD	Number/ person	MI	Number/ person	Stroke	Number/ person	HF	Number/ person
Age less												
65	I	545	120	0.22	50	0.09	33	0.06	4	0.01	7	0.01
	II	2,235	550	0.25	188	0.08	113	0.05	45	0.02	19	0.01
	III-NM	2,804	717	0.26	241	0.09	140	0.05	55	0.02	43	0.02
	III-M	4,299	1,176	0.27	502	0.12	310	0.07	116	0.03	65	0.02
	IV	3,771	993	0.26	326	0.09	183	0.05	99	0.03	64	0.02
	V	1,301	278	0.21	106	0.08	63	0.05	28	0.02	18	0.01
		14,955	3,834	0.26	1,413	0.09	842	0.06	347	0.02	216	0.01
Age less												
70	I	545	224	0.41	90	0.17	51	0.09	24	0.04	17	0.03
	II	2,235	1,047	0.47	406	0.18	201	0.09	105	0.05	57	0.03
	III-NM	2,804	1,205	0.43	392	0.14	219	0.08	119	0.04	84	0.03
	III-M	4,299	1,957	0.46	799	0.19	463	0.11	222	0.05	160	0.04
	IV	3,771	1,701	0.45	548	0.15	300	0.08	210	0.06	120	0.03
	V	1,301	526	0.40	200	0.15	114	0.09	77	0.06	56	0.04
		14,955	6,660	0.45	2,435	0.16	1,348	0.09	757	0.05	494	0.03
Age less												
75	I	545	360	0.66	133	0.24	68	0.12	50	0.09	39	0.07
	II	2,235	1,537	0.69	578	0.26	272	0.12	186	0.08	126	0.06
	III-NM	2,804	1,762	0.63	580	0.21	300	0.11	223	0.08	144	0.05
	III-M	4,299	2,978	0.69	1,193	0.28	619	0.14	404	0.09	291	0.07
	IV	3,771	2,516	0.67	826	0.22	420	0.11	356	0.09	250	0.07
	V	1,301	799	0.61	300	0.23	150	0.12	149	0.11	96	0.07
		14,955	9,952	0.67	3,610	0.24	1,829	0.12	1,368	0.09	946	0.06

Length of Stay

The length of stay for each cardiovascular disease according to SED measured by Carstairs Morris index is outlined in Table 89. There was a trend towards increased length of stay for any CVD admission in the most deprived. However, when specific cardiovascular diseases were examined socioeconomic gradients in the mean length of stay were observed, though many were non-significant. The length of stay for a coronary heart disease admission was nearly 4 days longer in the most deprived versus the least deprived. When social class was used as the measure of SED (Table 90) a gradient in the length of stay for any CVD admission was seen but no clear gradient for each of the specific cardiovascular diseases was observed.

Table 89 Length of stay for each type of cardiovascular hospitalisation over follow up according to Carstairs Morris index

		N	total los	95% CI		Mean	95% CI		P	Median	IQR		P
CVD	1	990	11727	9375	14079	14.34	11.46	17.21		6	2	13	
	3	2084	40261	30149	50373	20.02	14.99	25.05		6	2	13	
	4	3347	62666	50287	75045	19.50	15.65	23.35		6	2	13	
	5	5534	93185	82194	104176	17.38	15.33	19.43		6	2	13	
	6&7	3389	71791	58436	85146	21.94	17.86	26.02	0.06	7	3	15	0.005
		15344	279630	230440	328820	18.63	15.06	22.21		6	2	14	
CHD	1	990	1933	1667	2199	8.52	7.34	9.69		7	2	11	
	3	2084	5968	5469	6467	8.13	7.45	8.81		6	2	10	
	4	3347	9489	8341	10637	9.00	7.91	10.09		6	2	11	
	5	5534	21703	16406	27000	11.26	8.51	14.01		7	3	11	
	6&7	3389	14105	7827	20383	12.47	6.92	18.02	0.5	6	2	11	0.36
		15344	53198	39709	66687	9.88	7.63	12.12		6	2	11	
MI	1	990	1283	1097	1469	9.87	8.44	11.30		8	4	14	
	3	2084	3652	3296	4008	10.71	9.67	11.75		9	5	14	
	4	3347	6197	5123	7271	12.94	10.70	15.18		9	5	15	
	5	5534	13507	9037	17977	15.06	10.07	20.04		10	6	15	
	6&7	3389	10232	3976	16488	19.02	7.39	30.65	0.45	9	5	15	0.008
		15344	34871	22529	47213	13.52	9.25	17.78		9	5	15	
Stroke	1	990	4622	2696	6548	39.17	22.85	55.49		16	3	37	
	3	2084	25290	15462	35118	75.27	46.02	104.52		15	5	45	
	4	3347	33942	22113	45771	63.32	41.26	85.39		13	4	41	
	5	5534	44877	35743	54011	53.05	42.25	63.84		12	4	37	
	6&7	3389	38372	27244	49500	68.77	48.82	88.71	0.18	14	5	43	0.56
		15344	147103	103258	190948	59.92	40.24	79.59		14	4	14	

HF	1	990	1304	1008	1600	12.66	9.79	15.53		7	3	15	
	3	2084	1842	1545	2139	11.58	9.72	13.45		8	4	16	
	4	3347	7052	5387	8717	16.79	12.83	20.76		9	5	17	
	5	5534	8575	7231	9919	14.20	11.97	16.42		8	4	16	
	6&7	3389	6098	5486	6710	14.31	12.88	15.75	0.18	10	5	18	0.03
		15344	24871	20658	29084	13.91	11.44	16.38		9	5	16	

Table 90 Length of stay for each type of cardiovascular hospitalisation over follow up according to social class

		N	total los	95% CI		Mean	95% CI		P	Median	IQR		P
CVD	I	545	7112	4254	9970	14.40	8.61	20.18		6	2	12	
	II	2,235	30508	27557	33459	13.37	12.08	14.67		6	2	13	
	III-NM	2,804	47009	36862	57156	18.32	14.37	22.27		6	2	13	
	III-M	4,299	72285	60328	84242	17.49	14.60	20.38		7	2	14	
	IV	3,771	77456	64434	90478	21.59	17.96	25.22		7	2	14	
	V	1,301	33349	23976	42722	27.29	19.62	34.96	0.04	7	2	15	<0.001
		14,955	267719	217412	318026	18.74	14.54	22.95		6	2	14	
CHD	I	545	1306	1074	1538	7.96	6.55	9.38		6	2	11	
	II	2,235	6544	5977	7111	8.07	7.37	8.77		6	2	10	
	III-NM	2,804	10720	4459	16981	13.33	5.55	21.12		7	2	10	
	III-M	4,299	16987	12465	21509	10.85	7.96	13.73		7	2	12	
	IV	3,771	11358	10160	12556	9.54	8.54	10.55		3	3	11	
	V	1,301	3836	3394	4278	9.07	8.02	10.11	0.26	6	3	12	0.17
		14,955	50751	37529	63973	9.80	7.33	12.28		6	2	11	
MI	I	545	927	725	1129	11.30	8.84	13.77		9	5	14	
	II	2,235	3888	3461	4315	11.05	9.83	12.26		9	5	15	
	III-NM	2,804	8215	1974	14456	20.49	4.92	36.05		9	6	13	
	III-M	4,299	11715	7257	16173	15.43	9.56	21.31		10	6	15	
	IV	3,771	7074	5971	8177	13.08	11.04	15.11		9	5	15	
	V	1,301	2471	2095	2847	12.11	10.27	13.96	0.49	10	5	15	0.2
		14,955	34290	21484	47096	13.91	9.08	18.74		9	5	15	
Stroke	I	545	3531	757	6305	45.86	9.83	81.89		11	5	25	
	II	2,235	11933	9679	14187	38.37	31.12	45.62		14	4	43	
	III-NM	2,804	21663	14099	29227	54.43	35.42	73.44		13	4	38	
	III-M	4,299	36157	25433	46881	52.71	37.07	68.34		12	4	35	

	IV	3,771	45294	32920	57668	73.65	53.53	93.77		14	5	40	
	V	1,301	22096	13256	30936	89.82	53.89	125.76	0.19	17	6	50	0.039
		14,955	140674	96144	185204	59.14	36.81	81.47		14	4	40	
HF	I	545	908	721	1095	13.35	10.60	16.11		11	5	18	
	II	2,235	3639	3092	4186	13.78	11.71	15.86		8	5	16	
	III-NM	2,804	3930	2581	5279	15.00	9.85	20.15		8	5	16	
	III-M	4,299	6132	5358	6906	13.33	11.65	15.01		9	4	16	
	IV	3,771	6746	5358	8134	15.58	12.37	18.79		9	5	17	
	V	1,301	2943	2217	3669	17.31	13.04	21.58	0.26	10	5	18	0.53
		14,955	24298	19326	29270	14.73	11.54	17.92		9	5	17	

The cost cardiovascular disease

The total cost of admissions over the course of follow up was calculated using NHS costs. Over the course of follow up the most deprived accrued costs of £10.4 million (95%CI £8.6 -12.1 million) whereas the least deprived accrued costs of only £1.8 (1.47-2.2 million), nearly a fifth of the costs (Table 91). The cost per person was higher in the most deprived groups. To account for the shorter life expectancy, the cost per 100 person years of follow up were calculated and were similarly higher with increasing deprivation.

The cost of admissions was also calculated using social class (Table 92). In social class V a total of £4.9 million (95%CI £3.6-6.2 million) was spent on hospital admissions for cardiovascular disease. In social class I this figure was £1.8 million (£0.7-2.2 million). The cost of cardiovascular admissions per person again displayed a gradient with increasing cost with increasing deprivation. Similar results were observed when costs per 100 person years of follow up were calculated.

Table 91 Total cost, cost per person and cost per 100 person years of follow up of cardiovascular hospitalisations by Carstairs Morris index

		N	Total cost	95% CI		Cost per person	95% CI		Cost per 100 person years	95% CI	
CVD	1	990	1838840	1474637	2203043	1857	1490	2225	8331	6681	9982
	3	2084	5864784	4508431	7221137	2814	2163	3465	12737	9792	15683
	4	3347	9268959	7683509	10900000	2769	2296	3257	13924	11542	16374
	5	5534	13700000	12200000	15200000	2476	2205	2747	19198	17096	21300
	6&7	3389	10400000	8644849	12100000	3069	2551	3570	8865	7369	10314
		15344	41072583	34511426	47624180	2677	2249	3104	12702	10673	14728
CHD	1	990	287706	249306	326107	291	252	329	1304	1130	1478
	3	2084	882182	799565	964800	423	384	463	1916	1737	2095
	4	3347	1424624	1247787	1601461	426	373	478	2140	1874	2406
	5	5534	3019709	2433039	3606379	546	440	652	4232	3409	5054
	6&7	3389	1961437	1220061	2702813	579	360	798	1672	1040	2304
		15344	7575659	5949758	9201559	494	388	600	2343	1840	2846
MI	1	990	277182	236432	317932	280	239	321	1256	1071	1440
	3	2084	793952	705877	882026	381	339	423	1724	1533	1916
	4	3347	1377045	1120015	1634075	411	335	488	2069	1682	2455
	5	5534	2695642	2041238	3350047	487	369	605	3777	2860	4694
	6&7	3389	2101779	962366	3241193	620	284	956	1792	820	2763
		15344	7245600	5065929	9425273	472	330	614	2241	1567	2915
Stroke	1	990	1067839	640238	1495439	1079	647	1511	4838	2901	6776
	3	2084	5131479	3279293	6983664	2462	1574	3351	11145	7122	15167
	4	3347	7010453	4891650	9129256	2095	1462	2728	10531	7348	13714

	5	5534	9323859	7537612	11100000	1685	1362	2006	13066	10562	15554
	6&7	3389	7895208	5782386	10000000	2330	1706	2951	6730	4929	8524
		15344	30428838	22131179	38708359	1983	1442	2523	9410	6844	11971
HF	1	990	224401	170240	278561	227	172	281	1017	771	1262
	3	2084	297537	249058	346015	143	120	166	646	541	751
	4	3347	1142671	887325	1398016	341	265	418	1717	1333	2100
	5	5534	1448120	1210626	1685613	262	219	305	2029	1696	2362
	6&7	3389	9829343	882531	1083356	2900	260	320	8378	752	923
		15344	12942072	3399779	4791562	843	222	312	4002	1051	1482

Table 92 Total cost, cost per person and cost per 100 person years of follow up of cardiovascular hospitalisations by social class

		N	Total cost	95% CI		Cost per person	95% CI		Cost per 100 person years	95% CI	
CVD	I	545	1046991	674484	1419498	1921	1238	2605	8445	5440	11450
	II	2,235	4734851	4282977	5186724	2119	1916	2321	18144	16413	19876
	III-NM	2,804	6970454	5624946	8315962	2486	2006	2966	13929	11240	16618
	III-M	4,299	10400000	8939809	11800000	2419	2080	2745	16535	14214	18761
	IV	3,771	11300000	9575601	13000000	2997	2539	3447	14487	12276	16666
	V	1,301	4905107	3574343	6235871	3770	2747	4793	5717	4166	7268
		14955	39357403	32672160	45958055	2632	2185	3073	12485	10364	14579
CHD	I	545	190617	159877	221357	350	293	406	1538	1290	1785
	II	2,235	985167	890892	1079442	441	399	483	3775	3414	4136
	III-NM	2,804	1498997	760547	2237446	535	271	798	2995	1520	4471
	III-M	4,299	2278342	1843735	2712948	530	429	631	3622	2931	4313
	IV	3,771	1703256	1515021	1891492	452	402	502	2184	1942	2425
	V	1,301	554753	490329	619178	426	377	476	647	571	722
		14955	7211132	5660401	8761863	482	378	586	2288	1796	2779
MI	I	545	545	201511	161589	370	296	443	1625	1303	1947
	II	2,235	2,235	846232	741216	379	332	426	3243	2840	3645
	III-NM	2,804	2,804	1689665	555996	603	198	1007	3376	1111	5642
	III-M	4,299	4,299	2260264	1610826	526	375	677	3594	2561	4626
	IV	3,771	3,771	1579724	1308454	419	347	491	2025	1677	2373
	V	1,301	1,301	526627	440763	405	339	471	614	514	714
		14955	14955	7104023	4818844	475	322	628	2254	1529	2978

Stroke	I	545	708426	200142	1216711	1300	367	2232	5714	1614	9814
	II	2,235	2681861	2189098	3174624	1200	979	1420	10277	8389	12165
	III-NM	2,804	4584828	3090766	6078890	1635	1102	2168	9162	6176	12147
	III-M	4,299	7392436	5517640	9267232	1720	1283	2156	11753	8773	14734
	IV	3,771	9204139	6916172	11500000	2441	1834	3050	11800	8867	14743
	V	1,301	4581412	2803893	6358932	3521	2155	4888	5340	3268	7411
		14955	29153102	20717711	37596389	1949	1385	2514	9248	6572	11926
HF	I	545	156416	123162	189671	287	226	348	1262	993	1530
	II	2,235	617753	518641	716865	276	232	321	2367	1987	2747
	III-NM	2,804	641908	436262	847553	229	156	302	1283	872	1694
	III-M	4,299	986445	860832	1112059	229	200	259	1568	1369	1768
	IV	3,771	1077031	852644	1301417	286	226	345	1381	1093	1668
	V	1,301	474052	349595	598509	364	269	460	553	407	698
		14955	3953605	3141135	4766075	264	210	319	1254	996	1512

Population attributable fraction

The population attributable fraction was calculated for the traditional risk factors for cardiovascular disease and also for socioeconomic deprivation (Table 93). The fraction of cardiovascular disease that was attributable to SED in this cohort was 13.7%. This was higher than serum cholesterol but lower than age, sex, smoking, diabetes and hypertension. For cardiovascular disease, CHD and MI the attributable risk of SED was generally similar to most of the other cardiovascular risk factors of smoking, serum cholesterol and hypertension. The attributable risk of SED in stroke and HF was similar to serum cholesterol.

Table 93 Population attributable fraction for cardiovascular risk factors and Carstairs Morris index.

	CVD	CHD	MI	Stroke	HF
Age (55-64 vs. 45-54)	14.9	4.5	3.7	16.0	2.3
Sex (Men vs. women)	16.2	8.3	7.3	5.7	1.7
Smoking vs. non smoking	15.6	6.6	5.8	1.5	1.0
Cholesterol (>5mmol vs. <5mmol)	13.4	5.2	4.4	2.2	1.1
Diabetes vs. no diabetes	45.7	12.6	4.7	13.6	15.3
Hypertension (>140mmHg vs. <140mmHg)	17.3	6.4	5.1	4.4	2.4
Deprivation (most vs. least deprived)	13.7	5.4	4.3	2.8	1.0

Calculation of the average population attributable fraction associated with SED was similar to that of smoking and hypertension following adjustment for the other factors in the table (Table 94). This risk was present for all cardiovascular event types.

Table 94 Average population attributable fraction for cardiovascular risk factors and Carstairs Morris index

	CVD	CHD	MI	Stroke	HF
Age (55-64 vs. 45-54)	2.1	-0.3	0.3	16.0	8.9
Sex (Men vs. women)	3.3	10.1	11.5	-8.5	6.4
Smoking vs. non smoking	10.1	13.8	19.3	1.5	3.3
Cholesterol (>5mmol vs. <5mmol)	13.6	23.9	28.0	2.2	16.5
Diabetes vs. no diabetes	0.7	0.4	0.07	0.7	1.8
Hypertension (>140mmHg vs. <140mmHg)	10.4	10.8	9.8	17.4	20.7
Deprivation (most vs. least deprived)	7.8	13.0	10.2	22.9	4.3

The attributable fraction for SED measured by social class was similar to that of SED as measured by Carstairs Morris index (Table 95). A similar relationship to the other risk factors was also observed.

Table 95 Population attributable fraction of cardiovascular risk factors and social class

	CVD	CHD	MI	Stroke	HF
Age (55-64 vs. 45-54)	14.9	4.5	3.7	16.0	2.3
Sex (Men vs. women)	16.2	8.3	7.3	5.7	1.7
Smoking vs. non smoking	15.6	6.6	5.8	1.5	1.0
Cholesterol (>5mmol vs. <5mmol)	13.4	5.2	4.4	2.2	1.1
Diabetes vs. no diabetes	45.7	12.6	4.7	13.6	15.3
Hypertension (>140mmHg vs. <140mmHg)	17.3	6.4	5.1	4.4	2.4
Deprivation (most vs. least deprived)	12.4	3.7	3.1	3.6	1.7

When social class was used as the measure of SED the average attributable fraction was higher only for cholesterol and hypertension (Table 96).

Table 96 Average population attributable fraction of cardiovascular risk factors and social class

	CVD	CHD	MI	Stroke	HF
Age (55-64 vs. 45-54)	-0.7	-5.0	-3.8	14.7	1.5
Sex (Men vs. women)	4.3	6.9	11.4	-7.6	1.2
Smoking vs. non smoking	0.5	4.6	7.5	6.5	-7.6
Cholesterol (>5mmol vs. <5mmol)	13.9	33.5	29.8	-7.5	21.3
Diabetes vs. no diabetes	0.7	4.2	0.5	1.1	1.3
Hypertension (>140mmHg vs. <140mmHg)	13.8	16.8	13.4	18.0	25.0
Deprivation (most vs. least deprived)	11.4	7.3	10.8	13.2	24.7

Discussion

In this chapter I report that greater socioeconomic deprivation is associated with a greater risk of death at all ages. Furthermore, this translates into a longer life expectancy amongst the least deprived. This risk persists after adjustment for traditional cardiovascular risk factors. The risk of a cardiovascular death is also higher in the most deprived and is only attenuated but not abolished by adjustment for cardiovascular risk factors.

The most deprived also experience more hospital admissions for cardiovascular disease than the least deprived and tend to stay longer in hospital than the least deprived. Despite the shorter life span of the most deprived this increase in the number of hospital admissions led to a higher cost per person in the most deprived than the least deprived over the period of follow up.

All cause and cardiovascular mortality

Multiple previous studies have examined the relationship between socioeconomic deprivation and all cause mortality.[7,16,35,51,248-251] In all studies the most deprived display consistently higher mortality rates than the least deprived irrespective of the method of defining socioeconomic deprivation. Cardiovascular mortality has also been examined by a number of authors.[33,40,41,45,52,53,97,142,227,252] Not only is cardiovascular mortality higher in the most deprived but also coronary heart disease and stroke mortality. In this study I examined cardiovascular mortality and the results are congruent with other studies irrespective of the country examined or the measure of socioeconomic deprivation used. Few studies, however, have attempted to adjust the association between SED and cardiovascular mortality for traditional cardiovascular risk factors. In a study of 14 642 Finnish men and women Harald *et al*[142] only adjusted for smoking, hypertension and serum cholesterol. Strand *et al*[40] failed to adjust for the presence of diabetes. One study from Western Australia did adjust for all of the "traditional" cardiovascular risk factors and found that the risk of cardiovascular mortality was non-significant (HR 1.18 (95% CI 0.78-1.77)) in those with the least education compared to the most education, though follow up was relatively short (9 years).[253]

Premature mortality

As a consequence of the higher risk of all cause and cardiovascular mortality, the risk of death at predefined ages was performed. The association of SED with premature all cause

mortality has been reported before.[42,249,254] The relationship is seen in both men and women.[254] Similarly, reports of higher premature cardiovascular mortality have been published.[41,42,252] However, these studies are based on routine data sources such as hospitalisation databases or routine death certificate data and have failed to adjust for the cardiovascular risk factors that were adjusted for in this study.

Socioeconomic deprivation increases the risk of a number of diseases. This may occur through a number of pathways. Obvious pathways are through higher rates of smoking with in turn increase lung cancer rates. Increasing SED may work through other mediators such as poorer housing which may lead to increasing risk of respiratory disease. It is clear form these data that the risk of all cause and cardiovascular mortality is independent of traditional cardiovascular risk factors and therefore other pathways must mediate this relationship. Other suggestions have been explored such as work stress, psychosocial stress,[255,256] heart rate variability[195] and response to exercise[195]. Other hypotheses such as increased pathogen burden as a result of poorer environment have also been explored.[180] Whilst traditional risk factors do not appear to explain the entire relationship they are a large part of it.[38,257] In this study, as in all others, adjustment for traditional cardiovascular risk factors attenuates, but does not completely eliminate, the relationship.

Admissions

The burden of cardiovascular disease according to socioeconomic status is less well studied. Although absolute numbers of admissions have not been measured by SED over a period of follow up, it can be extrapolated, from studies of disease incidence that use hospitalisations as a proxy, [68,73,122] that the deprived individuals in a society experience more admissions. I have found that despite surviving longer, the least deprived, experience less hospital admissions for cardiovascular causes. As a consequence, the costs accrued over the lifespan of the most deprived, were higher than the least deprived individuals. Neither of these observations have been reported in the literature. These data have important implications for health systems around the world and policy makers.

This may at first sight be an intuitive observation. More deprived individuals tend to have poorer health, a worse risk factor profile, poorer health behaviours and more co-morbid disease. All of these factors would suggest that they are likely to experience more hospitalisations for cardiovascular disease. However, they also are more likely to die [32,49,97] and to die at an earlier age[42,252,254]. This would appear to present less of an opportunity to accrue costs i.e. to spend less time at risk for a hospitalisation. However, as described in

this chapter the most deprived are still experiencing more hospitalisations despite this increased mortality. Therefore, not only do the most deprived individuals live shorter lives but the quality of that life (as denoted by more hospitalisations) is poorer.

Length of stay

The length of stay for hospital admissions for a range of cardiovascular diseases has not been examined in relation to SED in one cohort before. The more prolonged stays in the most deprived may reflect a number of factors. It may reflect more severe presentations in the most deprived versus the least deprived, with a consequently longer recuperation time. For example, in a study of patients admitted to hospital with stroke, the most deprived were more likely to need assistance with walking as a consequence of their stroke than the least deprived indicating that they had experienced a more severe stroke.[115] In studies of myocardial infarction there is evidence that the severity of the myocardial infarct varies with socioeconomic deprivation.[77] In addition, the increased prevalence of co-morbid diseases which would slow discharge rates in the most deprived e.g. dementia [84] may also explain why length of stay is higher in the most deprived.

Another factor influencing the length of stay may also be the treatment received by individuals during a hospital stay. It has been described that the most deprived are less likely to receive certain pharmacological therapies[230] and procedures such as coronary angioplasty[79,231]. Whilst most therapies are instituted for the benefit of secondary prevention it would appear that the lack of prescription of these therapies may serve as a marker for less aggressive treatment in hospital which in turn may be a cause of longer lengths of stay.

Finally, SED is a complex construct of many factors. Not only does it capture material wealth, but it also may capture social support mechanisms, social isolation and environment.[4] These factors may also lead to increased length of stay. An individual with more social support and better finances may be able to leave hospital earlier than someone without and recover better[258]. They may be more able to return home to a more amenable environment following the development of cardiovascular diseases such as stroke than someone who lives in a more deprived area and who therefore may need to be re-housed.

Cost of cardiovascular disease

The cost to the NHS in terms of hospitalisations was estimated in these analyses and again despite living shorter lives the most deprived accrued the most costs over follow up. This is as a result of the number of admissions they suffered and the length of time spent in hospital per admission. This has important financial implications for the NHS and policy planners. Furthermore, deprivation not only costs society from the direct costs of healthcare but also in societal costs (time off work, unemployment, benefit payments) and therefore to understand the mechanism behind the drivers of increased costs, more and longer admissions, is crucial. As noted in the literature review, there is little information on the costs of cardiovascular care by SED.[138] The findings of the present study would suggest that the cost of SED to the NHS is high and efforts to reduce these inequalities need to be made.

Limitations

The cause of death was determined using death certificate data. This raises concerns about the validity of the diagnosis of a cardiovascular death. However, studies in the UK[259], Finland[260] and USA[261], and elsewhere would suggest that the validity of cardiovascular causes of death on death certificates are suitable for epidemiological research. These studies confirm that in older age groups the accuracy of a coronary cause of death is lower, though they disagree on the age at which the accuracy starts to fall, with a UK study [259]suggesting this is between 65-74 years and a study from the USA[261] suggesting accuracy is lower after the age of 75 years. Other studies of stroke and certified deaths from stroke in the UK would suggest that the use of a death record indicating that stroke was the cause of death has good accuracy and predictive value for identifying a stroke.[262]

The full burden of cardiovascular disease according to socioeconomic deprivation could not be calculated in this study. No data were available on what drug therapy each individual was prescribed or the primary care or outpatient care that they received. This area requires further research to help define and refine the full costs to a healthcare system of socioeconomic deprivation.

Summary

In this chapter I have demonstrated that SED is associated with a higher risk of all cause mortality, cardiovascular mortality and premature mortality. This association is present after adjustment for cardiovascular risk factors. The most deprived also used more hospital resources over the course of follow up. This was due to a larger number of cardiovascular admissions and a longer length of stay in the most deprived groups. This translated into a larger total cost to the NHS during the course of follow up. Finally, I report that the population attributable fraction of SED in a number of cardiovascular disorders was similar to that of classical risk factors for cardiovascular disease.

Discussion

Summary of findings

The aim of these studies was to assess the association between socioeconomic deprivation and the risk of a number of forms of cardiovascular disease in a large cohort of men and women over a prolonged period of time, and to determine whether an association persisted following adjustment for known cardiovascular risk factors. In this cohort, SED was associated with a higher risk of an incident cardiovascular hospitalisation, death following an incident cardiovascular hospitalisation, cardiovascular and all-cause mortality, lifetime hospital burden and cost of hospitalisations. There was however, no association between SED and the risk of recurrent cardiovascular hospitalisations following adjustment for recognised cardiovascular risk factors.

The relationship between socioeconomic deprivation and cardiovascular disease

In these analyses I have shown that SED is associated with the risk of a hospitalisation for cardiovascular disease, any coronary heart disease, myocardial infarction, stroke and heart failure. Whilst at first sight these findings are in keeping with the literature presented in the first chapter of this thesis, these analyses are important additions to the literature as no prior study has been able to examine this relationship in both men and women or to examine all these forms of cardiovascular disease in one cohort. This is a major strength of these studies. Previous high quality longitudinal studies such as the Whitehall studies[263] are limited by the inclusion of only men with a limited range of occupational experiences and therefore are not representative of the population. Also this study is the first to examine all forms of cardiovascular disease. Many studies have tried to find a mechanistic link between SED and cardiovascular disease.[38,226,255,257] However these analyses would suggest that SED mediates a higher risk for cardiovascular disease through either one common factor to all forms of cardiovascular disease or through multiple factors that are differentially important in the pathogenesis of each different form of cardiovascular disease. William of Occam stated "*Pluralitas non est ponenda sine necessitate; Plurality should not be posited without necessity*". Following Occam's razor it should be expected that a simpler explanation of a common pathway mediating SED and CVD risk would seem the most likely. However, Chatton's anti razor also may hold true in this setting in

that *"If three things are not enough to verify an affirmative proposition about things, a fourth must be added, and so on"* thus it may be that SED exerts its effect via different pathways. Much of current literature suggests that SED may exert its effect via different pathways.[38,255,257]

Employing a classical biological model of disease, the differential distribution of risk factors in different socioeconomic groups has long been proposed as a potential mechanism. Multiple authors report that differential distribution of risk factors explain most, if not all, of the differential rates of cardiovascular disease.[100,142,226,257] However, in these analyses the association between SED and each cardiovascular disease was still present after accounting for the different distribution of cardiovascular risk factors through the multivariable analyses. What is clear is that risk factors do tend to cluster in the most deprived. Understanding why this occurs and what may be done to change these unhealthy patterns is needed.

Should socioeconomic deprivation be a cardiovascular risk factor?

The variation in cardiovascular disease rates varies according to the distribution of the traditional risk factors of smoking, hypercholesterolaemia, hypertension and diabetes. However, the entire variation of CVD rates is not explained by these factors.[38,71,264] Socioeconomic factors seem to explain the remainder of this variation. This study, as well as others in the published literature, suggests that SED is indeed an independent risk factor even after adjustment for the above CVD risk factors. Kuller[265] has set out criteria to determine if a factor should indeed be called a risk factor. These criteria for a new risk factor are

1. *It should be shown experimentally that it would increase the extent of atherosclerosis or its complications in suitable animal models.*

This is of course very difficult, if not impossible to do in this context.

2. *Persons with CVD would have either a higher risk (if the factor is directly correlated with coronary disease) or lower risk of disease (if inversely correlated with the level of the risk factor) than carefully matched controls*.

Whilst this is not a case control study, prior case control studies have reported that SED is associated with a higher risk of CVD.[266]

3. *Distribution of risk factors should be correlated with the incidence, prevalence, and mortality of atherosclerotic disease within and between populations.*

This study has shown that SED is correlated with the incidence and mortality of CVD.

4. *People exposed to the factor would have a higher risk of coronary disease in longitudinal studies.*

Again these analyses of a longitudinal cohort clearly demonstrate that over a long period of time in both men and women the risk of CVD is higher in the most deprived.

5. *There should be a time-dose relation: the higher the dose the earlier the onset of the disease.*

A number of studies have reported that SED in early life is associated with the development of CVD in adulthood, suggesting that a prolonged exposure to deprivation leads to a greater risk of CVD in comparison to those who increase their social status through life.[267-269]

6. *The results of studies should be consistent from study to study, and ideally in different cultural settings.*

This study adds to the totality of the literature surrounding SED and CVD. It should be acknowledged that this cohort is limited in terms of its ethnic make up. However, other studies would suggest that the relationship between SED and CVD is present in different ethnic groups.[102,145]

7. *The relation between the risk factor and the disease should be independent of other known risk factors unless it enhances the predictive power of these risk factors.*

Investigation of this rule is a central part of this thesis. I have demonstrated that SED is a risk factor independent of the traditional risk factors for CVD. This relationship has been demonstrated in these studies for multiple forms of CVD i.e. coronary heart disease, stroke and heart failure.

8. *Evidence should be available in either humans or a suitable animal model that modification of the risk factor would result in the reversal of the progression of atherosclerosis or clinical disease.*

This rule is difficult to prove in the context of SED and CVD. Not only is changing SED difficult but it is very difficult to determine the causal link with any subsequent decrease in CVD rates.

9. *The risk factors should make sense in relation to a biological model for cardiovascular disease.*

Studies have reported that SED affects levels of other physiological cardiovascular risk factors and health behaviours which confer cardiovascular risk.

As can be seen these studies and others allow most of the above criteria to be filled by SED in relation to becoming a CVD risk factor. Kuller reported that few of the major risk factors met all of the above criteria for a relation with coronary disease. However, SED would appear to meet most of the above prerequisites for a new risk factor.

Utilising socioeconomic deprivation as a risk factor

Developed countries require risk factor screening that acknowledges the higher risk of the most deprived members of its society. Only through correct identification of these individuals will their higher risk be appreciated and interventions designed to lower their risk be accurately delivered. Brindle *et al*[270] examined the Framingham risk score in the Renfrew Paisley cohort and determined how it performed in each socioeconomic group. Cardiovascular disease mortality was underestimated by 48% in the manual participants of the cohort (i.e. the most deprived) as compared to 31% in the non-manual classes, the least deprived. A similar finding was reported for the relationship between SED as measured by Carstairs Morris index and the ability of the Framingham risk score to predict events. This leads to the conclusion that current risk scores underestimate the risk of cardiovascular mortality in the most deprived individuals in society. It is not only in Scotland that this has been observed. In the USA, a study of the Atherosclerosis Risk in Communities study examined the model discrimination and calibration of the Framingham risk score with and without SED as measured by income and by education.[271] In the most deprived the risk of coronary heart disease as estimated by the Framingham risk score was 3.7% as compared to 3.9% in the least deprived. The observed risks were 5.6% and 3.1% respectively again

demonstrating that this risk score underestimates risk in the most deprived. After addition of SED to the risk score the predicted risk was 3.1% in the least deprived and 5.2% in the most deprived, more closely matching the observed rates. These findings were also validated in the same study in another cohort, the National Health and Nutritional Examination Study.

In recognition of these findings, the UK now has two risk scores that incorporate SED into the risk score. The ASSessing cardiovascular risk, using SIGN (ASSIGN) risk score was developed in the Scottish Heart Health Extended Cohort to allow better risk predication amongst individuals of all socioeconomic groups.[272] In this study SED was measured using the Scottish Index of Multiple Deprivation (SIMD). This score incorporates multiple components from a number of social agencies. Small areas are assigned a score from 0.54 (the least deprived) to 87.6 (the most deprived) and the population is then divided in to quintiles. ASSIGN classified more people with social deprivation and positive family history as high risk, anticipated more of their events, and abolished the gradient in cardiovascular event rates seen when risk was predicted solely using the Framingham score. In England and Wales a prospective cohort study in a large UK primary care population was used to develop a risk prediction model that included SED.[273,274] In this study, version 14 of the QRESEARCH database, a large, validated electronic database representative of primary care and containing the health records of 10 million patients over a 17 year period from 529 general practices was used to develop and validate the score. In this risk score, SED was defined on the basis of the area based score, the Townsend score. An analysis of a risk score in acute coronary syndromes has also been tested with regards to its calibration according to SED and has been found to be useful in all groups irrespective of SED.[275] Therefore, increasing awareness of this issue will hopefully lead to SED being taken into account in the development of future risk scores.

Limitations of the studies

The current studies are not without their limitations. A strength of this study is that two measures of SED were examined, social class and Carstairs Morris index. However, social class could not be assigned to every individual in the cohort and women were assigned the social class of their husband if they did not have an occupation. Using an area based measure of SED can lead to the “ecological fallacy”, i.e. that the relationship between SED and CVD is the same at an individual level and the area level measure in the Carstairs Morris index. The assumption that individual members of the area are correctly defined by

the average characteristics of the small area assigned may in fact be false. However, the Carstairs Morris index is based on small enough areas that the ecological fallacy is less of a concern and the index has been well validated.[10,11]

There are limitations to the historical nature of this cohort. Whilst a mature cohort study is necessary to examine associations over a prolonged period, the long follow up does give rise to some problems. The cohort was examined at baseline only; follow up clinical measures were not available. The effect of changing risk factor profiles could not be assessed in these data therefore. Risk factors such as blood pressure and cholesterol change over time, often increasing with advancing age. However subjects in this cohort may have undergone lifestyle, behavioural and/or pharmacotherapeutic interventions aimed at modifying CVD risk factors over the course of follow up. There is evidence that the traditional cardiovascular risk factors have changed differentially by SED over time with those in the most deprived groups developing more unfavourable risk factor profiles.[146] For example, a large proportion of participants were smokers at baseline. With only one assessment of smoking status, taken at baseline, I could not assess how many people quit during follow up. Nor could I assess the potential impact of a CVD hospitalisation on smoking. Studies would suggest that the impact of a CVD hospitalisation on risk factors, such as smoking through cessation rates, differs by SED, with the least deprived being more likely to quit.[229] Other factors may be similarly affected differentially by SED such as cholesterol levels through differing rates of prescription of cholesterol lowering therapies.[165] These are limitations of the studies. Similarly, no information was collected during follow up regarding the use of evidence based therapies that might alter cardiovascular risk. Finally, whilst the long period of follow up is a major strength of these studies it is also a potential limitation. Regression dilution occurred as follow up progressed.[225] Past the period of 25 years of follow up the hazard ratios associated with SED started to fall. This is not due to the lack of an effect but rather regression dilution. However, the impact of regression dilution affects all variables but it is unclear how it affects SED specifically.

SED was also measured at only one time point in this study. The Carstairs Morris index applied was derived from the 1981 census. Therefore, the index may not have accurately captured the socioeconomic conditions of the cohort at recruitment. In addition by middle age, SED status is fairly well fixed it is not impossible that some movement in SED status occurred during follow up.[276] A number of other possible mediators between SED and the risk of CVD have been described in the literature such as behaviour, stress, job control[255], physiological variables such as heart rate recovery[195] etc. These variables were not

recorded or measured in this cohort and the effect of these on the associations between SED and CVD seen in this cohort cannot be estimated. As noted above, the continued effect or "dose" of SED may have a role to play in the development of CVD over a lifetime. SED was measured at the point of midlife, between the ages of 45-64 in this cohort. It is unknown what the cumulative life course "dose" of SED was in this cohort as childhood SED status is unknown in this cohort. Therefore, a life course approach to SED could not be made in this particular cohort. Finally, a family history of premature cardiovascular disease is recognised as a major risk factor alongside, diabetes, hypertension, smoking and serum cholesterol. This was not recorded in the cohort. However, the Framingham risk score also did not include family history of CVD as a variable and therefore the results of these studies are still valid.

Finally, it must be acknowledged that this cohort was restricted to the ages of 45-64 years at enrolment. Whilst the relationship between SED and CVD is certainly present in younger age groups[41] (and studies would suggest that the relationship is stronger[65]), caution should be used in extrapolation of the results of this thesis to other age groups.

How do we change the risk of the most deprived?

Efforts at the level of the individual

The above studies and results would suggest that SED is an important risk factor for cardiovascular disease, over and above the traditional risk factors. However, the exact mechanism by which this excess risk if conferred is open to speculation. What is becoming clearer from the literature is that SED exerts its effect through many pathways. Therefore, any intervention to change the risk of the most deprived needs to acknowledge this and try to change multiple possible pathways. Immediately it seems as if these interventions are out of the reach of individual health care professional. Altering SED seemingly relies on policy and government action to alter the disparities in society. Government level action is needed for example to change housing standards for the most deprived members of a society or help lower unemployment. The minimum wage is another area where policy change can have beneficial effects on inequities in a society or similarly banning unhealthy behaviour such as smoking will impact upon all parts of society. Other initiatives such as the introduction of health targets or reallocation of health care resources to more deprived areas are other examples of how policy may help to reduce the differences in CVD according to SED. Other factors are harder for the state to intervene in such as the

possibility that social support mediates part of the relationship between SED and CVD. However, through the improvement of communities and facilities this may lead to improvements in social structures and hence support mechanisms. However, more complex interventions will be needed to tackle the inequalities not only in cardiovascular health but health in general. I will return to these later.

These are difficult and daunting tasks for the clinician or health care professional. However, multiple areas exist where an individual health care professional can make a difference to the risk of CVD associated with SED. The first issue is of identification of risk. The ASSIGN[272] and QRISK[273,274] scores attempt to do this by including SED in their CVD risk scores. This will ensure that high risk individuals are appropriately identified in primary care and evidence based therapies that are known to lower risk of CVD are appropriately prescribed. This in turn will help to reduce the inverse care law [24], where the most deprived in most need of health care are less likely to receive it.

Change is also required early on in an individual's life course to alter the risk of future disease, and as a health care professional engaging with young adults about poor life style choices around risk factors such as smoking is possible and beneficial. Indeed risk factor management may have one of the largest roles to play in reducing the differences in CVD rates in the deprived members of society.[257] The INTERHEART studies indicated that the large proportion of attributable risk for myocardial infarction was explained by nine risk factors, smoking, diabetes, hypertension, abdominal obesity, exercise, alcohol, apoB/apoA1 lipoprotein ratio, and a psychosocial index that measured the presence of depression and stress at work and at home.[67] These factors accounted for 90.5% of the attributable risk of myocardial infarction in the 12461 cases of myocardial infarction in the study. In a recent analysis of the INTERHEART study, the addition of education as a marker of SED increased this attributable risk to only 92.7%.[68] This would suggest that most, if not all, inequalities in myocardial infarction rates could be eliminated if the nine modifiable risk factors could be improved. This does not mean that SED is not a risk factor or important risk factor for CVD but that the absolute inequalities may be explained by these risk factors, which explain the majority of cases in a population, even though they do not explain all of the association between SED and CVD. Thus, in absolute terms, treatment of known risk factors in a population such as smoking and high cholesterol will reduce SED differences in CVD rates. To further illustrate this point, take the following hypothetical example. If a population existed where all individuals smoked, were diabetic and had hypertension the relative differences in SED and CVD would be explained by the other factors such as cholesterol. However, whilst an intervention to reduce serum

cholesterol would reduce the relative inequalities in CVD it would not reduce the absolute burden of CVD which was driven by the ubiquity of the other major risk factors in this theoretical population. Therefore, health care professionals have the opportunity to reduce relative and absolute burdens of CVD in the population by adequately addressing the risk factor profile of patients at risk of CVD. A study of this theory was conducted in the Whitehall cohort.[257] The authors reported that reducing the burden of classical cardiovascular risk factors, blood pressure, cholesterol, diabetes and smoking would reduce by 69%, if current best available practice or pharmacotherapies were applied. If risk factors could be removed the reduction would be 86%. Therefore, despite this some inequality in coronary heart disease mortality would remain. The underlying reasons for such persisting difference are of course the subject of much current research in this area as the classical cardiovascular risk factors do not explain the entire gradient.

As noted the INTERHEART studies highlighted the important contribution of psychosocial factors to the risk of myocardial infarction. However, psychosocial factors may also explain part of the relationship between SED and CVD. Depression can be screened for using simple tools.[277,278] Through the identification of such patients appropriate pharmacological therapy or non-pharmacological therapy such as cognitive behavioural therapy could be prescribed in an effort to reduce such psychosocial risks. The reduction of other psychosocial stressors such as financial or housing worries is more difficult and lends itself to a political approach to altering SED differentials in CVD risk.

Finally, the use of multidisciplinary teams by health care professionals may also lead to improvements in health outcomes in all members of society. It is difficult for one health care professional to address all the determinants of health. The use of multidisciplinary teams maximises the chances of therapies being prescribed in appropriate doses, and, maximises the support an individual may receive in making hard lifestyle choices and alterations such as smoking cessation. Specialist knowledge on the complex societal and contextual effects of the causes of smoking[153], such as that held by smoking cessation staff may help to improve the chances of an individual ceasing to smoke.

Whilst most of these interventions are not targeting SED per se they do target the known modifiable risk factors for CVD that most health care professionals are comfortable dealing with. These interventions do however focus the health care professional to try and supply these treatments and services to the most deprived, and indeed all members of society, and try to ensure equitable access in an attempt to reduce social inequities and the burden of CVD overall in society.

Political efforts to reduce health inequalities

Whilst the individual health care professional can make some efforts to improve the health of individuals and therefore society as a whole, it is perhaps clear that given socioeconomic differences in health and CVD are the function of complex causes, that society level intervention will be required to help reduce these inequalities. From this study, and others, it has been shown that SED not only acts at the level of the individual but also at the level of small areas of residence.

Since devolution, a number of policy documents have focused on the issue of health inequalities in Scotland. The first, the 1999 White Paper, Towards A Healthier Scotland[21], recognised that health improvement initiatives should include not only lifestyle choices and the major diseases but also include life circumstances i.e. housing, employment, education, welfare benefits, childcare and community care. All actions were designed to reduce health inequalities. Policies outlined in this document were associated with funding commitments and aimed to redress inequalities through a number of schemes. For example, interventions were aimed at families and young children to improve social support through after school care and education, childcare tax credits. Other interventions were aimed at housing such as improving the insulation in homes of low income families; the Warm Deal Initiative. Towards a Healthier Scotland was followed by subsequent policy documents. The 2003 White Paper, Partnership for Care[279], Improving Health in Scotland: The Challenge[22], 2003, and the 2005 Delivering for Health report[280], all of which highlighted the need to reduce inequalities in health.

In 2007, the Scottish Government set up a Ministerial Task Force on Health Inequalities. The report of the Task Force, Equally Well[281], was published in 2008 and outlined a number of recommendations for dealing with the underlying causes of health inequalities. These recommendations fell under a number of headings: early years & young people; tackling poverty and increasing employment; physical environments and transport; harms to health and well being, alcohol, drugs and violence; health and wellbeing.

Equally Well was followed in 2008 by the Equally Well Implementation Plan[282] which sought to outline how the aims of the Equally Well report could be achieved via policy. A further publication listed the indicators to be used in assessing progress in tackling inequalities - Long-term monitoring of health inequalities: first report on headline indicators[283]. Finally, it was originally aimed that the Ministerial Task Force on Health Inequalities would be reconvened to review progress since the publication of Equally Well

in 2008. The Task Force is expected to report by the summer of 2010. The review will specifically consider whether any further actions are required to tackle the inequalities outlined in the three social policy frameworks - Equally Well, the Early Years Framework and Achieving Our Potential. This will consider the prevailing financial climate, new trends or concepts or evidence in health inequalities.

The reduction of health inequalities plays a pivotal role in the Scottish Government's overall purpose of sustainable economic growth. The Government has committed to increase healthy life expectancy and the proportion of income earned by the three lowest income deciles as a group by 2017. Inequality-related indicators also make up some of the forty-five national indicators being used to track progress towards the achievement of national outcomes.[284] Examples include, decreasing the proportion of individuals living in poverty, increasing healthy life expectancy at birth in the most deprived areas, and reducing mortality from coronary heart disease among the under 75s in deprived areas.

In parallel to these social model approaches to tackling inequalities, the health services in Scotland are being redeveloped according to proposals in a report on health care delivery.[285] This shifted the focus of care onto preventative measures, in an attempt to prevent these inequalities in health from occurring. This has not been the only change in preventative healthcare in Scotland. NHS Health Scotland has as one of its aims to reduce health inequalities. In Glasgow the establishment of the Glasgow Centre for Population Health was intended to develop a better understanding of health in Glasgow and to evaluate the impact of strategies with the aim of enhancing health and in particular reducing inequalities.

Future areas of research

This study consolidates the current level of evidence that SED is indeed related to the risk of cardiovascular disease, but furthers it by confirming the relationship in a number of cardiovascular outcomes, over a prolonged period, independent of cardiovascular risk factors. Just as these analyses examined a gap in the current evidence, other gaps still remain and should be the focus of further research.

As was noted above, the traditional cardiovascular risk factors only explain part of the association between SED and CVD. It is important to now try and elucidate the mechanism by which SED confers this extra risk. Authors have examined such issues as pathogen burden[180], access to healthcare[286], and the influence of peri-natal life[162] to name but a few

examples. However, no one unifying hypothesis has yet been found. As noted above, no one explanation may be found, though further research may elucidate the many pathways by which SED ultimately leads to a higher cardiovascular risk.

In recent years the rate of research in the field of genetic epidemiology has increased considerably. Some authors have examined focussed genetic differences in an attempt to explain differences in disease rates by SED.[163] However, overall this field of research is underutilised in the realm of SED and health, although this approach will need careful consideration of the ethical issues.[287]

Finally, one further major gap in our knowledge surrounding SED and CVD requires further investigation. In this thesis I was not able to examine the relationship between SED and other forms for cardiovascular disease such as atrial fibrillation and venous thromboembolism. These other cardiovascular disease have also been understudied with respect to SED differences in incidence, survival, treatment etc.[288,289] Further research on these and less studied cardiovascular diseases is required.

Conclusions

The conclusions and outcomes of the analyses presented in this thesis can be summarised as follows:

Socioeconomic deprivation is associated with higher rates of hospitalisation for cardiovascular disease in men and women irrespective of the measure of SED, either social class or the area based score of the Carstairs Morris index.

The association between SED and hospitalisations persists after adjustment for the traditional cardiovascular risk factors of age, sex, smoking, systolic blood pressure and diabetes.

The further adjustment for lung function as measured by FEV1, obesity as measured by BMI and cardiomegaly on a chest x-ray failed to explain or diminish this relationship.

The association between SED and CVD is similar in coronary heart disease, myocardial infarction and stroke and all cause mortality.

The effect of SED is long lasting and persists beyond 25 years of follow up.

SED is associated with higher mortality following an admission to hospital with cardiovascular disease again after adjustment for cardiovascular risk factors of age, sex, smoking, systolic blood pressure and diabetes and adjusting for the year of first developing cardiovascular disease.

SED is not associated with the risk of a recurrent cardiovascular hospitalisation.

The risk of all cause death is highest in the most deprived. Again this association persists after adjustment for cardiovascular risk factors.

The most deprived stay longer in hospital than the least deprived for a number of cardiovascular disease types including myocardial infarction and stroke.

The costs associated with cardiovascular disease admissions to hospital are higher in the most deprived despite their higher risk of dying during follow up. This is mediated by a higher number of admissions per person and longer in hospital stays in the most deprived.

The population attributable risk associated with SED is comparable to that of other traditional cardiovascular risk factors.

Appendix 1

Search strategy employed in the search of the literature.

1. exp Occupations/
2. exp Income/
3. exp Employment/
4. exp Population characteristics/
5. exp Education/
6. exp Health Behavior/
7. exp Poverty/
8. exp Poverty Areas/
9. exp Socioeconomic Factors/
10. exp Social Class/
11. exp Social Conditions/
12. exp Unemployment/
13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. (poverty or deprivation or deprived or ghettos or slums or disadvantaged or unemployed or unemployment).ti,ab.
15. (socio?economic$ or socio?demographic or inequality or inequalities or (inner adj (city or cities)) or ((low or high) adj1 (income or wage or salary or salaries))).ti,ab.
16. ((standard$1 adj2 living) or (blue adj collar) or (white adj collar) or ((working or middle) adj2 class$)).mp. [mp=title, original title, abstract, name of substance, mesh subject heading]
17. (socio?economic$ or poverty or depriv$).ti.
18. (poverty or deprivation or deprived or ghettos or slums or disadvantaged or unemployed or unemployment or (socio?economic$ or socio?demographic or inequality or inequalities or (inner adj (city or cities)) or ((low or high) adj1 (income or wage or salary or salaries))) or ((standard$1 adj2 living) or (blue adj collar) or (white adj collar) or ((working or middle) adj2 class$) or (social adj inclusion adj partnership))).ti.
19. 14 or 15 or 16 or 17 or 18
20. exp Heart Diseases/
21. *Cardiovascular Diseases/
22. exp Cardiovascular Diseases/
23. (cardiovascular or heart or coronary or cardiac or myocardial or stroke or cerebrovascular).ti.
24. 20 or 21 or 22 or 23
25. 13 and 24
26. 19 and 24
27. 25 or 26

Appendix 2

This appendix gives some examples of the results of the full multivariable models from the analyses of cardiovascular hospitalisations. Only the results concerning the analysis of a first cardiovascular outcome are provided to demonstrate the validity of the other variables in the models The full results of the unadjusted model, the model adjusted for age, sex, diabetes, smoking, cholesterol and blood pressure as well as the models including bronchitis, body mass index, cardiomegaly on chest x-ray and adjusted FEV1 are included.

Table 97 Full model for all CVD hospitalisations at 25 years with Carstairs Morris index

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Deprivation Category 1						
Deprivation Category 3	1.10	0.08	1.31	0.191	0.95	1.27
Deprivation Category 4	1.15	0.08	2.01	0.044	1.00	1.31
Deprivation Category 5	1.22	0.08	3.1	0.002	1.08	1.39
Deprivation Category 6 & 7	1.42	0.10	5.13	<0.001	1.24	1.62

Table 98 Full model for all CVD hospitalisations at 25 years with Carstairs Morris index adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Deprivation Category 1						
Deprivation Category 3	1.10	0.08	1.33	0.183	0.95	1.27
Deprivation Category 4	1.16	0.08	2.15	0.032	1.01	1.33
Deprivation Category 5	1.19	0.08	2.62	0.009	1.04	1.35
Deprivation Category 6 & 7	1.39	0.09	4.79	<0.001	1.21	1.58
Age (per year)	1.04	0.00	12.94	<0.001	1.03	1.04
Sex (male vs. female)	1.49	0.05	12.25	<0.001	1.39	1.58
Diabetes	2.19	0.24	7.17	<0.001	1.77	2.71
Smoker	1.44	0.05	10.5	<0.001	1.34	1.54
Cholesterol (per mmol/l)	1.07	0.02	4.58	<0.001	1.04	1.10
Systolic blood pressure (per mmHg)	1.01	0.00	14.44	<0.001	1.01	1.01

Table 99 Full model for all CVD hospitalisations at 25 years with Carstairs Morris index adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure, bronchitis, body mass index and adjusted FEV1.

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Deprivation Category 1						
Deprivation Category 3	1.09	0.08	1.2	0.229	0.95	1.27
Deprivation Category 4	1.12	0.08	1.61	0.107	0.98	1.28
Deprivation Category 5	1.14	0.08	2	0.046	1.00	1.30
Deprivation Category 6 & 7	1.30	0.09	3.81	<0.001	1.14	1.49
Age (per year)	1.04	0.00	12.27	<0.001	1.03	1.04
Sex (male vs. female)	1.51	0.05	12.29	<0.001	1.41	1.61
Diabetes	2.20	0.25	7	<0.001	1.77	2.75
Smoker	1.44	0.05	10.09	<0.001	1.34	1.54
Cholesterol (per mmol/l)	1.07	0.02	4.75	<0.001	1.04	1.10
Systolic blood pressure (per mmHg)	1.01	0.00	11.97	<0.001	1.01	1.01
Bronchitis	1.35	0.12	3.44	0.001	1.14	1.61
Body mass index (per kg/m^2)	1.01	0.00	2.84	0.005	1.00	1.02
Cardiomegaly	1.20	0.05	4.89	<0.001	1.12	1.29
Adjusted FEV1 (per %)	1.00	0.00	-5.2	<0.001	0.99	1.00

Table 100 Full model for all CVD hospitalisations at 25 years with social class

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Social Class I						
Social Class II	1.22	0.11	2.17	0.03	1.02	1.46
Social Class III-NM	1.19	0.11	1.88	0.06	0.99	1.42
Social Class III-M	1.47	0.138	4.35	<0.001	1.23	1.74
Social Class IV	1.29	0.11	2.88	0.004	1.09	1.54
Social Class V	1.40	0.14	3.46	0.001	1.16	1.70

Table 101 Full model for all CVD hospitalisations at 25 years with social class adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Social Class I						
Social Class II	1.29	0.12	2.73	0.006	1.07	1.54
Social Class III-NM	1.31	0.12	2.99	0.003	1.10	1.57
Social Class III-M	1.37	0.12	3.55	<0.001	1.15	1.63
Social Class IV	1.33	0.11	3.2	0.001	1.12	1.59
Social Class V	1.44	0.14	3.69	<0.001	1.19	1.75
Age (per year)	1.04	0.002	12.84	<0.001	1.03	1.04
Sex (male vs. female)	1.48	0.05	11.56	<0.001	1.39	1.58
Diabetes	2.17	0.24	6.93	<0.001	1.74	2.70
Smoker	1.45	0.05	10.71	<0.001	1.36	1.56
Cholesterol (per mmol/l)	1.07	0.01	4.86	<0.001	1.04	1.10
Systolic blood pressure (per mmHg)	1.01	0.0006	13.96	<0.001	1.01	1.01

Table 102 Full model for all CVD hospitalisations at 25 years with social class adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure, bronchitis, body mass index and adjusted FEV1.

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Social Class I						
Social Class II	1.27	0.120866	2.53	0.011	1.06	1.53
Social Class III-NM	1.31	0.122884	2.86	0.004	1.09	1.57
Social Class III-M	1.32	0.11995	3.02	0.002	1.10	1.57
Social Class IV	1.28	0.117988	2.63	0.009	1.06	1.53
Social Class V	1.36	0.138722	2.97	0.003	1.11	1.66
Age (per year)	1.04	0.003054	12.15	<0.001	1.03	1.04
Sex (male vs. female)	1.51	0.053251	11.71	<0.001	1.41	1.62
Diabetes	2.18	0.252124	6.75	<0.001	1.74	2.74
Smoker	1.45	0.052863	10.18	<0.001	1.35	1.56
Cholesterol (per mmol/l)	1.08	0.016114	5	<0.001	1.05	1.11
Systolic blood pressure (per mmHg)	1.01	0.000679	11.64	<0.001	1.01	1.01
Bronchitis	1.36	0.120321	3.5	<0.001	1.15	1.62
Body mass index (per kg/m^2)	1.01	0.004327	2.79	0.005	1.00	1.02
Cardiomegaly	1.21	0.045828	4.95	<0.001	1.12	1.30
Adjusted FEV1 (per %)	1.00	0.00073	-5.19	<0.001	0.99	1.00

Appendix 3

This appendix gives some examples of the results of the full multivariable models from the analyses that examined the risk of a recurrent cardiovascular hospitalisation according to SED. Only the results concerning the analysis of a recurrent cardiovascular hospitalisations are provided to demonstrate the validity of the other variables in the models The full results of the unadjusted model, the model adjusted for age, sex, diabetes, smoking, cholesterol and blood pressure as well as the models including bronchitis, body mass index, cardiomegaly on chest x-ray and adjusted FEV1 are included.

Table 103 Full model for all recurrent CVD hospitalisations at 25 years with Carstairs Morris index

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Deprivation Category 1						
Deprivation Category 3	1.01	0.10	0.13	0.894	0.84	1.23
Deprivation Category 4	1.07	0.10	0.72	0.471	0.89	1.28
Deprivation Category 5	1.05	0.09	0.6	0.548	0.89	1.25
Deprivation Category 6 & 7	1.02	0.09	0.26	0.797	0.85	1.23

Table 104 Full model for all recurrent CVD hospitalisations at 25 years with Carstairs Morris index adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure, year of first CVD event

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Deprivation Category 1						
Deprivation Category 3	0.99	0.10	-0.08	0.935	0.82	1.20
Deprivation Category 4	1.05	0.10	0.51	0.608	0.87	1.26
Deprivation Category 5	1.02	0.09	0.19	0.848	0.85	1.21
Deprivation Category 6 & 7	0.99	0.09	-0.15	0.885	0.82	1.18
Age (per year)	0.98	0.00	-4.68	<0.001	0.98	0.99
Sex (male vs. female)	1.11	0.05	2.35	0.019	1.02	1.21
Diabetes	1.13	0.17	0.76	0.445	0.83	1.52
Smoker	1.08	0.05	1.64	0.101	0.99	1.18
Cholesterol (per mmol/l)	1.09	0.02	4.5	<0.001	1.05	1.13
Systolic blood pressure (per mmHg)	1.00	0.00	2.89	0.004	1.00	1.00
Year of first CVD event	1.00	0.00	-0.11	0.915	0.99	1.01

Table 105 Full model for all recurrent CVD hospitalisations at 25 years with Carstairs Morris index adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure, year of first CVD event, bronchitis, body mass index and adjusted FEV1.

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Deprivation Category 1						
Deprivation Category 3	1.00	0.10	-0.03	0.973	0.82	1.21
Deprivation Category 4	1.04	0.10	0.39	0.7	0.86	1.25
Deprivation Category 5	0.99	0.09	-0.13	0.896	0.83	1.18
Deprivation Category 6 & 7	0.96	0.09	-0.41	0.684	0.80	1.16
Age (per year)	0.98	0.00	-4.76	<0.001	0.97	0.99
Sex (male vs. female)	1.17	0.07	2.8	0.005	1.05	1.31
Diabetes	1.07	0.17	0.39	0.694	0.78	1.46
Smoker	1.10	0.05	1.93	0.054	1.00	1.21
Cholesterol (per mmol/l)	1.09	0.02	4.56	<0.001	1.05	1.14
Systolic blood pressure (per mmHg)	1.00	0.00	2.06	0.04	1.00	1.00
Year of first CVD event	1.00	0.00	0.5	0.616	0.99	1.01
Bronchitis	1.04	0.13	0.31	0.756	0.81	1.33
Body mass index (per kg/m^2)	1.00	0.01	0.53	0.598	0.99	1.01
Cardiomegaly	1.18	0.06	3.38	0.001	1.07	1.31
Adjusted FEV1 (per %)	1.00	0.00	-0.71	0.48	1.00	1.00

Table 106 Model for all recurrent CVD hospitalisations at 25 years with social class

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Social Class I						
Social Class II	0.94	0.11	-0.56	0.578	0.74	1.18
Social Class III-NM	0.90	0.11	-0.88	0.38	0.72	1.13
Social Class III-M	0.91	0.10	-0.82	0.41	0.73	1.14
Social Class IV	0.93	0.11	-0.65	0.518	0.74	1.16
Social Class V	0.99	0.13	-0.05	0.957	0.77	1.27

Table 107 Full model for all recurrent CVD hospitalisations at 25 years with social class adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure, year of first CVD event

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Social Class I						
Social Class II	0.95	0.11	-0.41	0.681	0.75	1.20
Social Class III-NM	0.93	0.11	-0.59	0.552	0.74	1.18
Social Class III-M	0.90	0.10	-0.91	0.361	0.72	1.13
Social Class IV	0.94	0.11	-0.49	0.624	0.75	1.19
Social Class V	1.02	0.13	0.15	0.884	0.79	1.31
Age (per year)	0.98	0.00	-4.81	<0.001	0.97	0.99
Sex (male vs. female)	1.12	0.05	2.45	0.014	1.02	1.22
Diabetes	1.15	0.18	0.92	0.358	0.85	1.57
Smoker	1.09	0.05	1.74	0.083	0.99	1.19
Cholesterol (per mmol/l)	1.09	0.02	4.3	<0.001	1.05	1.13
Systolic blood pressure (per mmHg)	1.00	0.00	2.77	0.006	1.00	1.00
Year of first CVD event	1.00	0.00	0.01	0.99	0.99	1.01

Table 108 Full model for all recurrent CVD hospitalisations at 25 years with social class adjusted for age, sex, diabetes, smoking, cholesterol and systolic blood pressure, year of first CVD event, bronchitis, body mass index and adjusted FEV1..

Variable	Hazard Ratio	SE	z	P	95% Confidence Interval	
Social Class I						
Social Class II	0.94	0.12	-0.52	0.605	0.74	1.19
Social Class III-NM	0.94	0.11	-0.55	0.579	0.74	1.19
Social Class III-M	0.90	0.11	-0.86	0.391	0.72	1.14
Social Class IV	0.94	0.11	-0.51	0.61	0.74	1.19
Social Class V	1.00	0.13	0.01	0.989	0.77	1.30
Age (per year)	0.98	0.00	-4.87	<0.001	0.97	0.99
Sex (male vs. female)	1.18	0.07	2.89	0.004	1.06	1.33
Diabetes	1.09	0.18	0.55	0.583	0.79	1.50
Smoker	1.10	0.05	1.99	0.047	1.00	1.22
Cholesterol (per mmol/l)	1.09	0.02	4.37	<0.001	1.05	1.14
Systolic blood pressure (per mmHg)	1.00	0.00	1.87	0.062	1.00	1.00
Year of first CVD event	1.00	0.00	0.61	0.539	0.99	1.01
Bronchitis	1.01	0.13	0.11	0.91	0.79	1.30
Body mass index (per kg/m^2)	1.00	0.01	0.59	0.556	0.99	1.01
Cardiomegaly	1.18	0.06	3.2	0.001	1.06	1.30
Adjusted FEV1 (per %)	1.00	0.00	-0.75	0.454	1.00	1.00

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Stewart S, Murphy NF, McMurray JJ, Jhund P, Hart CL, Hole D. Effect of socioeconomic deprivation on the population risk of incident heart failure hospitalisation: an analysis of the Renfrew/Paisley Study. *Eur J Heart Fail*. 2006;8(8):856-63.

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Presentations to learned societies of work undertaken for this thesis

ESC Congress 2010, Stockholm, Sweden. 28th August – 1st September 2010. Jhund PS, Lewsey JD, Hart CL, MacIntyre K, McMurray JJV. Socioeconomic deprivation is associated with a higher risk of all forms of cardiovascular disease over 25 years: a cohort study of over 15,000 men and women. *Poster Presentation.*

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