PUBLICATIONS OF PUBLIC HEALTH M 195:2008

SOCIAL-CLASS INEQUALITIES IN ILL HEALTH

– the contribution of physical workload

Akseli Aittomäki

Department of Public Health, University of Helsinki, Finland

Akseli Aittomäki

Social-class inequalities in ill health – the contribution of physical workload

A doctoral thesis

To be presented, with the permission of the Faculty of Medicine, University of Helsinki, for public examination in lecture hall PIII, Porthania on 19 Sep 2008 at 12 pm

Department of Public Health
Faculty of Medicine
University of Helsinki

Helsinki, Finland
2008

ISSN 0355-7979
ISBN 978-952-10-1381-2
ISBN 978-952-10-1382-9 (pdf)

Cover design and photo: Akseli Aittomäki
(rooftops in Eira, Helsinki, 2008, skeleton
from Vesalius 1568/1725)

Helsinki University Print – Yliopistopaino
Helsinki 2008

Supervised by: Professor Eero Lahelma
Department of Public Health
University of Helsinki

Professor Pekka Martikainen
Department of Sociology
University of Helsinki

Ossi Rahkonen, PhD
Department of Public Health
University of Helsinki

Päivi Leino-Arjas, PhD, MD
Finnish Institute of Occupational Health

Reviewed by: Professor Seppo Pöntinen
Department of Sociology
University of Turku

Pekka Virtanen, PhD, MD
Tampere School of Public Health
University of Tampere

Opponent: Professor Jon Ivar Elstad
Department of Sociology and Human Geography
University of Oslo
Norwegian Social Research NOVA

Index

List of original publications

Aittomäki Akseli, Lahelma Eero, Roos Eva. Work conditions and socioeconomic inequalities in work ability. Scandinavian Journal of Work, Environment and Health 2003; 29 (2): 159-165.

Aittomäki Akseli, Lahelma Eero, Roos Eva, Leino-Arjas Päivi, Martikainen Pekka. Gender differences in the association of age with physical workload and functioning. Occupational and Environmental Medicine 2005; 62 (2): 95-100.
doi:10.1136/oem.2004.014035

Aittomäki Akseli, Lahelma Eero, Rahkonen Ossi, Leino-Arjas Päivi, Martikainen Pekka. The contribution of musculoskeletal disorders and physical workload to socioeconomic inequalities in health. European Journal of Public Health 2007; 17 (2): 145-150.
doi:10.1093/eurpub/ckl121

Aittomäki Akseli, Lahelma Eero, Rahkonen Ossi, Leino-Arjas Päivi, Martikainen Pekka. Job decision latitude as a potential modifier of the contribution of physical workload to poor functioning in middle-aged employees. International Archives of Occupational and Environmental Health 2008; 81 (8): 975-982.
doi: 10.1007/s00420-007-0291-z

Reference to doctoral thesis

Aittomäki Akseli. Social-class inequalities in ill health – the contribution of physical workload. Publications of Public Health M 195:2008. Helsinki, University of Helsinki, 2008.

Electronic version available at the University of Helsinki,
http://ethesis.helsinki.fi/

Abstract

This study focused on social-class inequalities in illness and incapacity, and the impact of physical workload and other work conditions on illness. The empirical work has been reported in four articles in published scientific journals. The summary in this publication contains an overview of the results, and a critical review of the theoretical issues and the relevant research tradition.

The main objectives of the study were: 1) to examine the contribution of physical workload, and to a lesser extent other work conditions, to social-class differences in illness and incapacity; 2) to examine the interaction effects of physical workload, job decision latitude, class position, age and gender on ill health; and 3) to test to what degree the association between mechanical work exposure and musculoskeletal morbidity may contribute to class inequalities in overall ill health.

The study participants were middle-aged employees of the City of Helsinki, the capital of Finland. The baseline data of the Helsinki Health Study, collected between the years 2000 and 2002, was used, and all the analyses were cross-sectional. The number of participants in the analysed data varied between 3740 and 8002.

The results indicated that physical work conditions make a marked contribution to social-class differences in overall illness, functional limitation, musculoskeletal morbidity and self-rating of health. The observed contribution to class inequalities in overall ill health was stronger for women than for men, almost half of such inequalities in women being attributable to physical workload. The effect of physically demanding work on functional limitation was not, for the most part, modified by job decision latitude. The effect of physical workload on functioning increased more with age among women than among men. Some, but not all of the contribution of physical workload to overall ill health was attributable to musculoskeletal morbidity.

Health and illness are essentially not unitary conditions, and various socially and structurally determined conditions are likely to contribute to social inequalities in illness, disease and dysfunction. The degree to which differences in physical conditions might explain social inequalities in ill health may have been overlooked. Differences in such conditions between the social classes continue to exist, and they are likely to explain inequalities in ill health to a significant degree.

Tiivistelmä

Tutkimuksen aiheita olivat yhteiskuntaluokkien väliset erot sairastavuudessa ja alentuneessa toimintakyvyssä, sekä fyysisen työkuormituksen ja joidenkin muiden työolojen vaikutus sairastavuuteen. Empiirisestä työstä on raportoitu myös neljässä kansainvälisissä tieteellisissä aikakauskirjoissa julkaistussa artikkelissa. Tässä julkaistu yhteenveto sisältää tulosten yhteenvedon lisäksi myös tutkimusta koskevien käsitteellisten ja teoreettisten kysymysten sekä tutkimustradition kriittisen katsauksen.

Työn päätavoitteita olivat 1) tutkia fyysisesti kuormittavan työn, ja jossain määrin muiden työolojen osuutta yhteiskuntaluokkien välisiin eroihin sairaudessa ja toimintakyvyn alentuneisuudessa; 2) tutkia työn fyysisen kuormittavuuden, työhön liittyvien vaikutusmahdollisuuksien ja hallinnan (decision latitude), luokka-aseman, iän ja sukupuolen yhteisvaikutuksia heikentyneeseen terveydentilaan; sekä 3) tutkia missä määrin mekaanisten työaltisteiden ja tuki- ja liikuntaelinsairastavuuden välinen yhteys voi selittää yhteiskuntaluokkien välisiä eroja heikentyneessä yleisessä terveydentilassa.

Tutkittavat olivat keski-ikäisiä Helsingin kaupungin työntekijöitä. Analyysit perustuivat poikittaisasetelmaan, ja käytetty aineisto oli Helsinki Health Studyn vuosien 2000 ja 2002 välillä kerättyä aineistoa. Analyyseihin käytetyssä aineistossa oli 3740:stä 8002:een tutkittavaa.

Tulosten perusteella fyysisillä (sekä fysikaalisilla) työoloilla on merkittävä vaikutus yhteiskuntaluokkien välisiin eroihin yleisessä sairastavuudessa, toimintakyvyn heikentymisessä, tuki- ja liikuntaelinsairastavuudessa sekä itsearvioidussa terveydentilassa. Naisilla lähes puolet heikentyneen toimintakyvyn ja koetun terveydentilan luokkaeroista vaikutti olevan selitettävissä fyysisellä työkuormituksella. Hallintamahdollisuuksien ei havaittu merkittävästi muuttavan fyysisen kuormituksen vaikutusta toimintakykyyn. Fyysisen kuormittavuuden terveysvaikutus voimistui kasvavan iän mukaan enemmän naisilla kuin miehillä. Osa, mutta ei koko fyysisen kuormituksen vaikutus yhteiskuntaluokkien eroihin heikentyneessä terveydessä vaikutti välittyvän tuki- ja liikuntaelinsairastavuuden kautta.

Terveys ja sairaus eivät ole yhtenäisiä tiloja, ja siksi monet eri sosiaalisesti ja rakenteellisesti määräytyvät olosuhteet todennäköisesti vaikuttavat yhteiskunnallisten terveyserojen syntymiseen. Fyysis-materiaalisten olojen vaikutusta terveyserojen syntyyn nyky-yhteiskunnassa on mahdollisesti aliarvioitu. Yhteiskuntaluokkien väliset erot fyysis-materiaalisissa olosuhteissa eivät ole kadonneet, ja nämä erot todennäköisesti vaikuttavat terveyserojen syntyyn.

Chapter I

Introduction – the issues of work and class inequalities in ill health

Illness, social stratification and physical work are all in themselves matters that have undoubtedly been topics for concern and contemplation throughout the history of human kind. The issues related to these aspects of the human condition are social, and correspondingly their interrelations came into focus in educated discussion with the development of the social survey. The history of the study of social class, poverty and health extends some two hundred years into the past, although some isolated references to related issues are occasionally to be found even in much earlier documents. The organisation of industrial work first became the subject of scientific attention near the beginning of the 20th century, but systematic research on the impact of physical workload on the development of illness and disease goes back less than forty years.

Despite a respectable early history, social-class inequalities in health and illness were a minor area of study up to the 1970s. Since then there has been a considerable expansion of research, particularly during the 1990s. The issue of differences in rates of illness, disease and mortality between privileged and underprivileged social classes has nevertheless proven to be a great challenge for the increasing number of scholars working on the subject. We might perhaps claim to be somewhat wiser than thirty years ago, but developing an understanding of the potential reasons behind social inequalities in health and illness still requires from the prospective student a considerable effort in terms of becoming acquainted with the various theories, explanations and methodological approaches developed so far. I have attempted in the theoretical and conceptual parts of this work to demonstrate that the equivocal nature of these issues may be characteristic of the very concepts of social stratification, health and illness.

This doctoral thesis is a study on work conditions and ill health, and particularly on the possibility of explaining class inequalities in ill health in terms of the distribution of physical workload across an employed population. The study belongs to the context of a wider discipline that could conveniently be called social epidemiology, the study of the impact of social conditions on illness and disease. The empirical work was carried out on a middle-aged cohort employed by the City of Helsinki in Finland. The City is a large and varied organisation, incorporating many services supporting the core public services of a municipality, and thus the

population studied may serve, with some reservations of course, as a model for the wider employed population. The work was done as part of a wider research project, the Helsinki Health Study, and the data utilised in this study were collected between the years 2000 and 2002.

I have deliberately chosen to use the term social class to refer to the aspect of social stratification studied. Many researchers in the discipline prefer to use terms that are closer to the experimental variables used, such as educational categories, household income or occupational classification. In my judgement, however, there is an assumption common to many working in the field of inequalities in health that there is a degree of consistency and unity in the stratification of society into more privileged and less privileged groups. When social classifications based on occupation are used to describe the social structure, it seems unwarranted to overlook class theory completely. It seems to me that authors such as Lynch and Kaplan (2000) or Krieger et al. (1997) have agreed on the significance of understanding the concept of social class. I have wanted to make it explicit that the intention is to study stratification as it is manifested in the organisation of production and the division of labour, and following Weber's (1904/1970) theories, I think it is justified to view such a position as conceptually distinct from social prestige. Finally, not all indicators of socioeconomic position may be equally applicable to the objectives of this study, as personal income, for example, cannot sensibly precede physical workload. An explicit relationship with class sociology is not commonplace in studies on social epidemiology, but I have sought to develop such a relationship to a reasonable extent, mainly in Chapter II. A theoretical framework that could, to some extent, be applied to this study was presented by Goldthorpe (1980), although the application of social categories in the data did perfectly conform to any particular sociological theory.

The origins of public health research in general and studies on class inequalities in health in particular are intertwined. Although notable contributions to the history of demography were made in the 17th century, it is well-founded to regard public-health research as having been established in 19th-century studies on the living conditions and health of the industrial working class, some well-known contributions including those by Chadwick (1842/1964) and Engels (1845/1971). Studies on industrial and rural populations were carried out in many countries (e.g., Villermé 1830 and 1840, Relander 1892/1992), often focusing on the living conditions and their potential influence on health in the poorest sections of the population. As is perhaps common to the history of science and thought, the early classical perspectives on the themes combined many aspects that later developed into somewhat differentiated areas of research.

Studies on class inequalities, or socioeconomic inequalities in ill health, put forward many different strategies for explaining the inequalities, and controversies over the most valid and predictive explanations have sometimes been heated. There has been a recurrent confrontation between the advocates of explanations referring to the effects of living conditions on health and scholars maintaining that the differences in ill health are essentially a consequence of the selection of the healthier into the privileged stratum (see e.g. Szreter 1984, West 1991). Today much of the research on inequalities in health is devoted to theories of psychosocial stress, or has a relatively empiricist focus on food behaviour and substance abuse.

The existence of physical and materially objective differences in the living conditions and work conditions between the social classes was the primary explanation cited by the founders of the discipline. A material approach towards explaining inequalities in ill health is still advocated by some authors, although it has faced some challenges regarding its explanatory power in today's Western-European society (see the accounts by Elstad 2000 and Blane et al. 1997, for example). Changes in the economic structure of society, in standards of living, working life and the most prevalent diseases raised the question of whether the same aspects of society that could have caused inequalities in ill health a hundred years ago are still equally relevant. Absolute material deprivation certainly has diminished quite considerably. However, it could likewise be noted that differences in material conditions between the strata remain prevalent. If improving material welfare is beneficial for health, differences in such conditions in the population may well remain relevant even when the average level of welfare is improving in general. A revised material approach has also been suggested (e.g., by Blane et al. 1997 and Lynch and Kaplan 2000), according to which individual behaviour is also affected and determined by material conditions. Many of the explanations given for socioeconomic inequalities in ill health, however, involve complex references to many social phenomena as well as individual characteristics, including macrosocial structures, the distribution of material welfare, the organisation of work, psychological states, habitual behaviour and the individual life-course. Some of the most relevant themes are reviewed in Chapter III.

Physical work conditions have been relatively marginalised in the discussion on social inequalities in ill health. Physical work in physically hazardous conditions as a potential determinant of differences in ill health between social categories has been for the most part overlooked, although there are a few previous studies, including the work of Borg and Kristensen (2000), Schrijvers et al. (1998) and Lundberg (1991). In the whole body of publications on inequalities in health, physical work conditions are rarely addressed. The work place has often been the research

environment, and has provided the context for defining ill health, but such studies have predominantly focused on the so-called psychosocial characteristics of the work environment. A major area of social epidemiology today deals with mental strain, the experience of rewards, organisational justice, and associated concepts and conditions. This approach is characterised by the assumption that the effects of relevant exposure are mediated first through psychological states and subsequently their transformation into physiological states.

There may be several reasons for the relatively small number of studies on physical work conditions as a contributing cause of social-class inequalities in ill health, one of which is certainly the difficulty involved in measuring such conditions reliably in large population samples. However, outside the branch of epidemiology focusing on whole societies, considerable research effort in the field of occupational health has been put into studying the relationship between physical work exposure and morbidity as such, and particularly musculoskeletal morbidity. According to Westgaard and Winkel (1996) earlier studies were more focused on short-term physiological responses or changes in work performance over periods of exposure, and long-term health outcomes were addressed from the 1970s on. Although the discussion on mediating mechanisms, particular musculoskeletal conditions, relevant exposure levels and proper measurement continues, it could be concluded that a marked amount of epidemiological evidence confirms increased musculoskeletal morbidity in those exposed to a high physical workload (see, for example, Bernard editor 1997, Westgaard and Winkel 1996 and Barondess et al. 2001). Studies on physical work exposure have often focused on particularly exposed groups, but research on employed populations more generally has also reported contributions of work conditions to musculoskeletal morbidity.

Physical workload is often thought of as a diminishing problem. We may have reason to believe that the most extreme conditions of physical toil and dangerous work environments have markedly improved in Western countries during the last hundred years through mechanisation, and possibly also legislation to some extent. Nevertheless, we have very little data on the level of physical workload in the whole working population, or on the trends in potentially detrimental physical work conditions. There is no evidence to support the assumption that physical work demands in general are continuously decreasing for all occupations, or that their health effects are continuously diminishing (for European data, see Paoli and Merllié 2001 and Parent-Thirion et al. 2007). The reduction in physical labour assumed from historical impressionistic observation probably mostly occurred before the emergence of present-day work epidemiology, and was likely to have been

connected, by and large, to the structural changes in the economy of industrial societies.

The concept of ill health is many-faceted. Illness could be concisely characterised as a condition rooted in organic dysfunction and manifest as incapacity and suffering – this conception I aim to clarify in Chapter IV with reference to the philosophy of von Wright (1963/1972). The subject of this study is ill health, a deviance from expectations of normalcy, and the intention is not to elaborate on any notions of positive welfare beyond freedom from illness. A potential conceptual issue concerning ill health is whether it could be described as one unity, or whether we should accept that it is an array of different conditions not reducible to one state or quantity. This study is broadly based on the assumption that, to some extent, the degree of incapacity and limitation constitutive of illness could be operationalised as a coherent quantity, or at least as a distinction in many cases.

Several somewhat different measures of ill health were used in the substudies, reflecting the functional limitation that is characteristic of the illness, self-ratings of overall health, and also specifically morbidity from musculoskeletal disorders. The measures include the Short Form 36 health inventory on functioning (see e.g., Ware and Sherbourne 1992), a work-ability index used in research on occupational health (see e.g., Tuomi et al. 1997), musculoskeletal morbidity based on self-reported diagnosed disorders, and self-rated health. Rather than remaining separate constructs, however, I think the aspects of ill health studied contribute to an overall view of social inequalities in illness.

Social inequalities in ill health are of significant political interest. With health care services and health promotion becoming increasingly important in national politics, there have been recent political initiatives to further our understanding of inequalities in health. Recent demand is motivated by the universal observation that, despite the largely continuous increase in the average standard of living and apparent improvements in population health in Western societies, differences in ill health between social classes still prevail. There is some indication these inequalities may even have been somewhat widening during the last twenty to thirty years (see e.g., Mackenbach et al. 2003).

However, it is worth noting that an understanding of how the world comes to be as it is, is not necessarily sufficient to bring about change. This study is not an intervention study or a study on policy, and thus it would be an exaggeration to promise that it will provide the tools for whatever change is desired. Yet, I do

believe that developing a best possible understanding of how social phenomena give rise to inequalities in ill health is a prerequisite for adopting sound political attitudes, and for guiding us on where to look when we desire to make changes.

The purpose of this study is to clarify some issues on how work conditions, particularly physical workload but also some other aspects of the work environment, are related to the development of ill health. A major question concerns the extent to which the dependencies between work conditions and ill health may account for class inequalities in ill health in employed populations. I have attempted to place the work in a somewhat well-reflected relationship with the wider context of the explanation of inequalities in ill health. Rather than resolving the issues, I think the study points to some shortcomings in the research so far.

Chapter II

Social stratification and class theory

The definition and analysis of class and the stratification of society constitutes one of the major areas of sociology. The nature of class is much contested. Stratification, understood broadly, exists in many aspects of society, in fact the existence of distinguishable strata is more a definitional issue than an inevitable and unambiguous fact of reality. Class, or social class, refers to the position people, as individuals or groups, occupy in the economic macrostructure of the society, particularly the structures related to production. For the majority of people this means, in practice, their contribution to society through paid work. By structure is meant the relatively permanent organisation of society into certain types of relationships between people, a pattern that is clearly beyond the influence of one individual alone, and difficult to change even when some extent of consensus on the need for change exists among large groups of people. Therefore it could be said that, to some extent, structure is independent of the individual, although it is self-evident that structures would not exist if no individuals existed. In fact, the economic structures of society referred to here, in particular, could be conceived of only as the organisation of connections between extensive numbers of people.

A position in production and the economic structure is not the only definition of class to be put forward. Contrasting theories have been presented by Pierre Bourdieu (1984), for example, who bases his definition on cultural and symbolic status alongside material advantage. However, Bourdieu's definition, in my judgement, differs to a relevant degree from the concept of class discussed by Marx, Weber, Dahrendorf, Wright, Goldthorpe, and many others. Weber in particular explicitly distinguished between prestige and class. Economic structure is interlinked in complex ways with political institutions, socialising institutions, status relationships, prestige, and symbolic systems, and for this reason class may seem like an all-encompassing category. For the purpose of any sensible philosophical or scientific analysis, however, a slightly more focused meaning needs to be delineated. The approach taken in this study is to examine the relationship between the economic structure as manifest in the division of work and health. On the basis of this framework we can safely dismiss the class concept of Bourdieu, as it is not compatible with the chosen premises.

The relationship between social epidemiology and class sociology is, to some extent, obscure. Socioeconomic position is the umbrella term social epidemiologists

like to use with reference to social stratification. Although its measurable manifestations, mainly education, occupation and income, have, to some extent, been studied as determinants of health and welfare each in their own right, nevertheless the discourse on social inequalities in health implies that these aspects of social conditions are parts of a somewhat consistent whole of inequality in terms of economic position. When occupations are classified it seems difficult to avoid involvement with some kind of class theory if one is to review critically the assumptions and premises on which the study is based. Minimal insight into the tradition of class sociology may therefore be desirable. The objective of this very brief review is to describe the most important features of the traditions that have most influenced, explicitly or implicitly, the definition of social class or of socioeconomic position in studies on social inequalities in health. It is by no means exhaustive of all major theories of class.

Classical Marxism

> "The produce of the earth – all that is derived from its surface by the united application of labour, machinery, and capital – is divided among three classes of the community; namely, the proprietor of the land, the owner of the stock or capital necessary for its cultivation, and the labourers by whose industry it is cultivated."
>
> David Ricardo, On the principles of political economy and taxation, 1817
>
> "The owners of merely labour-power, owners of capital, and land-owners, whose respective sources of income are wages, profits and ground-rent, in other words, wage-labourers, capitalists and land-owners, constitute then three big classes of modern society based upon the capitalist mode of production."
>
> Karl Marx, Capital volume III, posthumously published, as reprinted in Jordan (ed.) 1971

The notion of capital ownership and wage-labour as the defining attributes of the modern classes was not a completely original contribution from Karl Marx. The 19th-century political economists seem to have been fairly unanimous on the

principal classes of the emerging industrial economy, regardless of their political inclinations. The discussion here is, however, limited to the main features of Marx's presentation of class theory.

Marx was, above all, interested in describing and predicting – and promoting – social change. In his theories of historical materialism he describes how the capitalistic mode of production replaced the feudal mode of production. The main prerequisites of capitalism, according to this theory, are: 1) availability of labour power in the form of propertyless workers who owned their own labour power (as opposed to feudal serfs) and had to sell their labour, and 2) the transformation of property and the means of production into capital. The requirements are not, in fact, independent: property is capital in so far as it can produce surplus value, which in turn is created through the combined use of labour and means of production. When acquiring means of production also requires marked investment of property, the propertyless class has no other choice than to sell their labour to those who are in possession of the means of production. The surplus value produced in this work is, in its entirety, appropriated by the propertied class, the capitalist. Exploitation could be defined as the appropriation by the capitalist of the surplus value produced by the proletariat's work. (Marx 1867/1971 and 1867/1974)

In short, the classes proposed by Marx are the propertied bourgeoisie and the propertyless proletariat. Although the definition of class in Marxist theory is based on proprietary rights, it is not the ability to consume more, or the general amount of material welfare that is the defining feature, but the position that property allows in the production process, a position in relation to the propertyless class. This relationship in production then is predicted to increase the polarisation of property distribution, and thus to strengthen both the class situation as well as the resulting inequality in living conditions.

A particular relationship with production was nevertheless not sufficient to construct class as a class for Marx. What is essential is that a class has economic interests that conflict with those of an opposing class (or classes). This conflict of interests inherent in class structure is assumed to give rise to class struggle, which Marx saw as the central transforming force of history in general. In order to become relevant in social change, however, the interests of a class need to be realised in collective action. Collective class action to transform society requires a minimal extent of class consciousness, the conscious acknowledgement by members of a class of their common class situation. However, this requirement did not prevent Marx from believing that the unavoidable course of capitalism was increased

polarisation and, finally, revolution by the proletariat. This was seen to be dictated by the nature of capitalist production, and thus partly warrants criticism of Marxism for its ontological 'structuralism, i.e. the assumption that structures themselves are agents, the properties of which will dictate the development of society without any necessary reference to the actions of individuals. It is notable, however, that in this respect the thinking of Marx was not consistent, as he also discussed social mobility as a counter-force to class consciousness. (Wright 1985, Goldthorpe 1980, Jordan 1971).

One of the main issues in the discussion on Marxist class definition, i.e. the structure of society according to classical Marxist theory, concerns the question of the middle class or middle classes. Marx predicted that the polarisation of capitalistic societies would increase, and the middle class of the petty bourgeoisie, as well as the pre-capitalistic class of peasants, would be reduced to the proletariat (Marx and Engels 1848/1955). Many later, and contemporary, critics claim that this prediction has proved to be false, as the middle class has obviously grown as modern industrialism has proceeded. However, this is not true of the petty bourgeoisie, i.e. the self-employed. Self-employment has become increasingly marginalised in the corporate structure of society. Farming, in terms of the international markets for farming products, is increasingly a matter of large-scale enterprise. Neither is it true that Marx completely ignored the emergence of a managerial class. He did write that this class would grow in relative size, but saw its part merely as to serve the interests of the capitalist class at the expense of the truly working class, the proletariat (Goldthorpe 1980). Some Marxist theorists have maintained that, despite the apparent growth of 'white-collar' managerial groups, their work is in fact also progressively being downgraded to routine labour. However, attempts to confirm this empirically have not been successful. Furthermore, since on the one hand capital is largely owned by corporations, and on the other hand people in all occupations may own moderate capital investments, it has become quite difficult to find a relatively clearly demarcated class of capitalists.

Contradictory class locations – the Marxism of Erik Olin Wright

Of the contemporary scholars Erik Olin Wright has made a highly original and fairly well-known attempt to develop the Marxist definition of class in a way that would allow its application in quantitative population research today. Wright's approach is characterised by his requirement that the relationships between the

classes should be defined in terms of exploitation, the appropriation of surplus value produced by the exploited. Thus the Marxist emphasis on relationships in production is retained. The term 'contradictory locations' comes from the fact that several classes in the proposed schema are characterised as both exploiters and exploited at the same time. (Wright 1985, pp. 19-63)

Wright proposes a model of classes in which the relationships between them are defined in terms of three types of exploitation based on the control of three different assets. Capitalistic exploitation is based on the unequal distribution and control of capital assets: all employee (wage-labourer) groups, except top-management executives who become owners through option programmes, are capitalistically exploited. The differences between classes of wage-labourers are then determined by exploitation based on the unequal distribution of organisation assets on the one hand and credential/skill assets on the other. Wright defines organisation assets as effective control over the organisation of production and the complex division of work. Inherent in the concept of organisational exploitation is that by the virtue of effective control (although not ownership) over the means of production and the use of labour, a managerial/bureaucrat class is able to appropriate some of the socially produced surplus. Credential or skill assets refer to the possession of qualifications that make specific occupational positions accessible. In order to define the advantage the credentialed have as exploitation of the non-credentialed, it is assumed that acquisition of the credentials is limited, i.e. not everybody has free access to them, and that the 'appropriated surplus' exceeds the costs of acquiring the credentials. (Wright 1985, pp. 64-104)

There are several crucial weaknesses in Wright's theory. In my view the definition of organisational assets does not succeed in explaining the advantage of the managerial class in a completely unproblematic way. Managerial authority does entail limited control over the means of production and labour, but this is not an asset a manager can utilise for personal income. Indeed, the 'organisation asset' seems merely to be capital in disguise. Although managers have limited control over the means of production, this is generally in the interests of the owner, and does not give them the opportunity personally to appropriate the produced value. Furthermore, it may not be completely sensible to define non-proprietary control of one asset, capital in the form of means of production, as a new asset, the organisation asset. For the credentialed classes it is even more questionable whether their advantage could be termed 'appropriation of the surplus value produced by the exploited'. The highly educated, but non-managerial specialist is, by definition, not in a position to direct the labour of others or the surplus produced.

Class as a market situation in Max Weber's theory

Theorising on class constituted only a limited proportion of the total amount of Max Weber's theory. Unlike Marx, Weber did not seek to explain cultural, moral and political aspects of society as functions of the economy and production, and rather described the interplay between these various dimensions. In his essay "Class, status, party" (1904/1970) he defines the social order, the legal order and the economic order as distinct albeit interdependent systems of societal organisation. His idea was to limit the concepts of class, the class situation and the class struggle to the sphere of economic order.

With a view to describing how the distinct 'orders' of the economy and class on the one hand, and status groups and social honour on the other, affect each other, Weber presents a clearly formulated definition of class and the class situation. In short, it could be expressed as follows: class is a group of people that share similar opportunities for generating income on the commodities market and the labour market. The class situation, in turn, refers to the access to supply of goods, living conditions and experiences determined by the "power to dispose of goods or skills for the sake of income in a given economic order." (Weber 1904/1970) Later writers have frequently referred to the concept of 'life chances' as definitive in Weber's presentation of class (e.g., Lynch & Kaplan 2000). This seems slightly misleading to me, however. Weber uses the expression 'life chances' only very sporadically in "Class, status, party", and where it is used, it simply denotes the wide range of consequences that the available income opportunities have for an individual.

Weber considered access to goods or skills that could be utilised for income the basic criterion of class. In his later work he developed his concept into a systematic classification. This included a detailed description of different types of class situations determined by property and the lack of it, as well as commercial class situations determined by management and influence on economic policy or the lack thereof. Finally, Weber introduced four social classes broadly summarising similar class situations in the industrial society: 1) the working class, 2) the petty bourgeoisie, 3) the propertyless intelligentsia and specialists, and 4) classes privileged through property and education. (Weber 1914/1978)

The notion of skills and specific kinds of services as a potential class determinant has made Weber's definition attractive to later writers who wished to base their conceptions of class on occupation and education. The expression 'Weberian

tradition 'is sometimes used. To me, however, this seems to exaggerate the degree to which most schemas of class, or of socioeconomic position, have been constructed with reference to a discussion on the market situation of the classes, or on how status honour differs from the class situation.

Liberal theories of industrialisation and status attainment

A theoretical framework sometimes referred to as liberal theories of industrialisation was developed by various predominantly American, but also some European authors starting from the 1950s and 1960s and extending its influence even to today. The review presented here is no doubt incomplete, but given the abundance of sources in this framework more thorough review is not possible, and the idea is merely to describe the features that are most relevant to the case at hand.

The philosophical foundations of this approach were addressed most thoroughly by Talcott Parsons in his functionalist theories. Parsons considered the economic activity of occupational roles part of the 'instrumental achievement structures'. These structures are valuational in terms of better versus worse on the dimensions of skill and responsibility. Furthermore instrumental structures are subject to the demands of effectiveness and efficiency. It thus follows that differentiation in access to facilities and rewards is to some extent a necessary outcome of instrumental achievement structures, and that the differentiation is a prestige reward in itself. (Parsons 1951/1991, pp. 157-161)

According to Parsons, stratification basically denotes the moral evaluation of the strata by society. He describes American society as 'universalistic 'and achievement-oriented in the sense that estimations of an individual's moral quality are based on performance, and performance is evaluated through criteria that are not dependent on the particular individual's personal ties. Largely on this basis, Parsons assumed that relatively high equality of opportunity prevailed in American society. The extent of this equality, however, is ultimately limited by the 'solidarity of the kinship unit', i.e. the sharing of the advantages by the family members of the advantaged, irrespective of their personal achievement. The modern conjugal family serves to minimise these ambiguities. (Parsons 1940/1954, see also Parsons 1951/1991, pp. 62-64, 157-161)

The origin of the term 'liberal theories of industrialisation' is more clearly reflected in the writings of Clark Kerr and his associates. Kerr set out to invalidate the claims and predictions of Marxism, and to replace them with a new theory of the nature of industrial societies. Although Kerr et al. stated that their purpose was to analyse industrialisation rather than to predict the future of any societies, nevertheless, they consistently and explicitly attempt to reveal an 'inherent logic of industrialism' explaining the universal features of advancing industrialisation and its consequences for societal development. (Kerr et al. 1962, pp. 17-32)

Kerr and his colleagues begin their theory of industrialisation from the premise that industrial society is based on continuous scientific progress and the resulting continuous change in technology and production. The fluidity of the occupational structure in a constantly changing economy opens up occupational mobility, which according to Kerr et al. facilitates the creation of an open and mobile society. Such mobility is also based on, and requires, extensive education, which itself must be quick to adapt as new skills are constantly required on all levels of the occupational hierarchy. The structure of the labour force is highly differentiated occupationally, and hierarchically organised. Various levels of authority and specialisation serve to establish a hierarchy of numerous steps with respective differences in levels of compensation, i.e. income. (Kerr et al. 1962, pp. 33-46)

It should be noted that Kerr's 'logic of industrialism' is a collection of theoretical assumptions, at least as far as his own work with data is concerned. His relevant experimental work comprised comparisons of economic structures and histories in countries at different levels of industrialisation, and the formulated 'logic' served as an accepted premise and framework, not subject to validation or invalidation (1983). Some aspects of Kerr's theory seem to be more like ascriptive norm formulation than critical description – an issue made evident in his and his colleagues' explicit attempt to restate norms they presumed would promote industrialisation and economic growth (1962, p 44). Likewise, Parsons' equality of opportunity is an expression of an ideal, or a prediction of the existence of such, rather than proof that it prevails in society.

It became a practice among scholars affiliated to this line of thought to refer to stratification as occupational achievement or occupational success. Efforts were made to establish measurements of occupational rank on one continuous scale, and linear regression models were utilised to explain the position individuals achieved. Among some of the influential studies were those of Peter Blau and Otis Dudley Duncan (1967). However, they were somewhat sceptical about whether differences

in advantage were 'justifiable' by differences in ability, or whether the conditions of equality of opportunity actually prevailed. Nevertheless, they saw the existence of an occupational hierarchy as the fundamental source of all aspects of stratification (in a conscious reference to Weber's division of types of stratification), and contributed to the practice of taking occupational position as a continuous scale on which numerous occupational groups could be positioned in an ordinal hierarchy.

Service class versus the labour contract – John Goldthorpe's position

John Goldthorpe was one of the major authors of several influential studies on social mobility based on census and questionnaire data from the 1970s, both in Britain and across Europe. Although he had been involved in studies on occupational prestige, for the mobility studies he presented a class schema that adopted a more structural approach. He based his concept of class on two criteria, the market situation and the work situation as the constituents of class position. The market situation comprises the source and level of income, economic security, and chances of advancement i.e. career opportunities, whereas the work situation incorporates one's position within the system of authority and the degree to which this position is subject to control from above or entails relative autonomy. (Goldthorpe 1980, pp. 1-37, see also Erikson and Goldthorpe 1993 and Marshall 1990)

The major distinguishing feature of the schema, however, is the centrality of the concept of the service class. The coining of the term Dienstklasse – the service class – was credited to Ralf Dahrendorf (1959) and Karl Renner, although Goldthorpe further elaborated the concept. It was stated that the bureaucratisation of production and the transformation of ownership into corporate ownership in advanced industrial societies had facilitated the establishment of a class of corporate managers, officials, and professional specialists as the predominant class enjoying an advantaged position on the labour market and in 'systems of authority'. The conditions of this class were assigned the concept of service employment. This was taken to differ markedly from that of employment dictated by the so-called labour contract: whereas workers in labour contract employment sell their labour in discreet amounts (mostly time) in exchange for a per-piece or an hourly wage, and their work is tightly controlled and supervised, in the service relationship the employee needs to assume responsibility for certain organisational goals, the work is far less controlled from above, and compensation takes the form of a salary, which

will probably increase over the course of occupational life. Furthermore, according to Erikson and Goldthorpe, the service class has certain other advantages, such as more secure employment and secure pension schemes. (Goldthorpe 1980, Erikson and Goldthorpe 1993)

From the very beginning Goldthorpe's theory was associated with the experimental need to devise a classification schema suitable for application to large population data. As jobs and occupational situations in real life are not pure manifestations of ideal types, the classification came to have many categories, reflecting the assumed degree to which they manifested the conditions of either ideal type. Although the original term for the privileged classes was the service class, they have more commonly been called the professional classes, reflecting the more commonplace use of the respective English words. The schema includes a class for the self-employed, but does not incorporate those self-employed in professional occupations in this class. According to Goldthorpe, the difference between employment and self-employment in the professional class is in most cases an administrative detail rather than a real difference in condition. Thus a truly distinctive class position of self-employment is relevant only concerning those self-employed in non-professional occupations.

Operationalising class

The structuralist class approach defines class as a relationship with production and the economic system, in which the differences between the classes are more or less qualitative. In other words, the classes have different kinds of relationships with the system of production or, in less grandiose terms, different terms of employment and work in general. According to the status-hierarchy approach, society consists of a continuous range of ranks with ascending levels of qualification requirements and compensation. However, the operationalisation of these approaches into actual classifications tends not to be so completely contrastive. Even if the criteria could be formulated strictly on the basis of the kinds of material returns and opportunities that are available, or on the use of authority in work situations, in both cases it is certain that the categories will also differ in amount of social prestige. Likewise, although advocates of the status-hierarchy approach have often based their operationalisations on measured quantities of prestige, occupations have often been grouped together in categories that also allow a structural interpretation. The tables given by Blau and Duncan (1967) serve as a good example.

The distinction between white-collar and blue-collar work, or between non-manual and manual work, is a feature in the description of stratification that deserves some critical attention. This demarcation line tends to emerge everywhere in the context of stratification, even though it is evidently not directly warranted according to any social theory. In the end it assumed a central position due to practical difficulties in some of the experimental work of Erikson and Goldthorpe, as well as of Blau and Duncan. The level of compensation, which is essential to liberal approach, is not necessarily clearly differentiated on the two sides of this line, as skilled industrial work in particular tends to surpass many clerical jobs in terms of income. Correspondingly, the conditions of employment among retail sales workers, conventionally white collar, are largely of the contract-labour type. Moreover, the term manual is not really systematically descriptive of all jobs that are classified in the most underprivileged category. Not all such jobs include physical labour – consider porters and telephone-exchange workers, for example, whereas manual tasks may feature in jobs not in these classes. The industrial branch is likely to affect the allocation, especially in official classifications used by registration authorities. Of course, when an underprivileged class of 'manual' labourers is compared to all more privileged categories (as assumed or defined in theory), we can certainly trust in the power of the distinction to reflect with some precision the economic advantages that are also of interest to a class theorist. Comparisons across more detailed classifications may be problematic, however. This should be kept in mind, especially since this study examines dependencies between class, physical work conditions and health.

Throughout the study I adhere to the structural approach to class wherever critical discussion of occupational stratification and classification is necessary. The operationalisation of class, as well as interpretations of the findings, will be reflected against the theory presented by Goldthorpe when a theoretical framework is necessary. The classification procedure used is not the Erikson-Goldthorpe-Portocarero scheme, however. The allocation of people into social categories in this study is described in chapter VIII.

Chapter III

Social class and public health – from history to explanation

> "Tämä seikka [keuhkotautikuolleisuuden aluevaihtelu] riippuu siitä, että jota suurempi kaupunki on, sitä vähempi on ylipäänsä väestön fyysillinen vastustusvoima monen kaltaisten terveyttä heikontavain vaikutusten takia, erittäinkin alemmissa kansankerroksissa. Sellaisia vaikuttimia ovat esim. asuinhuoneiden ahtaus ja sen takia pilaantunut ilma, kosteus ja valon puute, köyhyys ja hyvän ravinnon puute, juoppous, siveettömyys, terveyttä heikontavat toimet, niin kuin työ useissa tehtaissa j.n.e. "
>
> "Th. Sörensen onkin näyttänyt että tuberkuloosiin kuolee Köpenhaminassa noin toista vertaa enemmän ihmisiä kansan alemmista kerroksista (käsityöläisiä, tehtaan työväkeä, päiväläisiä ja palkollisia) kuin varakkaammista. Tarttumisen tilaisuus on myös ahtaassa asuvan väestön joukossa suurempi kuin tilavammin asuvissa. "
>
> This [area variation in mortality due to consumption, i.e. pulmonary tuberculosis] occurs because the larger the town is, the weaker in general is the physical resistance of the people due to various debilitating influences, especially in the lower classes. Such influences include confined apartments and therefore spoiled air, damp and the lack of light, poverty and a lack of good nutrition, drunkenness, indecency, duties detrimental to health such as working in various factories.
>
> Dr. Sörensen has indeed shown that around twice as many people die of tuberculosis in the lower strata (artisans, factory workers and hirelings) as in the wealthier. Moreover, the chance of infection is higher among those dwelling in confined spaces than among those in more spacious accommodation.
>
> Konrad Relander 1885 in Duodecim, the journal of the Finnish Medical Society Duodecim

The above quotation from early Finnish literature on epidemiology and public health illustrates in an interesting way several features in the development of public

health studies. Firstly, the issues of urbanisation and population density were central in the early history: this dates back as far as John Graunt's studies on mortality:

> "I considered, whether a city, as it becomes more populous, doth not, for that very cause, become more unhealthful: ... " (Graunt 1665, p. 142)

Secondly, social-class inequalities in deleterious conditions are presented as a major determinant of population health. Such inequalities assumed major importance in the evolving studies on public health, more so, possibly, than at any later point in history.

Thirdly, the proposed causes of social inequalities in disease, including poverty, bad housing, nutrition, substance abuse and adverse work conditions, still feature in the current discussion on health inequality. Indecency may not be a term used to describe the habits of people nowadays, however, and studies on sexual and reproductive health are not currently at the centre of the discussion on class inequalities. Without doubt there have been great changes in all of the above-mentioned social conditions during the last hundred years. Nevertheless, extensive as these changes might have been, many of the corresponding conditions are still unevenly distributed among the social strata. Furthermore, we are fortunate in being able to claim that both theoretical and empirical advances have been made in explanatory models of social inequalities. However, not very many proposed explanations have been completely eliminated from the discussion. To some extent, questions of social epidemiology cannot be fully resolved even in theory as social conditions will continue to vary, and thus their relative contribution to potential social inequalities in ill health are likely to vary as well.

Lastly, there is the very interesting notion that there may be two biological mechanisms at work: on the one hand, there may be a general weakened capacity to resist diseases related to 'physiological weakness' as a consequence of eroding social conditions, and on the other hand, there may be increased exposure to a specific agent causing a specific disease. Discussion on general susceptibility as opposed to specific causes of specific diseases has remained topical in the theorising on disease causation (see e.g. Berkman and Kawachi 2000, Elstad 2000, Kunitz 2002), and many studies have been conducted with the a view to clarifying the biological basis of general susceptibility (see e.g. Cohen and Herbert 1996, McEwen 2000, Romero and Munck 2000, Brunner et al. 1997).

Early social medicine and class

Although earlier individual documents revealing the concern of some medical practitioners or social observers about the effects of poverty, living conditions and hard labour on health may well be found (see Ramazzini 1713/1940 and 1713/2001, for example), the development of such a concern into a societal discussion and further into an area of scientific enquiry is a modern phenomenon. Early social medicine evolved in parallel with the profound social changes brought about by industrialisation and urbanisation. Sometimes scholars, such as Akseli Koskimies (1916), divided the developing public health science into two branches, public hygiene and social medicine. For the latter it was characteristic to focus on the conditions of the disadvantaged social strata.

The early history of social medicine can be traced to the observations of medical practitioners on contagious disease, especially in urban environments in the 18th century. Some of these are documented at least in Germany, Britain and France, as described by Flinn (1965), for example. Systematic studies began to appear in many countries in the early 19th century. Chadwick (1842/1965), for example, cites several colleagues in other countries. The studies conducted by Louis René Villermé in the quarters of Paris (1830) are often mentioned as a historical reference. Villermé also studied the health of prisoners and workers in the cotton industry (1840). The most abundantly documented conditions are those of the industrialising and extremely rapidly urbanising Britain, however.

Many accounts of the living conditions in particular, and of some aspects of the work conditions of the working classes in Britain during early and mid 19th century, were written by both government-appointed investigators and individual observers. Among the most remarkable contributions is a report compiled by Edwin Chadwick in 1842 on 'the sanitary condition of the labouring population in Great Britain'. The report contains accounts of living conditions in the poorest districts of many towns and of contagious diseases in these districts as observed by medical officers, information about drainage systems, some investigation into crowded workplaces, systematic comparison of mortalities by area and class, the evaluation of the preventive measures available and those already in place, and recommendations for further action. The report focuses on the lack of proper drainage and refuse removal, overcrowded and badly ventilated apartments and work premises, and other aspects of poor housing, although there were also references to health-damaging habits caused by detrimental work conditions. The following passages describe the conditions of the poor:

> "Very few of the cottages were furnished with privies that could be used, and contiguous to almost every door a dung heap was raised on which every species of filth was accumulated, either for the purpose of being used in the garden allotments of the cottages, or to be disposed of for manure."
>
> "It has often fallen to my lot to be called to a labour where the wet has been running down the walls, and light to be distinguished through the roof, and this in the winter season, with no fire-place in the room."
>
> "The room contained three wretched beds with two persons sleeping in each: it measured about 12 feet in length and 7 in breadth, and its greatest height would not admit of a person's standing erect;"

It is of interest here how Chadwick operationalised class. In the chapter on mortality he consistently defined the classes as: 1) gentry and persons practising professions; 2) tradesmen and similarly circumstanced, including farmers; and 3) labourers, mechanics, artisans, farming labourers and so on. Although no table showing the population distribution for these classes is given, probably because such information was not available, from the numbers of deceased and their mean ages reported it could be calculated that the third class constituted the great majority. How many apprentices a master needed to have in his workshop to be classified as a tradesman can hardly be guessed, but the second class was considerably larger than the most privileged class of the gentry and professionals. The class inequalities in life expectancy were, perhaps not entirely surprisingly, extensive.

The most well-known description of social ailments of the early industrial era, apart from those in fiction, was written by Friedrich Engels, and was originally published in German in 1845. Apart from poor housing conditions, Engels attacked the conditions in the textile industry and mining in particular, which along with iron works were the most developed industries of the time (for discussion on economic history see Hopkins 1982 and 2000, for example). Although Engels may have been more committed to condemning the capitalist economy than to a critical evaluation of his sources or to verifying all the details he wrote about, many of the ailments he vividly depicted were probably, to some extent, real for a proportion of the working class. These conditions were also documented in many perhaps slightly more objective sources, including the factory enquiries and commissions on child labour appointed by the British government. While some historians (e.g., Hopkins 1982) have noted that the process of industrialisation regarding the whole of society was

slower than we might imagine today, for the present purpose it is not sensible to enter into any historical argument on whether large-scale industry was to be blamed for the misery of a large part of the population. While traditional work in the home and in workshop industry was certainly often repetitious, and in some cases probably physically strenuous, and may have involved risks of accident, it is likely that new work-related health risks were evolving, and some perhaps not entirely new ones intensifying, with the expansion of industrial activities such as mining. The following account of some of the health problems of coal miners in Scotland given by a medical doctor S. Scott Alison is taken from a lengthy report published in 1842.

> "The diseases of the pectoral organs are so very common among colliers that scarcely an individual above the age of 20 years... will be found in a healthy condition. For the first few years chronic bronchitis is usually found alone and unaccompanied by disease of the body of the lungs. The patient suffers more or less difficulty of breathing... he coughs frequently, and the expectoration is composed, for the most part, of white frothy and yellowish mucous fluid, occasionally containing blackish particles of carbon, the result of the combustion of the lamp, and also of minute coal-dust. ... Spurious melanosis, or "the black spit" of colliers, is a disease of pretty frequent occurrence among the older colliers, and among those men who have been employed in cutting and blasting stone dykes in the collieries. ... When the lungs of persons who have died of this disease are examined after death, they are found to be of a black colour, as if dyed, and to be the seat of much morbid alteration."

Although the transformation of society occurred later, and in many ways differently, in the northern periphery of Europe than in some of its more central parts, discussions on social conditions and health were not unheard of in 19th-century Finland. Despite the industrial working class being very small in what was still a predominantly rural society, the assembly of the Finnish Medical Society held in September 1887 discussed the actions that were necessary to improve the health of industrial workers, including the regulation of working hours, better housing and the restriction of child labour (Vilho 1887). The best known achievement of early Finnish social medicine is the thesis produced by Konrad Relander (1892/1992), later known by the Finnish name Reijowaara. Relander examined the living conditions of poorer sections of the rural population while he was working as a district doctor in Haapajärvi. His thesis contains a lengthy description of the housing conditions, accompanied by a wealth of numerical data. The daily rhythm of work and meal times, and the content of typical meals were also addressed, and

there was some description of other habits including drinking, clothing and religious practice. Relander's work was not welcomed by the Finnish scholarly community of the time, and its scientificity was disputed. It may have been, as suggested by Eero Lahelma et al. (1996) and Antti Karisto (1981), that Relander's choice of writing in Finnish rather than Swedish contributed to the poor reception.

Official statistics and class

The establishment of official statistics on mortality made a vital contribution to social epidemiology. As a side effect, the official social classifications devised for such statistics have been used extensively in research on inequalities in health. Although Finland, as part of the Swedish dominion before 1809, has one of the oldest centralised registers of deaths, established in 1749, it seems that for a long time it was not customary to systematically collect data on the occupation or class position of the deceased. The author of an article from 1916 reporting mortality by occupation in Helsinki during 1896-1915, Viktor Manner, complained about the data on occupation in the mortality registers: in most cases it was completely missing, and when present seemed to contain a lot of misclassification and vagueness. Manner's call for improvement in the recording of occupational mortality rates went unheeded. Following the Finnish civil war in 1918 the promising field of social medicine faded out, possibly partly because, as suggested by Lahelma et al. (1996), for example, the political atmosphere no longer was favourable for concern about social inequalities, and partly because the evolving biomedicine started to dominate the field of health science. It took a long time before mortality statistics by class were published in Finland.

In Britain the office of the Registrar General was established in 1837, but for a long time published mortality rates by area rather than by social class. Although there were early suggestions to adopt a systematic social classification to be used in official statistics on mortality, none was introduced until 1913. (Individual researchers had been using their own classifications for a long time, however.) The context surrounding the development of the Registrar General's classification of occupations and its underlying assumptions was described by Simon Szreter (1984). There was an underlying assumption that society comprised a coherent unidimensional hierarchy. According to Szreter the so-called naturalistic social scientists of the time, such as Francis Galton (1901), saw society as composed of layers of natural ability or 'genetic worth', a conception that was not necessarily

supported as such by the developers of the classification scheme, but which nevertheless imposed a kind of status hierarchy approach. The Registrar General's classification is notorious for preserving its fundamental characteristics, although with necessary ad hoc alterations to incorporate new occupational titles, until 1980, and even after this the same overall structure was retained (Szreter 1984 and Brewer 1986), until finally the scheme was replaced in 2000.

I am not aware of any publications reporting mortality in Finland by class prior to the 1970s. Statistics Finland seems to have instituted its first socioeconomic classification of occupations in 1972, followed by a revision in 1975, and this scheme was applied to mortality statistics from 1970-1979 (see Valkonen et al. 1990 and Martikainen et al. 2001). The classification was completely revised in 1980. (Technical details concerning the differences between the two schemes are described in a memo in English written by Tiina Pensola (2000) available in the Internet.) As with most official classifications in use, they appear not to have clear theoretical basis. The official classification currently in use in Finland is not intended to be completely hierarchical: there are three main groups of employees, upper white collar, lower white collar and worker, each of which is divided into subcategories based mainly on the industrial branch (Tilastokeskus 1989). All entrepreneurs and the self-employed fall in the same main category, as opposed to Goldthorpe's treatment of the assumed 'free professionals'.

Social stratification in epidemiology today – comments on Lynch and Kaplan

Various aspects of social advantage and disadvantage have been studied as determinants of health, and numerous authors have argued that there is consistency in social inequalities, as similar associations between many different aspects of social organisation and health have been observed. The concept of socioeconomic position has been used almost universally to refer to the position of the individual in social structure that determines material advantage or disadvantage and, to some extent, prestige. The term socioeconomic status has been commonly used, but has recently been fairly consistently substituted by socioeconomic position. Nancy Krieger (2001), for example, has been explicit about recommending the latter, as the expression status was clearly a misnomer when the majority of authors were referring more to a structural position than to social honour. Similar views have been advocated by Bruna Galobardes et al. (2006a and b), for example.

There have been comparably few contributions offering critical discussion on the concepts of social stratification as they appear in studies on inequalities in health: it is more common merely to list the different social and economic indicators utilised in the empirical analysis. Attempts to describe what kind of assumptions lie behind the thinking or to suggest on what assumptions the studies should be based have been rare. I have chosen to review the approach presented by John Lynch and George Kaplan (2000) because I think this contribution is worthy of mention for attempting to arrive at a kind of theoretical basis for concepts of stratification in social epidemiology. There are a few other accounts that could have been considered, such as those by Liberatos, Link and Kelsey (1988) and Krieger, Williams and Moss (1997).

Although Lynch and Kaplan discuss socioeconomic position, rather than social class, as the central concept refering to social stratification, their account begins from the premise that the origin of the concept lies, to some extent, in class theory. Reflecting this origin they base their approach primarily on the structural view of society inherent in most of the theories. They propose that the position of different socioeconomic groups is based on structures of production. These determine the distribution of various resources, and the use of resources by those privileged by the possession of them in turn dominates and excludes – and indeed exploits – those not thus privileged. A major step towards explaining inequalities in health proposed by Lynch and Kaplan is the notion that the structural position of groups determines both the resources in use and exposure to detrimental conditions, both of which may affect health.

Exploitation seems to be a difficult term in that it implies a moral evaluation of whether distribution inequality at a given instant is to be viewed as justifiable or not. It is much less ambiguous to describe a social condition characterised by a certain level of social goods as exposure, i.e. propose that living in such conditions may affect health more adversely than living in some other conditions. Furthermore a certain level of social goods may be a resource that will enable the conscious evasion of some inconvenient condition that would also be detrimental to health.

Lynch and Kaplan also draw attention to the behavioural, cultural and symbolic aspects of stratification (and cite Bourdieu 1984). They propose that variation in behavioural and psychological states between socioeconomic groups should be readily understood as conditions determined by the social structure. Although the expression 'determined by structure' emphasises forces beyond individual control over individual agency to a degree that is perhaps somewhat controversial, many

other researchers would agree on the relevance of the social context in shaping behaviour. It is slightly less obvious what Lynch and Kaplan mean when they refer to symbolic resources. Fortunately, further contribution to the controversial discussion on interdependencies between the social structure, behaviour and culture can be mostly avoided in this study, which seeks to examine physical conditions that are fairly obviously determined by social structure as an explanation for class inequalities in ill health.

Lynch and Kaplan further emphasise the importance of understanding various structurally determined exposure and access to resources with respect to different stages of life. They continue their account of different aspects of socioeconomic position by showing how conditions determined by the structural social position may affect health in specific ways in particular life stages or situations. Another relevant element of their exposition concerns how the interrelations between education, achieved occupational position, income, wealth, race and gender may modify the respective effects. Recognition of the interdependent pathways between the dimensions of social position and their effect on health has recently attracted increasing attention, as shown in Eero Lahelma et al. (2004), for example.

It has probably become clear to the reader that Lynch and Kaplan do not propose to adopt a distinctly formulated sociological theory of the structure of society. The main content of their account on social position and health might perhaps be summarised as follows: society is organised into somewhat clearly differentiated positions predominantly based on the organisation of production, and the distribution of social goods generally tends to follow the structure of these positions. However, these positions are not unequivocally captured by a single stratifying concept or measure, and understanding the impact of social position on life, or on health, often necessitates reference to several different aspects of the social condition of a given group of individuals.

Explanations for inequalities in health

Social-class inequalities in ill health have been found in all societies and at all times for which sensibly reliable data exists. The notion of social position, or the relation of a group of people to other groups of people in socially meaningful action, affecting the biological state of an organism so as to give rise to disease and illness, particularly somatic disease, does not seem to follow an inevitable logic per se. Thus

there is a need for an explanation of how such a link can occur. The task of providing such an explanation has been challenging both theoretically and empirically.

Explanations often take the form of propositions about conditions that are differentiated across social positions, and that are presumed to affect health. Such explanation strategies are causal in that the assumption is that social position essentially causes, via the proposed mediating conditions, different rates of illness. Jon Ivar Elstad (2000) emphasised that causal explanations are in principle divisible into two components: propositions about how social processes give rise to differences in the conditions of individuals, and propositions about how these conditions affect health. In addition to the causal explanations that involve identifying conditions capable of mediating the effect of the social structure on ill health, there are those that are based on selection, i.e. on the assumption that health affects the social position of individuals rather than vice versa. The majority of explanations put forward today are causal rather than selection-related. Issues concerning health-related selection into social positions, particularly in youth, may nevertheless have some contribution to make, and are still under discussion.

Differentiated participation in production and work on the one hand, and differentiated opportunities for consumption and the personal use of any existing facilities on the other, give rise to almost endless varieties of life conditions. Standard of living, work conditions, access to information and to various services could easily be seen as differentiated. I have mentioned how some authors and theories also address the interrelations between the social structure and culture. With such an abundance of conditions to choose from, it may not be surprising that causal explanation models have developed a considerable variety of propositions about how inequalities in ill health emerge.

In the following I will briefly address the main models used for explaining class inequalities in ill health. These models are not necessarily mutually exclusive, and many variants proposing complex interrelations of the basic versions have also been presented. Furthermore, I will not systematically review the evidence concerning which of the models are more or less appropriate in terms of giving the strongest predictions of existing inequalities in ill health, and will rather just give a few examples. It suffices to say that all four main types of explanation are backed by some data.

The structural framework of explanation

The terms structural explanation and materialistic explanation are sometimes used interchangeably in the literature (e.g., Blane, Bartley and Davey Smith 1997), possibly following the account given in the Black Report (Townsend and Davidson, editors 1982/1983, pp. 114-118). According to Elstad (2000), however, there is a relevant difference between the two. Structural explanations should be understood as referring to a framework implying that differences in social conditions are determined by the macrostructure of society. As individuals cannot completely freely choose their position in the social structure, neither are they completely free to choose their conditions. In contrast, materialistic explanations should be understood as referring to certain proposed causes of ill health, i.e. to proposition that differences in material conditions are the cause of differences in health. This distinction may be relevant in terms of conceptual clarity, as structural explanations alongside materialistic determinants could also imply non-materialistic determinants of health. Explanations referring to psychosocial causes of illness could often be described as structural with respect to how the differences in psychosocial conditions are assumed to arise.

Moreover, without reference to at least some kind of structural view, it might not be completely sensible to discuss social inequalities in ill health as a form of social inequity. If all conditions affecting health were completely freely chosen, undetermined by social position, the resulting differences in health could be hardly termed inequity. However, it would appear to me a puzzling statistical paradox that social inequalities in health should then be universal: there would be every reason to expect health-detrimental conditions to be randomly allocated across the social classes.

Materialistic explanations

Reference to differences in physical and material conditions between the classes as determinants of inequalities in ill health constitutes the materialistic explanation. It is assumed that economic structures expose the disadvantaged classes to excess in varieties of unfavourable objective and materially concrete external conditions. The existence of some extent of material difference may be somewhat axiomatic, but it is a question of what their power to influence illness and disease is.

Concern with poverty and the industrial abuse of the working population is the historical root of the materialistic explanation of class inequalities in health. It could hardly be claimed that poverty and health lacked research attention in the post-war period. It seems to me, however, that most of this research has been centred on issues of health care provision. In any case, epidemiological studies relating income levels, or social classes, to potential physical-environment conditions that could be more proximal determinants of ill health are few and far between. Furthermore, the main focus of research on poverty has long been on the third world, where more grave forms of absolute poverty are still abundant.

The causes hypothesised to mediate the effect of class position on ill health that could most conveniently be classified as materialistic are still of roughly the same basic types as in classic studies on public health, roughly distinguishable as factors related to residential environment and those related to work conditions. An extended material framework could also allow that material resources, mostly income and wealth, will determine access to many services that could affect health as well.

Physical environmental causes of social inequalities in ill health in today's society have attracted some attention from (predominantly British) authors studying health differences by area of residence. Unfortunately, class inequalities are often seen as something to be statistically eliminated as a confounding factor, and studies adjusting class inequalities for area effects are rare. There is a body of literature on environment and health as such that suggests some plausible conditions that could be assumed to mediate social-class effects through the physical environment, such as low-quality housing. Bornehag et al. (2001), for example, reviewed studies on dampness in buildings and health. Dampness has been found to contribute to the aggravation of various symptoms, respiratory infections and the development of asthma. Moisture damage has specifically attracted public attention, and there has been an increasing number of studies on moisture damage, microbial agents and health, such as the one conducted by Meklin et al. (2005). The overall effects of housing conditions on health were investigated by Anne Ellaway and Sally Macintyre (1998) and Julie Evans et al. (2000), for example, although according to Hilary Thomson et al. (2001), making inferences from housing-intervention studies is methodologically difficult. Studies on housing conditions and class inequalities in health are difficult to find.

The wider environment of the area of residence could also be a source of health hazards. Air pollutants might be more common in deprived areas, and affordable

housing could be expected to be more often built on former industrial land or close to industrial facilities, and might thus involve higher exposure to industrial chemicals. For example, Mai Stafford and Mark McCarthy (2006) listed four ecological and one multi-level study providing evidence for effect of local air pollution on ill health and mortality. Dangerous traffic arrangements have also been mentioned, and safe environments for children were especially emphasised in the Black Report (Townsend and Davidson, editors 1982/1983).

There is a wide variety of potential physical hazards in working life. Jobs of underprivileged class position tend to entail more exposure to environments carrying dust and various air-borne particles, as well as to working environments and tasks involving high accident risks. Physical load from work requiring heavy or sustained muscle work or other physiologically potentially detrimental use of the body is obviously more common in less privileged classes. There is extensive literature in the field of occupational health on the potential health effects of these conditions. The effects of exposure to air-borne substances and other contact with chemical agents at work are the subject of voluminous research. Readers interested in chemicals may refer to the 'NIOSH Pocket Guide to Chemical Hazards' (National Institute for Occupational Health and Safety, U.S. 2007), for example. Some estimates of the prevalence of chemical hazards at work in Finland have been reported in the work of Timo Kauppinen et al. 2000, 2004 and 2007. Considerable research effort has been directed to the health effects of mechanical workload in today's working life as well, and reviews by Bruce Bernard (editor, 1997) and colleagues, Jeremiah Barondess et al. (2001), Wilhelmina Hoogendoorn et al. (1999) and Andreas Maetzel et al. (1997) have generally confirmed physical workload to predict musculoskeletal morbidity. These data are addressed in more detail in Chapter VI. Social inequalities in physical work conditions are recognised among researchers working on social inequalities in health, but have seldom been subject to systematic study. The few existing studies, including those by Vilhelm Borg and Tage Kristensen (2000), Carola Schrijvers et al. (1998) and Olle Lundberg (1991) are also reviewed in detail in Chapter VI.

An extension of material causes may also include limitations in access to several kinds of services related to economically disadvantaged position. Access to services is dependent on income at hand, and may be further limited in deprived residential areas. Thus car ownership may become a factor in its own right, rather than simply a marker of welfare, if access to better equipped supermarkets, for example, is dependent on car use. Sooman et al. (1993) and Steven Cummins et al. (2005) studied area deprivation and the availability of foodstuffs in Britain. The elderly and the severely ill in particular may be dependent on services they can buy, and a lack

of assistance may lead to concrete hazards in the form of nutrition quality, accident risks, the implementation of ascribed medical care, and even hygiene. A recent study by Elina Nihtilä and Pekka Martikainen (2007), for example, reported on how income and housing conditions predict institutionalisation in the elderly. Potential differences in access to health care have also been suggested. The economically advantaged may gain some health advantage from having access to private health care.

Psychosocial explanations

Psychosocial explanatory models comprise a group of theories and approaches that explain the effect of social conditions on illness with reference to psychological states that social conditions cause. These approaches also often refer to some kind of structural differentiation between social positions, and are sometimes used to explain class inequalities in ill health.

The relatively ambiguous concept of stress, in various forms, features heavily in psychosocial explanations. The development of the concept began with the classic behavioural observation that perception of a threatening situation will result in mental arousal and create various physiological responses. Early stress theory was developed in particular by Hans Selye (1956), originally an endocrinologist. He described the physiological mechanisms of stress responses and developed the concepts of eustress, i.e. a stress resolved, and distress, i.e. unresolved stress. In Selye's terminology, however, stress was anything that made adaptive demands on the organism, and did not necessarily require conscious recognition. General maladaptive syndrome was a term Selye (1946) coined to describe the harmful condition resulting from continuous activation of sress responses.

The biological mechanisms of acute stress responses are described in a multitude of text books on psychology and physiology: the two central physiological systems are the autonomic nervous system on the one hand and the hypothalamus-pituitary-adrenal cortex axis on the other. Sympathetic and parasympathetic neural activity cause rapid short-term responses in tissues, whereas the circulating levels of corticosteroid hormones secreted from the adrenal cortex under the regulation of hormonal signals from the hypothalamus and the pituitary gland bring about slower and longer lasting physiological effects. The range of physiological processes these systems affect is vast, covering almost every major physiological function.

Chronic stress is a fundamental notion in social epidemiology. While a single confrontation with a predator – to use the classical example from the animal world – is transient, life in a complex society may entail conditions in which an individual is more or less continually subject to situations that may cause mental arousal. As a result, the physiological system may be affected not only transiently, but also permanently. For example Eric Brunner and Michael Marmot (2006) described how, according to the hypothesis, continual exposure to potentially stressful social conditions may transform the acute stress response so that initially transient activation becomes the new homeostasis of the organism. For example, whereas acute exposure to a stressor may result in a rise in blood pressure that subsides shortly after the exposure, continuous exposure to stressful conditions may lead to higher base level of blood pressure.

In a society characterised by structural differentiation, some people may be in a position in which they encounter more stressors than others who are more advantaged. A further sociological dimension is added to the model with the recognition that stressors are often not objectively defined, but require interpretation and are thus socially constructed (see e.g. Williams 1998). The variety of possible social stressors that could be hypothesised to cause continued arousal is essentially limited only by the imagination, and demonstrating the relevance of certain social conditions to the development of chronic stress in large groups of people, and even populations, is extremely difficult.

Psychosocial approaches differ with respect to the exact social conditions, and their origins, that are hypothesised to create excess stress in particular social groups. According to Aaron Antonovsky (1985), for example, it is not the exposure to potentially stress-provoking situations as such, but access to resources for resolving stressful situations that matters. Other scholars are more concerned with describing the social distribution of stressful life events, an approach Elstad (2000) referred to as the epidemiology of social stress. Some theorists refer to conditions of life in general, whereas others describe conditions particularly related to working life, prime examples including the theories developed by Robert Karasek (1979) and Johannes Siegrist (1996, see also Bosma et al. 1998, Marmot et al. 2006). To some extent, the job strain model proposed by Karasek and his colleagues can be considered a combination of an exposure and coping resource framework in the work context. It is worth noting here, however, that the models of Karasek and Siegrist are most often applied as predictions of ill health per se, and to a somewhat lesser extent as explanations of class inequalities in ill health, although Michael Marmot (2005) in particular presented job strain as the prime explanation for class inequalities.

In contrast, the theory of relative deprivation developed in particular by Richard Wilkinson (1999) is based on social inequality. In short, Wilkinson posits that the existence of a social hierarchy and social distinctions with higher and lower prestige in themselves create social anxiety. The possibility of being unfavourably valued in any situation is a source of humiliation, shame, feelings of devaluation, the fear of exclusion and aggression. Wilkinson broadly categorises these experiences as social anxiety. Lacking what is valued as good, be it material or symbolic, and what others may have, constitutes relative deprivation, and being relatively deprived is the prime source of social anxiety, which in turn creates a predisposition to illness and disease.

Lifestyle explanations

The concept of health behaviour, or health-related behaviour, is part of the standard discourse not only in epidemiology but also in clinical medicine, health policy and particularly primary prevention. What this concept entails is, in fact, a range of biological influences on the organism of the human body that have been shown to predict disease, and are shaped by everyday habits and lifestyles of people that are not immediately related to work and other social obligations. The most prominent habits included among these are familiar to everyone, including smoking, alcohol consumption and other substance abuse, dietary habits and leisure-time physical exercise. Sexual or traffic behaviour are also sometimes considered.

The description, ascription and measurement of relevant aspects of health-related behaviours is not simple, however. Martin Jarvis and Jane Wardle (2006), for example, discuss how smoking rates are derived from differences in uptake and quitting, and also how consumed doses and dependence vary according to deprivation. Dietary habits as health-related behaviour are particularly tricky in this sense, as the range of measurable quantities, at least in principle, is wide, and the question of what exactly constitutes a healthy diet is also subject to controversy.

Individual choice is often emphasised as the basis of differences in habits among people. What distinguishes health behaviour from other behaviour is the labelling of these behavioural patterns as ones that should be modified by the individual in the interests of health. Although it is open to question whether dietary and drinking habits and smoking could be considered objects of pure free will, they evidently allow for more individual choice than work conditions, for example.

Behavioural or lifestyle explanations of social-class inequalities in ill health spring from the observation that many unhealthy habits are more common in the disadvantaged than in the privileged classes. There may be a tendency, particularly in conservative politics, to end the discussion here, dismissing social-class differences in illness as worthy of no further attention in as far as they are explained by individual behaviour. However, the observation of underprivileged people 'behaving badly' is as such hardly more than an observation incorporating the condemnation of such behaviour. The question remains of why there are differences in these behavioural patterns between the social classes. This has to be addressed if the model is to explain health inequalities, at least in any sociological sense.

As Lynch et al. (1997) suggested, and which Elstad (2000) explained with somewhat more theoretical clarity, there are two principal types of framework in which social-class variation in relevant health-detrimental behaviour could be understood. The individualistic approach sees behaviour as an individual choice, and choices as dependent on individual beliefs, attitudes and knowledge. Both conceptual criticism of and empirical contradictions to this model have been put forward (see e.g., Jarvis and Wardle 2006). Clearly, the number of sociologists and anthropologists who would readily accept that behavioural phenomena such as food habits are purely individual is likely to be rather small. Many would prefer a framework interpreting behaviour related to health as a lifestyle element in a particular social context.

Lynch et al. (1997) suggested that social conditions related to the economic macrostructure are major influences on the adoption of certain patterns of behaviour. Stafford and McCarthy (2006), for example, reported a consistent effect of neighbourhood economic deprivation on smoking above the characteristics of individuals. Lynch et al. particularly emphasised conditions in childhood and adolescence, and many other researchers have conducted studies of childhood conditions and adult lifestyles (see e.g., Kestilä et al. 2006). A somewhat different view is advocated by authors who, often drawing inspiration from Bourdieu's (1984) theories, consider lifestyle to be essential attribute of what it is to be in a given social position. Social positions are distinguished partly through lifestyles, and securing social recognition happens through practices that affirm the social distinction. As Simon Williams (1995) explains in a rather complicated account, everyday action follows class-related preferences in an unreflected manner. From the Bourdieuan perspective, the incentive to continue class-related habits might perhaps even be likened to social obligation.

Selection and mobility

The idea that good health might lead to a privileged social position also has a long history. The early variants of this theory proposed in the late 19th and early 20th centuries have also been referred to as 'social Darwinism'. The central idea is that people are distributed in social positions according to an overall genetically determined innate ability, the genetic worth of the individual (see e.g. Galton 1901). The dubious nature of such an assumption, not only in a moral but also in a logical sense, is clear – assuming that the socially desirable characteristics of individuals are fully genetically determined was a far-fetched idea even given the state of knowledge on genetics at the times of Sir Francis Galton and other eugenists (on Galton's eugenic ideas see e.g., 1908, chapter XXI). The reduction of social processes to so-called natural selection was also suggested later, even though, as Denny Vågerö (1991) cleverly remarks, advocates of these theories never presented any genetic data.

Disputes about whether social mobility, i.e. changes in class position, could account for social-class inequalities in mortality and illness were rife during the 1980s (see, for example, accounts by Elstad 2000 and West 1991). The question was whether a substantial proportion of class inequalities could be a result of social mobility of the ill from the privileged to the underprivileged classes and mobility of the healthy into the privileged classes. Today there seems to be some general acceptance that mobility during occupationally active adult life makes a very small contribution at best. Results from the British Office for National Statistics Longitudinal Study were particularly influential: Blane et al. (1999, see also Bartley and Plewis 1997) reported that while those who were downwardly mobile were less healthy than those who were stable in the privileged classes, they were nevertheless more healthy on average than those in their class of destination. Likewise, those who were mobile from the underprivileged to the privileged classes were less healthy than those in the privileged classes on average. Thus the data presented by Blane et al. rather suggests that social mobility diminishes class inequalities in health. Conclusions suggesting a minor contribution of mobility have been offered also by Power et al. (1996) on the basis of earlier British data.

A new perspective on mobility explanations was advocated by Patrick West (1991), for example. West suggests that social selection should be seen as a result of discrimination against the ill, rather than of any supposed innate superiority of those who are healthy and in privileged positions. Further, while it seems unlikely that mobility during adulthood could cause social-class differences in health, the same does not apply to so-called inter-generational mobility, i.e. the determination of

adult social position in adolescence. There can be little doubt that severely disabling illness at a young age may affect processes determining class position in adulthood. However, people suffering from such illness at an early age are in a small minority, and the question of whether health-related selection occurs in generally healthy young people is much more complicated.

It seems to me that one highly relevant prerequisite for the health-related determination of social position has been overlooked both by historical Darwinists and, to some extent, by West. For an organic condition to affect social position it needs to be perceptible and socially meaningful at a relevant time, when events affecting the later social position are taking place. Even if there was a biological 'potential for health' set in childhood, it seems quite implausible that it would affect social phenomena in as far as it does not cause illness that limits social functioning, and cannot be observed by other people (and thus cannot be stigmatising). So far, body height and obesity seem to be the only proposed visible organic parameters that may influence the determination of social position in adolescents without severe illness. Although body height is associated with cardiovascular disease, recent data reported by Karri Silventoinen et al. (2006) suggests that this association is not caused by genetic factors or family background, and thus does not support the assumption that discrimination against short people could be a cause of social-class difference in cardiovascular disease. Obesity may be a slightly more plausible cause of both later illness and social discrimination, but the degree to which obese middle-aged people, among whom obesity-related disease is most commonly manifested, are markedly obese in adolescence is likely to be limited.

A somewhat different view on social selection in early life is based on the notion that behaviour related to health tends to be formed at an early age. Again, this would require that young people with potentially unhealthy habits are markedly discriminated against by educational institutions and employers. I find it more plausible to assume that being less rewarded in one's educational career is a determinant of adopting unhealthy behaviour rather than the other way round. The lifestyle approach to behaviour would support this preference. Here, however, we are entering an area of discussion in which the conceptualisation of 'causal explanation' and 'selection explanation' starts to become vague. If material deprivation in childhood causes both a disadvantaged social position and poor health in adulthood, should this be termed causation or selection?

Emerging complexity – and a simple strategy

The above account has already given some indication of how the different explanatory strategies tend to be intertwined, and the more detailed the questions that are asked, the more complexity is revealed. Several approaches attempting to embrace the complexity by proposing interdependencies between conditions as causes of social inequalities in ill health have been presented. The so-called life-course approach, covered widely in a book edited by Diana Kuh and Yoav Ben-Shlomo (1997, see also Ben-Shlomo and Kuh 2002), and by Lynch and George Davey Smith (2005), has been somewhat influential. The emphasis in this approach is on interdependence among the different conditions across different phases in the life-time of an individual. It is my impression that there is a growing trend to seek causes of public-health problems in childhood and adolescence.

An approach that might have merited being nominated as a type of explanation in its own right but was not considered above is the attribution of prenatal environmental influences to later ill health and class inequalities in ill health. The conditions that could cause the hypothesised long-lasting damage to the developing foetus naturally include the previously mentioned types, but the fact that these conditions pertain to the life of the mother, not of the individual himself or herself, makes this type of explanation seem radically different, both biologically and sociologically. The assumptions involved nevertheless seem to be quite daring. The distances between the neonatal period, the emergence of chronic disease and disability, and finally death are considerable for most Western citizens.

The above review started with material explanations of class inequalities in ill health not only because they have a particularly long history, but also because they seem to be most straightforward, and at least the explanations referring to housing conditions and particularly physical work conditions seem to involve less complex assumptions than other kinds of explanations. The main emphasis in this study was on physical work conditions, although psychosocial conditions at work were also addressed. The differences between social classes in physical work conditions are considerable, and definitely merit attention in the context of research on inequalities in health. The lack of such studies so far is identified specifically in Chapter VI.

Chapter IV

The concepts of health and illness

Health and illness are remarkably difficult to define in an unambiguous way. No single coherent definition is likely to hold, nor would be entirely feasible in all probability. The concepts are used in many contexts, and unitary definitions may not account for their full relevance. Illness has an enormous impact on human life. It is an aspect of reality rooted in physical conditions, the nature of organisms, social life, and individual experience. Similarly, despite the universal significance of the concept of health, its precise meaning is even more difficult to define. It is evident, however, that illness and health are, for the most part, interrelated, if not simply bi-polar. To speak about health is often to speak about illness, although contrasting views have also been presented.

A lot of discussion on the concepts of health and illness centre on two main aspects of illness. Firstly, its occurrence is based on physical reality, manifest in the biological processes of the body as an organism and its relationship to the natural environment. Secondly, it is a socially defined condition, an interpretation of the human condition that is dependent on values and is relative to social needs and functions. A comprehensive account of the relationship between these two aspects has so far been beyond the capacity of logical analysis, but many attempts to clarify the conceptual nature of illness, health and the associated concepts of disease and sickness have been made. The review presented here is limited and selective, (studies on lay definitions of health have been intentionally left out, for example) but I believe it will clarify some issues related to ill health. Although the account begins with a few tricky philosophical expositions, the rest of the chapter is less logically tortuous.

Health as a variant of goodness – the philosophy of Georg Henrik von Wright

According to the philosopher Georg Henrik von Wright (1963/1972), inherent in the concepts of health and illness is a specific meaning of good, which von Wright also calls medical goodness. Medical goodness is related to utilitarian good, specifically it is a subcategory of beneficiality rather than usefulness (another type of utilitarian good). Beneficial differs from useful in the sense that it does not promote

the achievement of a specific end of action, but it promotes the good of a being in general. In the primary sense of the concept of health the being is a living creature, a plant, an animal or a human.

The goodness of health is based on the performance of the body or its faculties. It is nevertheless significantly different from the instrumental goodness that is usually attributable to tools, and from technical goodness that is usually attributable to skills. The goodness of organs, although related to the organs function is not related to a specific activity. Good organs and bodily faculties are good for the individual who has them, not for a specific end of action. Moreover, organs and faculties are innately good for their purpose. Their function is something they innately do, not something they can be used for. Von Wright refers to the functions of organs and facilities of the body and mind as essential functions. They are essential because should an individual fail to perform them in a situation in which such is ordinarily, "by nature", expected, it is considered abnormal or defective.

Thus, goodness of health cannot be understood without reference to the normal. An organ, or faculty of the body or the mind, is good when it is performing as expected, according to its innate goodness, and it is bad when it is a source of evil to the individual to whom it belongs. However, organs are good not because they are beneficial, but simply because they do not cause evil. According to von Wright, the evaluation of bad health has two components: firstly, judgement of the presence of an evil, manifest in pain or incapacity, and secondly, the assumption that this evil is caused by an abnormality located in the organs and bodily faculties.

According to von Wright the definition of goodness of health as the absence of evil is the privative notion of health. It is its the basic meaning. He does acknowledge the existence of a positive meaning of health – feelings of fitness and strength that are joyful or pleasant – but this is different from the privative notion of health. The positive notion of health is closely connected to a form of goodness that is different from the medical goodness connected to the privative meaning – that of pleasure or hedonic good.

Von Wright's analysis of the concept of health does not make a distinction between the 'objective' and 'medical' on the one hand and the 'subjective' and 'experienced' on the other. His term medical goodness does not refer to the so-called medical model of health (which is considered below). Indeed, his analysis points to how professional and non-professional evaluations of health and illness exhibit fundamentally the same characteristics – on the one hand it is presumed that

the condition is caused by disorder in the organs or bodily faculties, and on the other hand the condition is valued on the basis of experienced pain and incapacity. Someone experiencing discomfort, pain or incapacity will not generally regard the experience as bad health if he or she does not believe that this experience is caused by a deviant or subnormal condition in some bodily function.

Many authors writing on the sociology of health like to point out that medical judgement of disease (by medical professionals) does not require the individual to be experiencing illness. Modern medicine can locate abnormalities in the body and classify them as disease regardless of the individual's experience. In the light of von Wright's analysis, however, it seems to me that this view is somewhat flawed. According to Wright, badness of health, i.e. illness of the body or part of it, can only be understood as pointing to the evils of pain and incapacity. In more logical terms:

> "The evil which bad organs cause is constitutive of the badness of the organs themselves, one could also say." (von Wright 1963/1972, p. 56)

Without going further into the issue here, I would like to suggest that the apparent unrelatedness between the professional evaluation and the individual experience of hypertension, for example, may also be partly due to the modern physician's aspiration to predict pain and incapacity before they are apparent. However, the conceptions of health, illness and disease employed in health care and by medical professionals are also manifold, and are not easily captured in simplistic comparisons.

Disease as a medical concept

The definition of health, illness and disease in Western professional medical practice, or medicine as science, has been discussed by sociologists, philosophers and clinicians. I do not attempt to review this discussion here, but rather summarise some central aspects of what has been commonly seen as a biomedical framework in the sociology of health based on a few existing accounts.

The practice of clinical medicine is essentially dependent on the concept of disease. The definition of disease in the medical context reflects the tendency of Western medicine to base its practices on scientific knowledge, specifically that of natural science. The biomedical concept of disease relies on the objective measurement of

natural parameters of the individual's organs, organ systems and, to some extent, their functions.

The classical paradigm of the biomedical model was developed during the 19th century and reflected the success of the germ theory and infectious medicine. Mildred Blaxter (2004) lists the main features of the classic medical model of disease:

1) Specific aetiology: a disease is caused by a specific identifiable natural agent or agents. The most straightforward example of such an agent is an infection-causing microbe.

2) Generic disease: every disease is universally identifiable by its distinguishing features, including both causes and symptoms. A disease is similar in all individuals, societies and cultural environments.

3) Deviation from the normal: disease could be described in terms of findings and measurements of physiological parameters in the individual that deviate from the normal. Disease is altered physiology differing from the average.

4) Scientific neutrality: diseases have to be defined on the basis of objective findings rather than the interpretation of the observer.

The biomedical model was further elaborated following later developments in biomedicine. It has been recognised that it is often impossible to pinpoint the specific sufficient causes of a disease unambiguously. Disease often results from a complex interaction between external causes and function of the organ systems, and symptoms are often more accurately described as consequences of reactions of physiological systems, rather than as direct consequences of the presence of an external agent. Chronic conditions that are common today tend to have a complex aetiology characterised by what Stephen Kunitz (2002) has called 'multiple weakly sufficient causes'. The positivist ideal of disease as decribed by Blaxter is clearly outdated, but the problems and limitations of this model illustrate the challenges in arriving at a scientific definition.

One specific philosophical debate concerns whether the concept of disease is always dependent on values, or whether the definition is value-free. Christopher Boorse (1977) described disease as a theoretical notion independent of value judgements. Boorse defines disease as any state that reduces the efficiency of any part of the organism in its biological function. Its main elements are biological

dysfunction and statistical abnormality. According to Boorse, once physiology has identified a biological function for any part of the organism, the failure of this function could be called disease. Failure here is defined as efficiency below the statistical normal in performing the presumed biological function. Although the exact definition of statistical normality in any given parameter requires a cut-off point, according to Boorse it does not require value evaluation.

Boorse's admirably elegant definition is explicitly theoretical, and he distinguished disease as a theoretical concept from illness as a practical concept. Obviously, we should not consider medical practice to be solely limited to, or primarily motivated by, a theoretical definition of disease. Bjørn Hofmann (2005), for example, describes how medical professionals seem to rely on several different and even contrasting definitions of health and disease, and authors such as Fulford (1993) have suggested that, in practice, it is not possible to analyse the meaning of all instances of disease without reference to illness. Furthermore, the notion of disease in terminology used in medical practice does not seem to follow any universal theoretical definition, and Kunitz (1983), for example, identified differences between clinical specialties. The philosophical issue of whether there is anything real that is common to all instances of disease other than that they are labelled disease, has been addressed by D'Amico (1995), for example, but I make no attemt to explore this debate here. It suffices to assume that disease, by and large, primarily refers to natural phenomena such as those described by Boorse, although a comprehensive definition may necessitate reference to evaluation by the individual and by others, and potentially even to the function of health care and the task of the health professions.

The Parsonian sick role as an approach to the social meaning of illness

A specific research tradition in sociology focuses on the institutions of the practice of medicine and their relations to both individual behaviour and society at large. A major influence in this branch of sociology was the functional approach of Talcott Parsons. In line with Parsons' theoretical approach, illness as a social role has been the main theme in this line of study, which has further developed into what could be called the study of illness behaviour (see, for example, Young 2004).

Parsons (1951/1991) began by defining illness as functional disturbance both in the biological system of the organism and in the social relationships of the individual. Because illness disturbs the effective performance of social roles, society

has a strong motivation for regulating it, and for minimising illness and the behaviour associated with it. Parsons introduced the concept of the sick role to describe the social position of the ill.

Four relevant so-called institutional expectations are ascribed to the sick role: 1) the sick are exempted from social obligations and role responsibilities otherwise applicable to them. This exemption requires legitimation by a physician; 2) the individual is not held responsible for being in a state of illness, it is not regarded as conscious choice; 3) illness has to be seen as undesirable by the individual in the sick role, and thus the ill have to be motivated to get well; 4) the ill must seek "technically competent" help, i.e. medical care to remedy the illness. The sick role is thus transformed into patient role. According to Parsons, the isolation of the patient from society is of functional importance in terms of protecting society from "malingerers" and reducing the motivation to adopt the deviant sick role. (Parsons 1951/1991, pp. 433-439, see also Parsons and Fox 1952)

Parsons' approach has also been subjected to wide criticism. In the main it is not directed so much at the definition of the sick role as such, but rather at the short comings and narrowness of the approach as a theory of social determination and the meaning of illness. For example, Ellen Idler (1979) summed up her criticism in two main points. Firstly, in focusing on the social system to regulate illness behaviour the approach fails to recognise how illness in itself is defined socially. It offers no conceptualisation of how illness is defined and experienced at first hand, but takes the fact of illness more or less for granted. The perspective is limited to the context of medical care, and does not analyse the concept of ill health in that particular setting either. Secondly, the approach essentially does not account for how ill health may be caused by social structure and action, and socially determined conditions in general. A further criticism could be added: in focusing on the relatively transient isolation and institutionalisation of the sick, the Parsonian approach also fails to account for the total long-standing social consequences of ill health.

Despite the evident limitations of the Parsonian tradition, it has the capacity to clearly emphasise normative interests in health. Twaddle and Hessler (1977), for instance, suggested that there are, in general, two labels for deviant behaviour: when it is assumed to have been chosen by the individual it is likely to be labelled crime, whereas when it is assumed to be caused by conditions beyond the individual's will it is likely to be labelled sickness. Although this could hardly be taken as an apposite description of what illness and health essentially mean, there is some intuitive appeal in this sweeping description of social significance of defining illness.

Medical, experiential and social dimensions of health – the three-model approach

Many scholars writing on the sociology of health have somewhat systematically assigned different meanings to the concepts of disease, illness and sickness, arguing that these constitute the medical, the subjective-experience and the social-participation models of health respectively. Among those who have consistently developed this approach has been Andrew Twaddle (1994, see also Twaddle and Hessler 1977, and the account by Hofmann 2002), although numerous authors have put forward various closely related definitions. Nevertheless, it seems to me that there is no systematic assignment of strictly distinct meanings to disease, illness and sickness in the literature, with the possible exception of a philosophical discussion by Twaddle, Lennart Nordenfeldt and Bjørn Hofmann (see Hofmann 2002). However, this kind of three-model thinking has become somewhat common in social epidemiology as well. Accounts of the meaning of these concepts in survey-based health research have been written for example by Blaxter (1989) and Purola (1972).

The essential characteristics of the triad (I have borrowed this wonderful expression from Hofmann) are more or less the same, although the details may vary slightly. The following is a brief summary of Twaddle's view. Disease is a physiological state that reduces, or has the potential to reduce, the physical capacity or life expectancy of the individual. It is natural in the sense that it exists independently of observation, and is objectively measurable. Illness is a state based on feelings, and can only be experienced and perceived by the individual in question. Sickness is the social category of unhealth, and is an identity given to the individual by others on the basis of failure in the performance of expected activities (a notion certainly echoing Parsons).

The three-model approach is certainly problematic, not least because it seems to overestimate the degree to which these three concepts actually may be defined in isolation. The problems with defining the reduction of physical capacity in a naturalistic and objective manner were addressed above, but attempts to define this triad again highlight how difficult it is to do so without reference to individual experience and social expectations. Basing the definition of illness excessively or solely on feelings is even more problematic, as not all undesirable feelings are seen as illness. This particularly applies to somatic illness. Nordenfelt has also noted that the social category of being ill cannot be exclusively based on failure in performance,

as in many cases people are described as sick even if no such failure in performance is apparent or even expected.

The general system theory of the 1970s, with its hierarchy of systems within each other, may have seemed to open up a fruitful framework for a three-level model of health. The attempt at a system-theoretic definition made by Tapani Purola (1972), however, did not seem to achieve much more clarity than other presentations. Assuming in general that illness is a disorder in a system, he described the human being in terms of three systems feeding information to each other: the organism system, the personal-perception system and social-adjustment system. Purola's intention was to include both participation in and the performance of social obligations, as well as the influence of social norms and knowledge, in the system of social connections, and he used the term social morbidity to refer to disorders in this system. The distinctive system of personal perceptions of health and illness was dependent upon receiving information from the organism system and the social system. In my view, Purola's social and individual systems are quite confusing and difficult to tell apart in that the interpretation of illness seems to be located in both, and he did not address in depth the potential criteria for disorder in the organism.

Mildred Blaxter's (1989) review of health models in epidemiology is, by and large, a classification of the measures used in existing empirical literature rather than analysis of the theoretical foundations of each model. Blaxter's categories include the medical model, the social-interactional or functional model, and the subjective model. The emphasis in the medical model is on the prevalence of medically defined disease or abnormality. The social-interactional or functional model incorporates attempts to evaluate the limitations on activities imposed by illness, operationalised as reports of limitation by disease, restricted activity days or sickness absence. Finally, the subjective model incorporates self-assessment of general health status (on a bad-good scale) and reports of symptoms. This allocation of measures into categories shows how these measures are different empirically, but does not shed much light on the underlying concepts. Asking people to report symptoms on a predefined list does not give much indication of how illness is conceived of by the respondent or the researcher. It is possible, even likely, that respondents report symptoms prompted by the survey questions even if they do not interpret them as illness.

Measuring illness and morbidity

Textbooks on medical sociology often emphasise from the start the fact that symptoms, deviance in bodily functions and diagnosed conditions may exist without the individual in question feeling particularly ill. Indeed, there have been many studies, reviewed by Sally Macintyre (1986), for example, showing that people may be suffering from a multitude of diseases, symptoms and different physical ailments and still describe themselves as generally healthy. Life is full of short illness episodes and long-lasting minor physical irregularities. Such conditions may be defined as illnesses or diseases when specifically brought to attention, but do not ordinarily interfere with people's perceptions and experience of themselves as being in good health. The same applies to professional evaluation when the whole of the individual is considered (hence the notion of "otherwise generally healthy" patient in medical records). Epidemiological studies have shown that the majority of people suffer from various minor dysfunctions or symptoms. Thus one could perhaps assume, that these conditions do not necessarily markedly affect the general health status of the individual, in other words, do not make the individual markedly ill.

Ill health is not a unitary condition to begin with. It is a rich variety of physical (or psychological) deviances, and the description of general health status has obvious philosophical problems. However, there is also an indisputable logic in the grading of ill health. A person who has to limit his or her daily activities because of cardiac insufficiency is obviously more ill than someone who has a small itchy rash. There are many reasons why social and epidemiological investigation should be concerned with such differences in the extent of being ill, primarily because if no gradation is possible the possibility of distinguishing someone who is ill from someone who is healthy is essentially lost. When the Parsonian sick role, for example, is attributed to a person, the process of legitimating the sickness involves an evaluation of the extent of the illness. It is tempting to point out here that this evaluation is essentially functional: it concerns the functional limitations that the illness is likely to impose on the person, including already apparent limitations as well as assumed potential limitations should whatever condition caused the illness proceed untreated.

It is customary in social epidemiology to talk about limiting illness. An early example cited by Macintyre (1986) is a post-war American health survey conducted by Earl Lomon Koos (1954/1967): he divided illness into non-disabling and disabling types, the latter being disruptive in terms of performing normal duties. Since then many surveys have measured the simple distinction of limiting versus non-limiting (see the review conducted by Blaxter 1989, for example). The

established concept of limiting longstanding illness refers to longstanding – as opposed to transient – illness, disability or infirmity that causes limitation in relevant activities. Relevant activities may be more accurately defined as paid work, housework, ordinary daily activities, and in some cases even as something the respondent needs or likes to do. The most simple approach is to ask people whether they have such an illness, but at least in the 1980s measures were also constructed from inventories consisting of different diseases and longstanding symptoms. Although in most cases such composite measures were based on self-reported data, similar measures could be, in principle, based on medical data from health-care registers as well. Problems related to summing items on different conditions to construct a single measure are the same for self-reported and health-care-derived data, however. The choice of conditions measured to begin with, the choice of items included in the index, and the mathematical relations of the items when indices of a range of scores are constructed, may become determinants of what is found. Although the intention may be to create a measure on a more objective basis than simply asking about longstanding illness, the result may be that it is less clear what exactly is being measured. There are further problems related to data from health-care systems because treatment, especially hospital treatment, does not necessarily follow from having a disease or illness as such, but is dependent on care practices.

Another standard instrument of morbidity is self-rated health, referring to the respondent's own rating of his or her overall health status along the axis of good versus bad. This kind of overall evaluative rating seems at least as such to be conceptually different from limiting longstanding illness in that there is no reference to illness being caused by a specific condition. Health is considered in terms of a unified experience, expressible from excellent to poor, and thus the fundamental qualitative differences between health and illness are not apparent, at least in the formulation of the items. However, according to studies carried out by Kristiina Manderbacka (1998a and b), for example, the evaluation of self-rated health is predominantly based on conditions causing illness (i.e. assumed physiological deviance), their severity and the related restriction of activity. People's ratings thus seem to some extent to follow the conceptual analysis of von Wright. Furthermore, the focus is often on those reporting less than good health. It thus seems that this practice has the effect of making self-rated health a measure of dysfunction after all, as good health is most sensibly understood as expected normalcy. Many studies have confirmed that self-rated health predicts mortality, and attempts to explain this prediction have also been made (see the review in Idler and Benyamini 1997, and the studies carreid out by Heistaro et al. 2001, Mackenbach et al. 2002 and Jylhä et al.

2006). In short, it seems that self-rated health correlates with biomedically defined conditions, but its explanatory power is not entirely reducible to these conditions.

Functioning as a quantity of illness

All the approaches to defining health and illnesses discussed above seem to illustrate, in a way or another, how functional evaluation is embedded in the very notion of ill health. Although limitation imposed by illness and disease may not be fundamentally a completely unitary continuum, it seems sensible to assume that comparisons of the severity of limitation are possible, even feasible in relation to many issues that could be considered relevant. Various concepts and measures of disability and dysfunction have been developed for this purpose, the earliest suggestions for such instruments dating back to the 1960s according to Hunt and McEwen (1980) and Macintyre (1986). The objective of this work is to operationalise ill health as departure from normal functioning and to quantify the degree of disruption in such functioning by measuring most ordinary areas of normal activity.

A major motivation for developing measures of functioning has come, somewhat surprisingly perhaps, from the need to evaluate the effectiveness of medical care. To what extent care has resulted in better health, or in many cases rather diminished illness, cannot be measured in terms of biomedical markers. It is well-known that dysfunction and the severity of illness cannot be inferred merely from biomedical data. Many instruments for measuring functioning have been developed and are in use, most of them having been designed for particular clinical contexts and thus focused on the specific limitations certain disorders and diseases tend to cause. Overall approaches to measuring functioning and functional limitation have also been developed. The most well-known instrument is probably the Short Form 36 health inventory that is used in this study. John Ware and Cathy Donald Sherbourne (1992) described the conceptual background of this measure: this is covered in Chapter VIII.

The terminology concerning what the instruments measure, however, is not completely consistent. Some authors refer to the quality of life. This seems unwarranted as it adds a new concept that is obviously even far vaguer than the concept of health itself, and would seem to necessitate much more emphasis on feelings of fulfillment rather than experience of dysfunction. As the existence of

functional limitation is essential to illness, we should limit our focus and our conceptual thinking to degree of incapacity, and not make any further questionable assumptions about their significance to perceptions of life in general.

Chapter IV

Conceptualising workload

Subjecting work and the work environment to scientific study requires a degree of conceptualisation. Work is a rich environment manifesting physical conditions, patterns of human interaction and large-scale social organisation, and occupies a central position in the life experience of the individual. In the context of this study, work is conceptualised predominantly as an environment containing factors that may influence the physiological and psychological state of the individual, and through these pose potential threats to health.

This study covers several somewhat differentiated aspects of work conditions. Physical workload is understood as the general amount of demands on the workers ability to perform physical tasks requiring significant muscular effort. This term is thus somewhat general, and the relevant quantities could be more exactly defined in terms of biomechanical exposure. However, as the level on which these conditions could be measured in this study reflects the variety of different tasks in the work, rather than the precise natural scientific measurement of the forces involved in executing the tasks, it seems to me that the terms physically demanding work or physical work tasks are more justified in this study.

Physical work conditions include not only physically demanding tasks but also many aspects of the work environment can be conveniently classified under this heading. Breathing air is a potential medium of physical and biological exposure to dust, various particles and micro-organisms. Direct skin contact with chemicals and infectious agents is at least a potential risk, if not a continuous exposure, in some work environments. Environmental conditions such as noise, lighting, temperatures and humidity may affect the individual physiologically or interact with other conditions to increase risk. Furthermore, work arrangements, the tasks performed, the working methods and features of the environment combine in determining accident risks, which is likely to be difficult to operationalise in a coherent measure.

Working conditions include a wealth of organisational, social and informational conditions and demands, all of which, together with physical workload, are also connected with the productive demands of the work. There are many approaches to conceptualising, measuring and studying these various aspects of work. Some attention in this study is directed towards work demands and conditions that have also been commonly labelled psychosocial conditions, although the exact definition

of how these conditions are 'psychosocial' seems to be somewhat vague. A theoretical framework, where such is necessary, for these conditions can be derived from the job demand and control model proposed by Robert Karasek and his colleagues, which is briefly reviewed below. I make no attempt to review various other approaches to the social aspects of work and their relation to individualistic psychology. Instead, I consider at greater length a few conceptual approaches to physical workload that feature in the literature on occupational health.

A model of mechanical exposure

According to Westgaard and Winkel (1996) mechanical exposure could be defined as work tasks and actions that create biomechanical forces in the body, or as these very forces. The term is most typically used in ergonomic studies on the physical parameters of work actions and short-term physiological responses in the muscle and connective tissue, but its application in epidemiological studies has also been justified. Jørgen Winkel and Svend Erik Mathiassen (1994) noted that conceptually mechanical exposure could be expressed as an unlimited number of force vectors affecting any part of the body over time during a work task. Rolf Westgaard, Winkel and Mathiassen (Westgaard and Winkel 1996, Winkel and Mathiassen 1994, Winkel and Westgaard 1992) further proposed breaking down the concept into three components: level of exposure, duration of exposure and repetitiveness. These three components can theoretically be observed in any given force vector in the body: the level of exposure is the force at that point in the body, duration is the length of time the body is subjected to the force, and repetitiveness is the frequency of force peaks. Winkel and Mathiassen also propose the term variation pattern to denote how a certain exposure level recurs over a cycle in a work task.

Although mechanical exposure may refer to the physical parameters of work demands outside the individual, or to the biomechanical forces created in the individual's body in performing these tasks, models related to biomechanical exposure tend to emphasise the distinction between these two. Westgaard and Winkel (1996, see also Winkel and Mathiassen 1994) proposed a mechanical-workload model consisting of four components:

1) external exposure, the work demands specified independently of the individual and measured in terms of working height, the weight of objects or task duration, for example;

2) internal exposure defined as biomechanical forces inside the body, and measured in terms of electromyographic load, intramuscular pressure or abduction degree in the limbs, for example;

3) acute responses, which are divided into physiological and psychological responses: the former include changes in muscle performance, strength and endurance, changes in blood flow, blood pressure and heart rate, and changes in electrolytes and metabolic products, while the latter include fatigue, pain and discomfort or comfort;

4) musculoskeletal health, which could be improved or impaired as a result of long-term exposure.

The determination of each component from the previous one is according to the model influenced by effect modifiers, including factors both in the external environment and in the individual. The model does not specify modifiers for each phase given their proposed and potential numbers. Winkel and Mathiassen (1994) also propose an additional step between internal exposure and acute responses. They call this active internal exposure, denoting the fraction of internal exposure causing the biological responses in the tissues. This concept presumes a threshold level below which the responses of interest are not created.

Physical workload as a pathway

What is called the workload pathway model here is an approach advocated by Frank van Dijk and his colleagues. There are several versions of the model, but the differences between these are minor. A comprehensive tracking of the origins of the model cannot be provided here because some of the discussion is published only in Dutch (van Dijk et al. 1990). According to the concise formulation presented by Jeannette Paul et al. (1994), the model comprises the following five steps in which external factors interact with individual characteristics to cause a pathway from the work situation to musculoskeletal symptoms and morbidity.

1) Work situation, which denotes all the potential sources of loading in the work content, environment and social relationships at work. Work content is defined as functions the worker is required to perform. Paul et al. also include decision latitude

(see the chapter on Karasek) in the work situation, as it is assumed to modify the loading factors and their effects.

2) Actual work performance, which refers to the tasks and actions that the worker performs during a working day. Work performance is largely determined by the work situation, but may vary from day to day. Workers may also consciously modify their performance: if they anticipate a low capacity to perform certain tasks, for example, they may reorganise their work (provided that the work environment allows this).

3) Posture and exerted force, which means that work performance is transformed into mechanical exposure characterisable in terms of forces exerted and the positions of body segments. Posture and created forces are influenced by the work methods used, which may depend on several individual characteristics as well as on external factors such as workplace design and properties of tools.

4) Load on the musculoskeletal system: Paul et al. emphasise that the transformation of external forces into internal forces exerted on different tissues is also dependent on the bodily structure of the individual worker.

5) Musculoskeletal complaints and morbidity: the balance between load on the musculoskeletal system and the capacity of the musculoskeletal system of the individual to sustain load and fully recover from it determines whether acute and long-term symptoms will develop.

Another version of the model reported by Bart de Zwart et al. (1995) refers to the second step as the 'actual working method', and attributes factors such as lifting technique to the second step, 'actual working method', rather than the thrid step, 'posture and exerted force'. This discrepancy in detail between presentations of essentially the same model demonstrates the difficulty of indentifying precise descriptive levels in the action of the worker. It could thus be concluded that no obvious dividing lines exist, and that distinguishing between factors such as work situation, work demands, work performance and work methods is dependent on what is being examined. As the action of the worker in reality is a manifestation of any of these levels, a lot depends on what level of abstraction is operationalised in the measures.

Steps one and two in the workload pathway model precede the external exposure as formulated in the mechanical model developed by Westgaard and Winkel,

whereas step three corresponds roughly to the external exposure in the mechanical model, and step four roughly to internal exposure. The two models were relatively successfully combined in a review written by Marco Hoozemans et al. (1998). This synthesis simply treats steps one to three (work situation, actual working method and posture/movements/forces) in Paul et al. as subcategories of external exposure, and adopts internal exposure, acute response and long-term effects from Westgaard and Winkel.

The model developed by van Dijk and his colleagues has sometimes also been called 'the dynamic workload model.' The figures presented by these authors often include a box called 'work capacity', from which the effects are presumed to affect each step of the pathway. Both Paul et al. and de Zwart et al. emphasise that the characteristics of the worker may introduce feedback effects at any stage of the pathway. The capacities of the worker influence the transformation of demands into work methods, of work methods into forces, and of forces into physiological responses. Both short-term and potential long-term effects influence individual capacity, and therefore introduce feedback effects.

Relationship to stressor-strain concept

The stress-strain model, or more accurately the stressor-strain model, is sometimes used to refer to a workload framework that has been used by certain German and Finnish research groups (e.g., Ilmarinen 1985, in Finnish, Rohmert 1984, in German). This conceptual framework is not specific to the physical or psychosocial workload, but is a general formulation of terms concerning work factors and health outcomes. It may have been influenced by theoretical accounts such as the one presented by Raija Kalimo (1980), and probably reflects the use of the terms stress, strain and over- and underload in occupational psychology in the 1970s. Much of the research in occupational psychology concerned the relationship between psychological job stressors and work satisfaction, work performance and mental-health outcomes. Concepts such as person-environment fit and overload were discussed (see, for example, the reviews by Karasek 1979 and Kalimo 1980). The distinction between stressors and stress reactions can be traced back to Hans Selye (1956), and a full review of theories of stress is beyond the scope of this work.

According to the approach advocated by Ilmarinen and colleagues, for example, work content is comprised of work demands, or stressors. The framework is not

very specific about what level of abstraction should be utilised to characterise these demands. The demands then interact with the individual characteristics of the worker. When there is an imbalance between demands and capacities – either overload of demands or too low demands with respect to capacity – strain ensues. Strain is described as a condition characterised by short-term physiological and psychological effects. Prolonged strain, in turn, is likely to result in adverse health outcomes. The work environment, both physical and social, could be described as a factor that further modifies the stressor-capacity interaction. (Tuomi et al. 1985)

This stressor-strain concept is not necessarily completely incompatible with the theoretical models presented above. The description of the relationship between work and health, however, is clearly less precise concerning the presumed mediating mechanisms of any effects. There is also an interesting emphasis on a kind of 'homeostasis' as opposed to the more rigorous cause-effect pathways of the models presented above. The concept of strain used in this framework has not been particularly widely adopted or established in public health epidemiology, however. The term work strain is more often used in connection with the workload model developed by Karasek.

Demands and decision latitude – Robert Karasek's model

At the turn of 1970s and 1980s Robert Karasek (1979) proposed a model of work environment and psychological strain he originally called the job strain model. According to Karasek's own account, the model was a new approach combining what until then had been separate investigations on workload and work-output demands on the one hand and decision authority and discretion on the other. This model later became very popular in social epidemiology primarily because Karasek et al. (1981) managed to demonstrate that it predicted not only job dissatisfaction and exhaustion symptoms but also cardiovascular disease. The model has also been referred to as the demand-control model. This model is not the primary focus of this study, but as the work-content dimensions presented in the model, i.e. demands related to accomplishing work tasks on the one hand and job decision latitude on the other, are addressed, its main features are briefly reviewed.

According to the model combined high job demands and low decision latitude result in mental strain. When it was introduced by Karasek in 1979 mental strain was also operationalised as mental exhaustion and depression, and was measured. Later

research has almost altogether ignored this aspect of strain as an independently measurable psychic state. Karasek was also quick to abandon the direct measurement of strain. The term job strain was then often utilised with reference to the proposed detrimental combination of work characteristics, and it is almost implicitly presumed that strain is also internalised as a psychic state of the individual.

Job demands in the model primarily referred to pressures related to work performance, including the amount of work to be done, piecework, time pressure, the hectic nature of the work, conflicting demands, interruptions, and the need to wait for work from others. Thus the demands dimension could be more accurately called work output demands. The specific items applied in the measurement of demands have varied. The operationalisation of job decision latitude in Karasek's original presentation of the model was substantially influenced by the discretion measures developed by Gardell, Kohn and Schooler and several other authors examining autonomy and skill use (see Karasek 1979, Muntaner and O'Campo 1993). The measure has two main components: decision authority and intellectual discretion, or skill discretion as it has been later more consistently called. In 1981 Karasek et al. defined decision latitude as control over the use of skill, time allocation and organisational decisions. Items constituting skill discretion have included learning, the use of creativity and abilities, variation in tasks, and repetitiveness. It was originally hypothesised that in highly repetitive work even when the tasks originally required skill, over time performing them becomes routinised. Decision authority correspondingly includes making decisions about work tasks and organisation of work, and influencing the work environment as well as company policy.

Karasek combined the two work-content dimensions in his famous four-field diagram, with decision latitude on the vertical axis and job demands on the horizontal. The quarters of the field were assigned job types according to the expected level of strain involved: a low-strain job for low demands and high decision latitude, a high-strain job for high demands and low decision latitude, a passive job for low demands and low decision latitude, and an active job for high demands and high decision latitude. The diagonal penetrating the diagram from the low-strain to high-strain corner denoted the unresolved strain dimension, and the intersecting diagonal from passive to active denoted the activity-level dimension.

Karasek et al. suggested in their 1981 study that there may be modifiers other than decision latitude that affect the development of unresolved strain, such as social support at work. However, it was a long time before the combination of these three

content dimensions was examined. The model extended to include social support has been called the iso-strain model. The addition of this dimension may nevertheless be more problematic than at first appears in that it is not clear whether it is possible to define social support as a dimension of work content in the same manner as demands and decision latitude are defined in the original model. Furthermore, the work-content dimensions of Karasek's model have been used in experimental work alongside many other work-characteristic measurements, making the relationship with the original model relatively vague at times.

There has been a notable amount of criticism of the job-strain model as well. Carles Muntaner and Patricia O Campo (1993) give a relatively exhaustive account of the criticism from the perspectives of experimental psychology on the one hand and sociology on the other. Some of the sociological concerns have revolved around the issue of how authority as reflected in decision latitude is part of social position, and indeed may be a criterion of social class, as clearly proposed in both Goldthorpe's (1980) and Wright's (1985) theories of class. The concern is not only that decision latitude is highly likely to be correlated with various social conditions, the contribution of which would be very difficult to eliminate in study settings, but also that class structures could be seen as the prime force that determines decision latitude at work. Sensible interpretation of decision latitude may not even be possible without reference to class structure. Muntaner and O'Campo attribute these challenges in the Karasek model to its emphasis on psychology: only the immediate environment the individual confronts is addressed, and concepts of social conditions are formulated from the perspective of the individual.

In the context of this work it could also be asked to what extent the output demands operationalised in the Karasek model also reflect physical work demands. The pressure to work fast, piecework and other related demands are likely also to indicate increased exposure to physical strain when the job includes physically demanding tasks. This seems to call into question whether the model only concerns the psychosocial characteristics of work, which is the common view in social epidemiology. The term 'psychosocial' seems to reflect the assumed biological mediating mechanism of the effect rather than the nature of the work conditions as such. To my knowledge there have been no theoretical or empirical attempts to incorporate the physical workload into Karasek's model, although many scholars would certainly agree on the need to account for physical conditions alongside the dimensions of Karasek's model in studies of the effects of work conditions on overall physical illness.

Chapter VI

Previous research – a review of relevant empirical studies

The history of systematic statistical enquiry into social inequalities in ill health is for the most part the history of studies on mortality. Deaths have been systematically recorded for many centuries, and these records have always been the most readily available data for investigations on population health. The advantages of studying mortality also include the objective nature of death, although in so far as cause of death is considered, even death is not so unambiguous: indeed, the expression 'cause of death' already reveals a causal assumption linking death to disease in life. Ill health, however, burdens human life with many other sufferings and inconveniences than that of premature death.

It seems that national registration authorities and institutions responsible for health and social investigation started to collect survey information on the living conditions and welfare of the population in many northern and central European countries in the 1970s (see, for example, the national reports in a World Health Organisation publication edited by Illsley and Svensson in 1984, and a related issue of Social Science and Medicine likewise edited by Illsley and Svensson in 1990). Many of these interview or questionnaire surveys featuring representative population samples also included some items on health. However, the resulting data did not always seem to attract immediate research attention directed to social-class inequalities in health. Furthermore, the results of such research activities were often circulated only in national forums, and international scientific publication was not commonplace. Indeed, much of this information is practically inaccessible to the present-day student of health inequalities. Some studies were published in the 1980s, but most of the literature seems to date back to the turn of 20th and 21st century.

Class inequalities in overall physical morbidity

A thorough review of the research thus far on class inequalities in health was compiled in 1980 by the Working Group on Inequalities in Health commissioned by the British authorities. Known as the Black Report after the chairman of the working group Sir Douglas Black, and publicly distributed in paperback form edited by Townsend and Davidson (1982), the report is one of the most influential

documents in the field of class inequalities in health. The paperback version contained only two tables on class differences in morbidity, alongside numerous ones on mortality, the source of the former being the British General Household Survey of 1976. Class inequalities in limiting longstanding illness were observed, ranging from a prevalence of around seven percent in the professional class to around 25 percent in the unskilled-worker class (Townsend and Davidson eds. 1982/1983, p. 63), the ratio between the extreme classes thus being approximately 3.1.

A cross-country welfare study was carried out in the Nordic countries with data collected in 1972 (Allardt 1981). The reported prevalences of limiting longstanding illness were devised from an inventory of illnesses. (Although the term limiting longstanding illness was not employed, the conceptualisation and construction of the measure corresponded to this concept.) Class inequalities were reported only in the form of comparisons between white-collar groups, the working class and farmers. If the reported age-standardised prevalences for illness are expressed in odds ratios, the differences between the white-collar groups and the working class varied between ca 1.4 to 1.7 in the four countries studied (Karisto et al. 1978, Karisto 1984).

Among the earlier contributions to studies on morbidity is a study conducted by Lundberg (1986) on class differences in overall morbidity in Sweden and Britain. Self-reported longstanding illness was available for both countries, and the Swedish data also included morbidity indices calculated from an inventory of diseases in which the respondents stated whether they had the particular conditions or not. For cross-country comparison Lundberg devised a social classification for the Swedish data that was comparable to that of the Registrar General. The data for both countries showed class inequalities corresponding to the hierarchical order of the classes of the Registrar General's classification. The odds ratios for the lowest unskilled worker class compared with the managerial/professional class were 2.67 for Britain and 1.59 for Sweden, respectively. The lower relative inequality in Sweden has been questioned in many later studies (e.g., Lahelma and Arber 1994, Cavelaars et al. 1998), and was probably due to comparability problems. The Swedish data showed larger inequalities in circulatory problems and pain and aches than in longstanding illness.

Several studies have since reported and compared social-class differences in self-reported overall morbidity in the Nordic countries and Britain (Lahelma and Arber 1994, Lahelma et al. 2001). Consistent class inequalities in limiting longstanding

illness and self-rated health have been observed. A Western European comparison was presented by Cavelaars et al. (1998), who studied morbidity differences by social class in Denmark, France, West Germany, Great Britain, the Netherlands, Sweden and Switzerland, drawing on national surveys on living conditions and welfare between 1986 and 1992. National occupational classifications were converted to the Erikson-Goldthorpe-Portocarero classification scheme as far as possible. Information on inequalities in self-rated health was available for all seven countries. Additional data were published on functional disability, chronic conditions and any longstanding health problems in the countries for which the data on the particular outcome were available. The class inequalities were fairly consistent for less than good self-rated health, although the total population prevalence of less than good self-rated health varied considerably between the countries. Odds ratios below the total population prevalence were found among both the higher and the lower managerial/professional classes. Among the manual worker classes the odds ratios were above total population prevalence, the unskilled-worker class displaying a higher odds ratio than the skilled-worker class in five of the seven countries. When inequalities were summarised as the odds ratio of all worker classes (including the foremen class V in the Erikson-Goldthorpe-Portocarero scheme) compared to both managerial/professional classes (i.e. classes I and II), the social-class differences in self-rated health ranged between 1.63 and 2.79 in the seven countries studied. The relative differences in functional disability, chronic conditions and any long-standing health problems tended to be comparable to those in self-rated health, although there were no observable differences between the skilled and unskilled manual classes, and any long-standing health problem indicated slightly lower relative inequalities.

The Nordic research project 'Social variations in health: Nordic comparisons and changes over time' focused on the social-class differences in morbidity from the mid-1980s until the mid-1990s (Lahelma et al. 2001, see also Lahelma et al. 1994). In the Finnish population sample the prevalences of less than good self-rated health according to the Finnish official classification ranged from 23% in the upper white-collar groups to around 42% in the worker class in both genders for the year 1994, the age-standardised odds ratio amounting to ca 2.6. The corresponding odds ratio for limiting longstanding illness was 2.8 (Manderbacka et al. 2001). Male farmers, however, seemed more likely to report poor self-rated health than the working-class men. Farms in Finland have remained relatively small and the farmer class may be in a less advantageous socioeconomic position than in some other European countries. The results from the other Nordic countries were of roughly similar magnitude in terms of the relative differences between the employed social classes (Lundberg et al. 2001, Lissau et al. 2001), although in the Norwegian sample no class inequalities

were found in limiting longstanding illness in women (Dahl and Elstad 2001). The relative morbidity level observed in the self-employed varied by country, which is likely, to some extent, reflect variation in what constitutes the self-employed class. Although all of the Nordic countries experienced an economic boom and a subsequent deep recession during the study period, the results mainly showed stabile class inequalities in health.

Socioeconomic inequalities in major disease groups

There numerous studies on socioeconomic inequalities in certain diseases and the major disease groups. Given the many socioeconomic indicators used, it may be hard to find studies on a particular disease or disease group that directly concern social-class differences. Furthermore, the extent to which the studies focus on mortality or morbidity varies according to the disease, the most lethal conditions obviously tending to be measured against mortality data. The aim in the following short and extremely selective review is to draft an overview of the known inequalities in diseases and disease groups that are causing the most concern over public health in Western countries. It should be noted that the diseases in question by no means cover the whole variety of diseases in any population, and thus do not 'sum up' the total burden of disease, or the social inequalities in disease.

A review of studies on coronary heart disease and socioeconomic position in terms of social class, education, income and home ownership conducted by Kaplan and Keil (1993) confirmed the association of a disadvantaged socioeconomic position with coronary heart disease: socioeconomic indicators were somewhat consistently found to be determinants of incidence, prognosis and survival. The excess risk among the socioeconomically disadvantaged seems to be partly but not completely caused by biological factors associated with so-called health behaviour, i.e. smoking, hypertension and a high body mass index, and possibly to some extent diabetes and high blood-cholesterol levels. The association between socioeconomic disadvantage and mortality from coronary heart disease, however, has not been invariable across time. Kaplan and Keil (1993), like González et al. (1998), concluded that evidence from the period 1930-1950 suggested no association between social class and mortality from coronary heart disease in men, while among women the association was also evident in early studies. It has been hypothesised that extensive tobacco smoking in men of all social classes in the 1950s may explain the similar rate in all classes.

According to Valkonen et al. (2000) the age-standardised death rate (per thousand person-years) from ischemic heart disease in Finland in 1991-1995 was 212 for the manual class and 116 for the non-manual classes in men, and 42 and 19 respectively in women, thus approximately double in the manual compared with the non-manual classes in both genders.

Kunst et al. (1998 a) studied stroke mortality in twelve Western countries between 1980 and 1989, and observed an excess stroke mortality in the manual classes compared with the non-manual classes in all of them. In the majority of the countries the relative inequalities in stroke mortality were larger than in mortality from ischemic heart disease. According to the data reported by Valkonen et al. (2000) the mortality ratio for cerebrovascular diseases (including stroke) in the manual compared with the non-manual classes in Finland in 1991-1995 was 1.7 in men and 1.5 in women (ratios calculated by the author). The differences in the absolute mortality rate were much lower than in ischemic heart disease, however, especially in men, because of the lower total mortality for cerebrovascular diseases.

The International Agency for Research on Cancer, a suborganisation of the World Health Organisation, published a circumstantial report on social class, other socioeconomic factors and cancer (Kogevinas et al. editors 1997). Faggiano et al. (1997) reviewed the evidence on socioeconomic differences in cancer incidence and mortality, while Kogevinas and Porta (1997) reviewed studies on social inequalities in cancer survival. Mortality from all cancers was higher in the disadvantaged groups in most populations, although the incidence of all cancers was less strongly and less consistently associated with socioeconomic disadvantage than mortality. Socioeconomic differences in incidence varied according to the type of cancer: a consistent excess risk was observed in the disadvantaged groups for some cancers, whereas for some other cancers the socioeconomically advantaged carried an excess risk. Cancer survival, however, was generally somewhat poorer in the disadvantaged socioeconomic groups in all studied cancers, especially for cancers with a good prognosis such as breast cancer. The difference may be partly due to differences in time of diagnosis, however: not only does it potentially have a real effect on prognosis, later diagnosis also artificially shortens the observed survival times (Kogevinas and Porta 1997).

The epidemiological transition, which denotes that the leading causes of death in the population have shifted from infectious diseases to cardiovascular and metabolic diseases and cancer, has reduced public-health interest in infectious diseases in Western countries, and as a consequence social inequalities in infectious diseases

have attracted very little research attention in recent times. Studies on social-class inequalities in childhood have reported class gradients in infectious diseases in children. The Black report, for example, shows a clear social-class trend in mortality from infectious and parasitic diseases in children of less than 15 years of age in 1970-72 (Townsend and Davidson, editors 1982/1983). Studies on adults in European populations are very scarce.

Studies on social-class inequalities in musculoskeletal disorders have been faced challenges on account of the variable definitions and measurements of disorders, and the difficulties of producing reliable measurements in large population surveys. The majority of studies on socioeconomic inequalities in musculoskeletal disorders have focused on disorders of the lower back. Dionne et al. (2001) reviewed a large number of studies on the relationship between formal education and back pain. They grouped the studies in three categories: those examining educational inequalities in the occurrence (incidence and prevalence) of back pain and the duration of back-pain episodes in the general population, those examining inequalities in outcome of back-pain episodes, and those examining inequalities in outcome of medical treatment. Low education was associated in most studies with a higher prevalence of back pain, although educational inequalities seemed to be stronger for duration and recurrence than for onset of back pain. There was also a consistent association between low education and less favourable functional outcomes of back-pain episodes, while the results for inequalities in the outcomes of medical treatment varied.

Hagen et al. (2005) studied social-class, educational and income inequalities in chronic musculoskeletal symptoms lasting over three months in a large Norwegian population sample. The study used the Erikson-Goldthorpe-Portocarero classification scheme, and the data were derived from repeated surveys, first in 1984-86, and later in 1995-1997. Marked class inequalities in chronic symptoms were found when other classes were compared to professional classes I and II. The differences between the intermediate and the lowest classes were small and statistically non-significant among the men, but larger and statistically significant among the women. Those who had changed social class, either upwards or downwards, and those not in employment also reported more chronic musculoskeletal symptoms than those with a stabile position in the professional classes.

There has been some recent research on socioeconomic inequalities in rheumatoid arthritis. Swedish and Danish studies have reported educational and social-class

inequalities with higher incidences in the socioeconomically disadvantaged, especially in seropositive rheumatoid arthritis (Bengtsson et al. 2005, Pedersen et al. 2006). A Norwegian study examined differences in disease activity and severity in patients with rheumatoid arthritis living in affluent and deprived areas. Area affluence was not correlated with clinical indicators of disease severity, but it was correlated with measures of functioning, those living in deprived areas reporting more functional limitation and disability (Brekke et al. 1999). Potential exposure that may link social class to the development of rheumatoid arthritis is still unclear, although smoking may contribute as it has been shown to predict incidence of rheumatoid arthritis (e.g., Heliövaara et al. 1993).

Work disability and social class

Class differences in the incidence of disability retirement have attracted some research attention, and these studies also potentially contribute to an understanding of social-class differences in musculoskeletal morbidity. In addition to providing information on class differences in functional disability, data on work disability caused by musculoskeletal disorders may indirectly enhance understanding of the contribution of physical work conditions and musculoskeletal disorder to these differences. Six such studies were available for review here, although a couple others are cited in the international literature, and undoubtedly many more national data sources exist. According to these studies, there are considerable class inequalities in the incidence of disability retirement, and particularly in the retirement due to musculoskeletal disorders.

A cohort of Finnish men classified as healthy at the age of 20 were followed up in a study on mortality and incidence of disability retirement conducted by Kaprio et al. (1996). The size of the cohort was 1 712 men, and the mean follow-up time was 46 years. The social classification used was a variant of the official Finnish classification published by Statistics Finland in 1972. (The classification has been considerably modified since then.) Mortality hazard ratios for the worker classes compared with clerical and professional classes ranged between approximately 1.6 to 2.4, and intermediate mortality rates were observed among farmers. The hazard ratios for all-cause disability for the worker classes (excluding clerical workers), compared with the executive class, were between 2.6 and 3.8. Hazard ratios for musculoskeletal disorders were markedly higher than for other causes, peaking at 9.8 for the unskilled-worker class compared with the executive class.

Gubéran and Usel (1998) analysed the incidence of disability retirement and mortality in a 20-year follow-up study of 5 137 men aged 45 at baseline living in Geneva, Switzerland, and grouped according to the Registrar General ś classification. Relative class differences in disability retirement were considerably higher than differences in mortality. The odds ratio for partly-skilled and unskilled classes compared with professional class I was 11.6. However, the difference between Registrar General's classes I and II was already almost four-fold, and thus the remaining inequalities between the other classes were not quite as extraordinary as the difference between the extreme classes suggests. Cause-specific incidences were also reported, and particularly high class differences were found in disability retirement on account of musculoskeletal diseases and neoplasms.

Månsson et al. (1998) studied a Swedish cohort of 5 798 middle-aged men aged 48 years at baseline, followed up for 11 years. Social class was determined according to the Nordic classification versions of 1974 and 1978. The relative risk for all-cause disability retirement was 3.0 for both blue-collar classes compared with high and intermediate white-collar classes together, and 1.8 for the lower white-collar class. The relative risks for retirement due to musculoskeletal disorder were 4.2 for the blue collar and 2.3 for the lower white-collar compared with the high and intermediate-level white-collar classes.

Hagen et al. (2000) carried out a register-based study of the incidence of disability retirement due to back disorders by occupational social class and formal education in Norway. The data included all employed men and women aged 20-53 years in the total population of Norway, followed-up for the incidence of disability retirement for 11 years from 1983 to 1993. Consistent inequalities by social class according to the Norwegian official classification were found. The odds ratios for disability retirement due to noninflammatory back disorder for the two worker classes were approximately 2.0 when compared to the higher professional class, and those for the lower professional and the two routine non-manual classes ranged from 1.3 to 1.6. Inequalities in disability due to inflammatory back disorder were less steep. The number of years of formal education also had a particularly strong effect on work disability due to back disorder: the beta coefficient for each year of education was -0.24, meaning an odds ratio of 3.3 for a five-year difference in formal education, for example.

Two other studies on social class and disability retirement have been published in international journals that were available for review, one from Norway (Krokstad et al. 2002) and one from Sweden (Upmark et al. 2001). Krokstad et al. followed-up a

sample of people living in one Norwegian county for 10 years, and found the social-class inequalities to be somewhat higher for men between the ages of 20 and 49 than for those aged 50 years and above. Upmark et al. followed-up a cohort of Swedish men aged 24-26 years at baseline for 18 years. The social classification used was a crude collapsed version of the official Swedish occupational social classification. The odds ratios for the skilled and unskilled manual worker classes were 2.0 and 2.9 respectively compared with all of the non-manual classes.

Class inequalities in functioning

Apart from studies on social class and disability retirement, class inequalities in functioning and disability in the working-age population have attracted little research attention. Although many more or less established inventories have been used to study the functional outcomes of medical care, the application of such measures to wider population samples has been mostly limited to the Short Form 36 health inventory, and even this measure has not been abundantly used in studies on class inequalities in ill health.

Hemingway et al. (1997) studied inequalities in functioning among the British civil servants of the Whitehall Study, reporting Short Form 36 subscale scores for functioning by employment grade. When a three-category hierarchical classification of the Whitehall employment grade was used, the odds ratio for poor functioning indicated by the lowest quartile on the physical functioning subscale of the Short Form 36 inventory was 2.2 for the lowest compared with the highest grade category in men, and 3.2 in women. There was also evidence of more functional limitation in the lower employment grades on seven of eight subscales (all except vitality) in men, and on four of eight subscales in women. The strongest sizes of the effect of employment grade on the subscale score were for physical functioning subscale. The findings also suggest that this effect was partly mediated through chronic disease and partly through other factors, potentially differences in physical fitness and in functional demands. Another publication on the Whitehall participants (Martikainen et al. 1999) also reported class inequalities in functioning decline over a follow-up period of two to four years. The odds ratio for a decline in the physical-component summary score above the highest quartile point of decline was 1.6 for the lowest of the three categories compared with the highest in men, and 1.3 in women.

Martikainen et al. (2004) compared occupational social-class inequalities in Short Form 36 functioning among the Whitehall employees, the Helsinki Health Study employees, and two Japanese employed cohorts. The differences between non-manual groups were somewhat smaller for poor functioning as indicated by the lowest quartile of the physical-component summary score in men in Helsinki than in men in London, the Japanese men falling in between. Furthermore, poor functioning was more common in the manual worker class than in the non-manual groups in Finland and Japan, although the London cohort did not include a manual worker class. The results among the women were similar to those for the men in Helsinki and London, but no consistent occupational-class differences were observed among the Japanese women.

Only one study on social class and the Nottingham Health Profile was available for review here: Hunt et al. (1985) studied functional limitation by means of a postal questionnaire survey conducted in England. They found inequalities, according to the British official classification, in limited functioning across several different areas of activity in men between 20 to 65 years of age, but no clear social-class differences in women.

Physical workload in the population

Knowledge about the prevalence of exposure to physical work involving considerable marked biomechanical loads and the distribution of exposure levels in the general employed population is very limited. Detailed studies on physical work exposure tend to focus on particular occupations or particular industries, and the samples are often small. One major reason for the lack of studies on exposure in the employed population may well be the difficulty of obtaining reliable measurements in large population samples. It is extremely difficult to obtain adequate and accurate descriptions of the duration, force, weight, and number and temporal sequence of repetition in questionnaire and interview surveys relying on self-reports, the responses most often being given outside of the work situation. The available survey data therefore describes physical work exposure on a much more general and approximate level. There are some large cross-sectional surveys on working conditions incorporating data on physical workload. Large-scale European surveys have been conducted since 1990, and the Finnish Institute of Occupational Health started to carry out regular cross-sectional surveys in Finland in 1997.

The European Foundation for the Improvement of Living and Working Conditions has carried out a European survey of work conditions every five years since 1990 (Paoli 1992 and 1997, Paoli and Merllié 2001, Parent-Thirion et al. 2006). The data is collected in face-to-face interviews with employed persons in randomly selected households in predefined areas. The total sample sizes have varied between approximately 15 000 and 30 000 respondents. There are slight differences in the reporting of the results between the published reports, and comparison of the results from the latest survey in 2005 with those of previous surveys is for this reason difficult. Furthermore, as the European Union has expanded new countries have been included in the survey, thus complicating interpretations of aggregate results.

The prevalence of reporting lifting or carrying heavy loads all the time or almost all the time in work in the European surveys varied between nine and 12 percent, and at least a quarter of the time between 31 and 37 percent. There seemed to be a slight increase in the reporting of heavy load handling across the years, but it is questionable whether it is warranted to interpret this as a real change in physical exposure. It is impossible to know for certain whether the increased reporting is related to actual increases in objective quantities of lifting frequency, load weight or time spent with upper body in a certain rotation degree, for example, especially when the self-report items are as vague as those used in the European surveys. Lifting 'all the time' can hardly mean that there is no instance in the working day when the respondent does not use muscle power to move an object upwards. The reported rate of working in tiring or painful positions almost all of the time was 18% in 1995 and 2000, and that for at least a quarter of the time varied between 45 and 47 percent in 1995-2005. Rates for repetitive hand or arm movements were reported only by Parent-Thirion et al. (2006), and up to 62% of the respondents reported making repetitive movements at least a quarter of the time. No information on the higher exposure category is available for repetitive movements.

The Finnish Institute of Occupational Health used somewhat more accurately formulated items concerning physical work conditions in the Työ ja terveys (Work and Health) telephone-interview surveys conducted four times between 1997 and 2006. The survey comprises independent cross-sections of the Finnish population, including non-employed people. The number of employed participants varied between 2 053 and 3 481 each time. The results have been published in two forms. Those concerning individual items are given in table reports (Piirainen et al. 1997, 2000 and 2003, Perkiö-Mäkelä et al. 2006), while combined data for work load items is regularly published in review of work conditions and health in Finland, which also

includes information from other data sources (Kauppinen et al, editors 2000, 2004 and 2007).

Approximately eight percent of the respondents, both men and women, in the 2003 and 2006 surveys reported being required to do manual lifting and to carry heavy loads several times during a working hour, and approximately 24% (including those in the preceding category) reported several daily instances. Of those who reported lifting and carrying, 23% reported handling loads weighing more than 25 kg. The use of muscle force to handle tools or move heavy objects (other than lifting) for at least one hour in the working day was reported by approximately 20% of the men and 10% of the women. There was a higher reported incidence of lifting and carrying in 1997 and 2000 than in 2003 and 2006, but this may have been attributable to changes in the interview items between 2000 and 2003. It is not possible to combine the data provided by Piirainen et al. (2003) and Perkiö-Mäkelä et al. (2006) on the frequency of exposure and the weight of loads handled. It is relevant that different ways to define the exposure magnitude, in this case by weight category in addition to the instances of exposure per time period (a working day), result in entirely different prevalences. Assuming that the frequency of exposure and the weight of the loads handled were not correlated, we would expect the proportion of respondents lifting weights of over 25 kg several times an hour to be of the magnitude of two percent. (This estimate may be conservative, as lifting frequency and load weight could be expected to be somewhat correlated positively). On the other hand, the prevalence of approximately 40% for any daily manual lifting and carrying gives an entirely different impression. The difference between the effects of these two levels of physical exposure is likely to be substantial as well.

Working posture was measured in the Työ ja terveys interview studies in terms of working in a slouched position or otherwise with the back bent, squatting or kneeling, working with the hands above shoulder level, and bending and rotating the neck. The respondents indicated the duration of exposure during a working day in rough categories. Exposure of at least an hour in the working day for each item individually varied between 11 and 24 percent. The proportion of respondents exposed to any difficult working posture for more than four hours a day, according to Takala and Virtanen (2004), was 16% in the 2003 data. Repetitive hand or arm movements were reported by between 25 and 30 percent of all respondents.

The Finnish surveys did not identify any notable gender differences in physical task requirements in terms of manual load lifting, repetitive movements, difficult postures including back bending, neck rotation, kneeling, squatting and sustaining

the arms above shoulder level, and overall perceived physical strain at work, with exception of the need to use force in handling tools, which was more prevalent among the men (Takala and Virtanen 2004, Piirainen et al. 2003, Perkiö-Mäkelä et al. 2006). European surveys (Parent-Thirion et al. 2006) indicated that carrying and moving heavy loads was more common among men than women. High frequency of difficult postures was similar for both genders, although moderate exposure may have been slightly more common in men. No gender difference was found with regard to the the average level of repetitive movements. However, when mechanical exposure was considered by gender and age group in the latest European survey, young men seemed to be exposed to the highest levels, and the exposure decreased with age among the men. No age trend was observed among the women. Physical environment conditions such as noise, extreme temperatures, smoke or dust in the air, and exposure to chemicals were more common for the men than the women in the European surveys. To the author's knowledge there, is only one longitudinal study examining changes in the physical workload of a follow-up cohort: Torgén and Kilbom (2000) observed a slight decrease in physical work demands among men, but no change among women.

Physical workload as a determinant of musculoskeletal disorders

Musculoskeletal disorders are common in all populations, and it is clear that specific adverse work conditions are not a necessary cause of all such morbidity. Nevertheless, detrimental work conditions might have strong effects on the development of such disorders in exposed groups. It is obvious that physical exertion may cause fatigue, discomfort and pain, and high sudden peak loads in particular can cause immediate injuries such as ligament and tendon ruptures. One could thus reasonably assume that long-term exposure may also cause permanent organic damage. Historical concern about such damages is documented in the writings of Bernardino Ramazzini (1713/1940, see also the extract published in a journal in 2001), for example. Modern scientific enquiry into the long-term effects of physical workload on musculoskeletal morbidity began in the 1970s (see Westgaard and Winkel 1996).

Ergonomic and biomechanical laboratory studies have examined the potential biological mechanisms of the effect of mechanical exposure on disorder and morbidity, and there is relatively diverse literature on the physiological, cellular and histological changes potentially caused by biomechanical load. As noted by

Westgaard and Winkel (1996), the studies have mainly concerned short-term responses, and potential long-term changes are more difficult to examine and demonstrate. An extensive report on the physiological and cellular mechanisms identified in laboratory studies was compiled by a working group set up by the U.S. authorities under the name The Panel on Musculoskeletal Disorders and the Workplace (Barondess et al. 2001). Armstrong et al. (1993) also described potential mechanisms leading to long-term changes in tissues (1993). Damage may be caused not only by the direct shearing and deformation of tissue as a result of compression or stretching, but also by insufficient blood flow due to compression and the accumulation of toxic metabolites. Repeated exposure may lead to permanent changes and degenerative processes. Armstrong et al. (1993) also cite some evidence indicating that microruptures, cell death, inflammation and fibrosis may occur in muscle, tendon and nerve tissues. Potential changes in joint structures are less effectively studied in laboratory settings, because narrowing of articular space and the destruction of cartilage in articular surfaces, for example, are permanent and accumulate over long periods of time.

The question of the potential effect on disorder and morbidity, however, is essentially an epidemiological one. There are two extensive reports, compiled in the U.S., reviewing the epidemiological evidence that mechanical exposure at work causes of musculoskeletal disorders of the neck, the upper extremity and the low back, the first by edited Bernard and colleagues (1997) and the second the above-mentioned Barondess et al. (2001). The former report evaluated the evidence in terms of magnitude of association, temporal relationship, and exposure-response dependence in an epidemiological setting, and to some extent considered consistency with regard to ergonomic and biomechanical laboratory studies. Barondess et al. covered the epidemiological evidence concerning mechanical exposure in slightly less detail, but equally considered so-called psychosocial factors, and covered the biomechanical literature more extensively. There are many earlier reviews on physical work exposures and musculoskeletal disorders, although often with more limited scope, including Armstrong et al. (1993), Winkel and Westgaard (1992) and Kuorinka and Forcier (editors, 1995). My main focus in the following is on the conclusions drawn by Bernard et al, but I also consider other studies of which I am aware if they add or change these conclusions.

According to Bernard et al, there was strong evidence that static loads, static contraction and extreme postures exerted considerable effects on disorders of the neck. There was also some evidence of the effect of repetitive and continuous hand or arm movements. As far as disorders of the shoulders were concerned, the evidence mainly pointed to the effect of work involving sustained or repeated

flexion or abduction of the arms over 60 degrees. However, recent studies by Hoozemans et al. (2002a and b) found support for an association between the exertion of force in pushing and pulling and shoulder disorder. Similar results were obtained by Harkness et al. (2003), whose study also suggested that lifting may contribute.

Carpal tunnel syndrome and epicondylitis of the elbow are widely believed to be caused by mechanical work exposure, although these disorders also occur in the absence of documented work exposure. According to Bernard et al, there was strong evidence that these conditions are caused by forceful repetitive hand movements and repetitive movements in which hand or wrist postures markedly deviate from the centre position. The evidence concerning postural exposure alone or repetition alone was less clear. These disorders are also recognised as occupational diseases in the legislation of many countries. However, as Walker-Bone and Cooper (2005) note, the strength of the observed association between mechanical exposure and carpal tunnel syndrome varies, and there has been controversy over the appropriate case definition for the syndrome. Bernard et al. also found strong evidence that highly repetitious and forceful hand exertion had an effect on hand and wrist tendinitis.

Bernard et al. found consistent evidence of an association between low-back disorder and lifting and forceful movements, the magnitude varying between odds ratios of two to 11 for exposed compared with unexposed groups. There was also consistent evidence of an effect of bending and twisting of the back on low-back disorders, although there were fairly few follow-up studies on low-back disorder and work exposure. Hoogendoorn et al. (1999) found a few more follow-up studies on back pain and load handling, four out of seven confirming statistically significant effects. Several later follow-up studies, including those conducted by Eriksen et al. (2004), Harkness et al. (2003) and Hartvigsen et al. (2001), have further reported effects of load handling on the development of low-back pain. Both Hoogendoorn et al. and Bernard et al. also concluded that there was evidence suggesting that whole-body vibration is a determinant of low-back disorder. It has been pointed out, however, that while whole-body vibration occurs mostly in vehicle driving, it may be difficult to separate the effect of vibration per se from other biomechanical factors characteristic of driving (see Heliövaara 1999 and Hoogendoorn et al. 1999). In general, interpreting the findings concerning the effect of physical exposure on back pain is particularly complex as these fairly common conditions often cannot be biomedically confirmed, and are not necessarily diseases in the strict biomedical sense. A similar organic condition is more likely to cause disability and suffering for those whose work is physically demanding than for those whose work does not

make particular demands on the capacity of the back to sustain loads. According to Heliövaara (1999), some studies have shown that load handling and difficult postures contribute to degeneration and herniation of the intervertebral discs. On the other hand, Videman and Battié (1999) concluded that pathological studies had so far failed to settle whether a history of occupational mechanical exposure affected degenerative changes in the spine, such as narrowed intervertebral disc space, the development of osteophytes and ruptured intervertebral discs. Nevertheless, a study conducted by Leino-Arjas et al. (2002) reported considerably high hospitalisation rates for lumbar intervertebral disc disorders in occupational groups characterised by physical demands at work.

The association between osteoarthritis of the knee and hip and physical work exposure has received some research attention. According to a review conducted by Maetzel et al. (1997) there was evidence of a strong relationship between work involving a lot of knee bending and osteoarthritis of the knee. Some studies also suggested an association between a high physical workload and osteoarthritis of the hip, but the evidence was weaker than for the knee. Some later studies have found an association between knee osteoarthritis and a history of a generally high physical work load and load lifting, in addition to kneeling and squatting (see Manninen et al. 2002 and Coggon et al. 2000).

Overall, research so far seems to demonstrate that physical work exposure is a major contributory cause of various musculoskeletal disorders. There are methodological weaknesses in the available evidence, as the majority of studies are based on retrospective or cross-sectional information. However, longitudinal research has confirmed the findings of case-control studies and cross-sectional surveys. The amount of epidemiological evidence of an association between physical work exposure and musculoskeletal morbidity is in my opinion vast. However, there is still debate concerning the exact causal interpretations in that definitions of musculoskeletal disorders tend to rely on reports of pain, and the fact that there is less evidence of biomedically verified tissue deformation in the low back and upper extremity is a point some authors tend to raise. Nevertheless, it seems slightly misleading reasoning to reject proposed causality against all other evidence if permanent tissue deformation cannot be demonstrated. Incapacity and pain can certainly be caused by biological processes not observed as such morphological changes. Furthermore, while it is reasonable to assume that higher demands made on the musculoskeletal system as such are likely to result in symptoms even if there are no persistent changes in tissues (and thus in some sense strict biomedical criteria for disease are not met), in my view this suggests that the causal effect might be temporary, and thus should vanish soon after the exposure is removed. To some

extent this might be the case, but clearly not all of the effect of mechanical exposure on musculoskeletal morbidity is only short-term.

Finally, it should be noted that all of the above evidence concerned the more or less gradual development of potential health effects over long-term exposure, and accidents resulting in immediate injuries were generally excluded. However, accident risks are also correlated with mechanical exposure in that manual material handling and the exertion of forces, for example, are characteristic of tasks involving particular accident risks as well.

Many occupations of less privileged class position, and especially those involving high physical demands, are dominated by one gender. Thus most of the studies examining physical work demands as determinants of disease and morbidity focus on one gender or the other. Whereas gender differences have sometimes been considered (see e.g. Maetzel et al. 1997), the results of the different studies are not very easily comparable. There have been few attempts to carry out systematic observation of gender differences in the contribution of the physical workload to morbidity, but some findings have been presented. The results have been inconsistent. Hooftman et al. (2004) concluded that the evidence was inconclusive for most types of exposure, although in some cases the effect of biomechanical load on musculoskeletal disorder was stronger among men than among women. However, it seems that there may have been a noteworthy methodological drawback in this review in that only relative risks and odds ratios in the exposed groups were considered, and no attention was given to absolute differences. Given that musculoskeletal disorders have often been observed to be more common in women, higher overall prevalence alone may result in lower risk estimates. Let us assume that women have higher morbidity than men in the absence of any work exposure. If both men and women are then exposed to similar work loads, the relative increase in morbidity in men is larger even if the effect of the exposure per se is the same for both genders.

Decision latitude as a determinant of ill health and related class inequalities

Karasek's model suggesting that high output demands at work combined with low decision latitude will result in an adverse internal state called strain, and further predispose to bad health, has been amply studied as a potential predictor of cardiovascular disease. Systematic reviews carried out by Belkic et al. (2004) and

Hemingway and Marmot (1999), and two other reviews by Schnall et al. (1994) and Marmot et al. (2006) were considered here. According to Schnall et al, Belkic et al. and Marmot et al, there is strong evidence that high output demands and low decision latitude have an effect on cardiovascular disease, although some studies not confirming the predictive value of the model have also been published. However, upon closer inspection it seems that the evidence may not be so convincing on whether in fact it is the combination of high demands and low decision latitude that is the most powerful predicting variable, or whether the independent main effects of high demands and low decision latitude when simultaneously accounted for are equally predictive.

It seems that the evidence of an effect of job decision latitude on cardiovascular disease is somewhat more consistent than the effect of high output demands, as was observed by Bosma et al. (1997), Hammar et al. (1998) and Alterman et al. (1994), for example, and as Hemingway and Marmot (1999) also concluded in their review. The biological mechanism mediating the association remains controversial to some extent, but elevated blood pressure and plasma fibrinogen levels, for example, have been suggested (see Kjeldsen 2006, Steptoe and Willemsen 2004, Steptoe et al. 2003 and Ishizaki et al. 2001). The question of biological mediation is complex, and demonstration of an association with a single biological quantity raises the further question of a complete physiological pathway. However, the demand-control model could be interpreted in the context of the general hormonal stress framework.

The origin of Karasek's model was in the research on the psychological well-being of employees, and there have been many studies examining the suggested association between work conditions and psychological outcomes. However, this body of literature is not reviewed here. Studies on job control and somatic disorders other than cardiovascular disease are fewer in number, but there have beem some on musculoskeletal disorders. Bernard et al. (1997) found a reported association between job decision latitude and overall musculoskeletal symptoms in some studies. In their case-control study investigating the effects of physical and psychosocial work conditions on care-seeking for low-back pain, Vingård et al. (2000) found that low skill discretion was associated with back pain particularly in men, although the findings concerning the association between decision authority and back pain were ambiguous. The data also indicated considerably elevated risks among those exposed to combined high physical workload, high psychosocial demands and low decision latitude, but from the data provided by Vingård et al. it is impossible to judge whether this was indeed due to a synergistic interaction rather than mere additive accumulation of exposure.

Devereux et al. (2002) found in their cross-sectional questionnaire survey that both physical exposure and psychosocial work conditions affected upper-limb disorders. However, the biomechanical load they measured included only lifting and whole-body vibration, and thus the psychosocial measurements may have been partly confounded by repetitive movements, for example. Furthermore, from the data provided it is impossible to distinguish the effect of decision latitude from the effects of output demands and low social support.

Leino-Arjas et al. (2004) studied patients who were hospitalised on account of lumbar intervertebral disc disorders, and the prediction of hospitalisation by occupational title. Occupations were linked to data on various work exposures and other factors provided in a job exposure matrix – in other words, they considered information on average occupational exposure from another data source. Employment in an occupation characterised by low decision latitude was associated with higher incidences of care for intervertebral disc disorder, following adjustment for physical exposure in the job matrix. The use of the occupational exposure matrix to measure decision latitude is, of course, somewhat problematic, given that decision latitude could vary to a significant extent between workplaces.

Contrary to many other studies, the results reported by Östergren et al. (2005) indicated a clearly synergistic effect of mechanical exposure and adverse psychosocial conditions on shoulder and neck pain in women: the risk associated with combined exposure to a high mechanical load and Karasekian high-strain work was considerably higher than the product of the main effects. By way of contrast, no effect of psychosocial conditions on shoulder and neck pain was found in men. Again, whether the effect in women was more related to demands or to decision latitude was not reported. Overall, it could be concluded that the relationship between job decision latitude and the incidence of musculoskeletal disorders is as yet unclear, although studies reporting such associations have been published.

Despite the extensive literature on the association between psychosocial work conditions, characterised in terms of output demands and decision latitude, and circulatory health outcomes in particular, studies on the contribution of decision latitude to social-class inequalities in health are not numerous. Indeed, the interest of most researchers has rather been in statistically eliminating the contribution of class position and other factors associated with it from their analyses. Bewildering as it may be, I have not been able to find any studies reporting on class inequalities in cardiovascular disease and the Karasekian work condition dimensions other than those published by the Whitehall research group, and even these do not give the

latest data from the research project. Marmot et al. (1997) found that decision latitude contributed to the social-category difference in coronary heart disease in male civil servants included in the Whitehall study. This contribution was larger than that of conventional biological risk factors such as smoking, blood cholesterol, hypertension and lack of exercise. The results for women were ambiguous, and did not indicate a contribution to diagnosed ischemia. Later results from the Whitehall study have indicated that the Karasek model predicted cardiovascular disease particularly in women, but the potential contribution to class differences in cardiovascular disease has not been reported (Kuper and Marmot 2003).

A couple of studies have examined the contribution of decision latitude to social-class differences in overall physical health. Schrijvers et al. (1998) focused on self-rated health among Dutch employed men and women in a large questionnaire survey utilising the social classification of the Erikson-Goldthorpe-Portocarero scheme. The contributions to social-class differences in poor self-rated health were considerable, among men in particular, the proportions explained varying between 12 to 52 percent for different classes compared with the higher-grade professional class in men. The contribution of decision latitude was partly overlapping with that of physical work exposure. This study is reviewed in detail below. Martikainen et al. (1999) studied inequalities in physical functioning among the Whitehall civil servants, and found that low decision latitude accounted for some of the social category difference in decline in physical functioning in men when the functioning measure was the Short Form 36 physical component score. However, when the conventional behaviour variables (substance abuse, diet and exercise), economic difficulties and problems with housing were included in the model, decision laitutde added little further explanation. Overall, there is as yet insufficient data on the potential contribution of job decision latitude to class inequalities in health.

Physical workload as an explanation for class inequalities in ill health

There has been little epidemiological research on the physical workload as a determinant of class inequalities: only three previous studies on class inequalities in health and physical work were available for review. One study on the combined contributions of psychosocial and physical work factors to class inequalities in health is also included. The following figures on proportions of class differences explained by adjustment for physical work conditions refer, unless otherwise indicated, to percent changes in the model estimates. When these were not reported,

or if the changes were calculated directly as proportions of odds ratios in the original publication, I have calculated the percent changes in the model estimates according to the data provided.

Lundberg (1991) concluded in his study on the Swedish population that physical work conditions were the primary cause of class inequalities in physical illness. Lundberg analysed interview sata on 6174 participants aged 15-75 years comprising a sample broadly representing the Swedish population: the data was mainly cross-sectional, but also included earlier interview material on the work conditions of the retired, for example. The aim was to test causal factors as explanations for class inequalities in health, the factors studied including economic resources in adulthood and childhood, physical work conditions, Karasekian psychosocial work conditions, the lack of social contacts, and smoking and alcohol consumption. Given the statistical data Lundberg could present the conclusion may be daring, but it is true that the demonstrated effect of physical work factors on class differences in ill health was much larger than that of the other measured factors.

Lundberg used a dichotomous illness outcome, which indicated the presence of any reported disease from a selection of serious diseases, or ample symptom reporting, or serious functional limitation as expressed by not being able to run 100 metres or climb stairs. According to this measure the prevalence physical illness was considerably high at 44%. Work requiring being able to lift 60 kg, or including monotonous movements or difficult postures indicated physically heavy work. Physical-environment hazards were measured separately in terms of daily contact with various ailments. The social-class measurement followed the Nordic Socioekonomisk Indelning classification scheme.

The application of variables in logistic regression and the method for assessing attenuation differed slightly from what is the convention today. However, from the data provided the odds ratio for physical illness for all the manual classes as well as the self-employed and farmer classes compared with the highest white-collar class, could be estimated at around 1.7. Lundberg calculated that physical work conditions explained 14% of the class inequalities in physical illness. The percent changes in the model estimates for the individual classes reveal an effect of about the same magnitude, a 17-19-percent decrease for the worker classes, 13% and 7% for the self-employed and farmers, and 19% and fice percent for lower and intermediate white-collar classes compared to the highest class. The effects of other causal mediating factors on class differences in physical illness were much smaller.

The fact that the age distribution in his sample was so wide may have affected Lundberg's results. Illness in people aged from 15 to 75 is very different, and it is debatable whether mere statistical adjustment for age group can fix this problem. There were other problems particular to this study: the health outcome was constructed from potentially too heterogeneous measurements, and there was a fairly high prevalence of this dichotomous outcome.

Schrijvers et al. (1998) found that hazardous physical conditions and low job decision latitude explained a considerable proportion of the social-class differences in self-rated health in the employed population, together accounting for approximately 30-76 percent of the difference between the other classes and the highest class in men, and 26-33 percent in women. The studied population was an employed subsample (7 028 participants) of a representative cross-sectional sample of the population of 18 Dutch municipalities, and the data was collected in 1991 by means of a postal questionnaire.

Schrijvers et al. used the Erikson-Goldthorpe-Portocarero classification scheme and found consistent inequalities with odds ratios for less than good self-rated health among the lowest class (unskilled manual workers) of 2.92 and 3.28 among the men and women, respectively, compared to the highest class (higher-grade professionals). The mediating variables included hazardous working conditions, the Karasekian dimensions of output demands and decision latitude, and social support. Hazardous working conditions were measured on six questionnaire items apparently mixing physical task demands and environmental factors, although Schrijvers et al. do not give a clear indication of how the items were formulated. The measure was operationalised in the analyses as a continuous variable indicating the number of hazards present, thus ranging from zero to six. In the light of the most common population-survey instruments, it seems unlikely that the items quantified the level of exposure precisely.

There was considerable attenuation in the odds ratios for less than good self-rated health among the men in the self-employed and manual classes following adjustment for physical hazards – of the order of a 30-50-percent reduction in the model estimates. The effect among the women was slightly more modest, the reductions in odds ratios for the self-employed and manual classes ranging between approximately 15 and 25 percent. Minor contributions were also found in the routine non-manual class for both genders, and in the lower grade professional class for women.

Borg and Kristensen (2000) examined both physical and psychosocial work conditions as explanations for class inequalities in the deterioration of self-rated health in a Danish cohort of employed persons aged 19-59 years at baseline. Theirs is the only longitudinal study on class inequalities in health and physical work conditions I have found. They estimated that both psychosocial and physical work conditions together accounted for more than half of the inequalities in worsened self-rated health after a follow-up of five years, although my interpretation is that the results rather suggest a contribution of approximately one third. They used eleven scales describing different work conditions, the highest contribution coming from the scale they referred to as ergonomic exposure.

Deterioration in health was assessed in terms of less than good self-rated health after the five-year follow-up among the respondents who rated their health as good or very good at baseline. Using a classification that was probably a version of the official Danish one, Borg and Kristensen found systematic class inequalities in worsened self-rated health: the two blue collar worker classes showed odds ratios of 2.82 and 3.39 for worsened self-rated health compared to the highest class of executives and academics, while those for the other white-collar classes were 1.33 and 2.10.

The contributions of work conditions and life-style factors were analysed by means of two types of models. First, the contributions of all work-condition scales together and of all life-style factors together were analysed in models for worsened self-rated health as a function of class as a categorical variable. Secondly, a single estimate for class inequalities was considered preferable for modeling the contribution of individual scales, and an interval class scale was devised in which the intervals corresponded to half of the proportion of people in the class added to the cumulative proportion of people in all the classes above it, thus resulting in a continuous variable with theoretical range from zero to one, the lower classes having higher values. The value for each class on this scale thus depended on the distribution of people in the classes. The association of this kind of scale with a health outcome expressed as an odds ratio has been termed the relative index of inequality. Borg and Kristensen found a relative index of inequality of 4.23 in worsened self-rated health. Whether this figure has a straightforward sensible interpretation I will not speculate on further here.

The interpretation of Borg and Kristensen's findings is complicated because they used numerous work-condition scales, and there is no description of the items used to construct them. Physical work conditions were measured on scales named

ergonomic exposure, chemical exposure, climatic exposure and physical exposure. The differences between ergonomic exposure and physical exposure, and between physical and climatic exposure are hardly self-evident, but it seems likely that physical-task exposure, i.e. exerting muscle power to move objects, maintain certain postures and perform repeated movements, are measured primarily on the ergonomic-exposure scale. The highest contributions to class inequalities measured in terms of the relative index of inequality were found for ergonomic exposure and repetitive work, 21-percent and 14-percent reductions in the model estimates (according to my calculations on the data presented). The repetitive-work scale may include short-cycle repetitions of movements as well as repetitiveness of other work tasks, and could also include physical as well as other work conditions. Contributions were also found, in order of decreasing magnitude, for skill discretion, climatic exposure, job insecurity, physical exposure, decision authority and chemical exposure. The total contribution of physical work conditions (excluding repetitive work) was approximately 30% on average for the categorical-class model, and approximately 40% for the interval class scale model.

A North American study carried out by Warren et al. (2004) reported considerable contributions of physical and psychosocial work characteristics to inequalities according to what they called occupational attainment in self-rated health and self-reports of musculoskeletal and cardiovascular morbidity. Unfortunately, the authors did not analyse the contributions of physical and psychosocial work characteristics separately, and the distinct effects cannot be inferred from the reported estimates. The participants in question were 4 422 men and women who graduated from Wisconsin high schools in 1957. The design of this particular study was cross-sectional, however, based on data from years 1992 and 1993, as relevant work-characteristic measurements were not available from earlier phases.

The interpretation and comparison of the findings of Warren et al. is slightly complicated by differences in methods and reporting from the European studies reviewed. They analysed gradients in self-rated health by means of ordered logistic regression, which assumes similar effects of independent variables on all dichotomisations of the dependent variable. Inequalities in musculoskeletal morbidity were analysed by means of linear regression. The musculoskeletal outcome was a scale constructed from a list of symptoms and medical conditions, and was assumed to be continuous. The study was not on class as such, as the occupational independent used was a continuous scale of 'occupational education', adhering to the occupational-attainment tradition. The analyses also included independent variables on education and income.

Warren et al. do not report reductions in model estimates between the modelling steps in cases in which the observed dependence in occupational standing fell below level of 95-percent statistical significance when the new variables were added. These, however, could be calculated from the reported estimates. When physical and psychosocial characteristics were added to a model that was previously adjusted for health-behaviour variables and family socioeconomic background in childhood, the reductions in the estimates for the effect of occupational standing on self-rated health were of the order of 60-70 percent for women and 30-40 percent for men when the percentages are calculated as proportion of the reduction from the estimates unadjusted for both work characteristics, and health behaviours and childhood socioeconomic background. Thus these results suggest that the proportion of occupational difference in self-rated health explained by work characteristics was more than half for men and somewhat below half for women. As far as musculoskeletal morbidity was concerned, the corresponding reductions in estimates for the effect of occupational standing following adjustment for work characteristics were approximately 60% for women and 40% for men of the unadjusted estimates. The contributions to the effect of occupational standing on cardiovascular morbidity were much smaller.

The statistical methods used by Warren et al. involve a number of assumptions that may not becompletely unproblematic. Assuming the effects of the determinants on any transition of two categories of self-rated health is not completely warranted when it is questionable whether all the transitions measure the same thing: the difference between bad and worse versus at least mediocre health may well measure different aspects of health than the distinction between less than excellent versus excellent, for example. The results of ordinal logistic regression may, in such a case, be devoid of sensible interpretation, and an ordinal logistic model may be more appropriate than linear regression merely from a formal statistical point of view. Moreover, the grounds for assuming that both the work-characteristics measurements and the musculoskeletal scale are truly scaled variables could also be called into question. It seems reasonable to assume that the above-mentioned deficiencies are likely to result in a loss of information and statistical power, and therefore the results of Warren et al. are more likely under- rather than overestimate the modelled associations. However, if the associations of both occupational position and work characteristics with health outcomes are underestimates, it is not possible to say whether this would result in under- or overestimation of the contribution of work characteristics as shown by attenuation in the model estimates for the effect of occupational position on health outcomes when work characteristics are added.

It could thus be concluded that all of the four reviewed studies suggest considerable contributions of physical work conditions to class inequalities in self-reported overall health status. According to Lundberg (1991), physical work exposure was the strongest candidate for a cause of class inequalities. Schrijvers et al. (1998) found the contributions of physical working conditions and job decision latitude to be of similar magnitude, and together accounted for approximately half of all of the observed class inequalities in self-rated health in men, and somewhat below half in women. For the lowest classes the contribution was even higher than the average. Borg and Kristensen (2000) found in their follow-up study that physical work conditions accounted for at least a third of class inequalities in the worsening of self-rated health. The results reported by Warren et al. (2004) suggested an even higher contribution for physical and psychosocial work conditions together than the results of Schrijvers et al. indicated. According to the studies conducted by Lundberg and Schrijvers et al. the contribution of physical work conditions was markedly higher among the manual classes than among the other classes. This could indicate that the difference in exposure to detrimental physical conditions between the manual classes and the privileged classes is steeper than the corresponding differences in other conditions that may mediate the effect of a manual-class position on health.

There are certain limitations that apply to all of the studies on physical work conditions and class inequalities in ill health reviewed abvove, and likewise to all studies based on similar survey methodology. The observed contributions to class differences may, at least theoretically, be attributable to unknown variables sharing common variance with physical exposure. All four studies nevertheless took into account the possible effects of the most widely studied psychosocial work conditions, i.e. those included in the Karasek model. Food behaviour, physical exercise and substance abuse are theoretically possible confounders, but recent studies have not found systematic associations between work conditions and such behaviours (Lallukka et al. 2004). In my view no other sensible confounding factors have been suggested. Apart from the work of Borg and Kristensen, the studies on the contribution of physical work exposure to class inequalities in health are cross-sectional. However, it seems unlikely that health-related selection into disadvantaged classes could cause an association between physical work exposure and health. Selection related to poor overall health status, and especially to poor physical functioning, into work involving high physical exposure is much less likely than selection out of such work, because decreased functioning will result in poorer performance and increased absenteeism. Thus it is unlikely that the contribution of physical work exposure to class inequalities in ill health is related to selection.

Limitations concerning the measurement of physical exposures constitute a major weakness in all of the studies, however. The crucial factor is not the reliance on self-reports as such, but the failure to provide respondents with accurate enough items and response scales expressed in objective terms to make it possible for them to give information that is reasonably reliable and valid as measurement of exposure that is essentially an objective quantity. There is also the danger with more subjective and vague item scales that respondent health will affect the rating of physical exposure, thereby exaggerating the causal dependence.

Chapter VII

The scope and objectives of the study

The main topic of this study is the potential contribution of work conditions to class inequalities in illness and incapacity. It also addresses the potential interaction effects of physical workload and other work conditions, age, and gender on illness.

Several questions related to these issues have been under-researched so far. Most notably, the contribution of physical work conditions to class inequalities in illness calls for more attention. Especially when many adverse conditions and inconvenient features of work are somewhat correlated, the lack of direct attention to physical conditions is a relevant concern, as the neglect of a potential contribution may bias the conclusions about the effects of other conditions. Given that physical workload is a determinant of increased musculoskeletal morbidity, it was also hypothesised that this association could mediate a major proportion of the contribution of physical workload to overall ill health and incapacity.

The original reasoning behind Karasek's theory was, in part, that if employees are given enough authority over their own work conditions, it may alleviate the detrimental effects of high demands. My interpretation of Karasek's model is that demands could denote any output demands, and thus fundamentally also reflect higher physical exposure levels. Thus, on the basis of the theory, it seems perfectly logical to assume that decision latitude will also alleviate the effects of high physical demands in work.

Although physical work conditions are strongly associated with class position, the classes are not completely differentiated in this respect. Many jobs undertaken by those in the most underprivileged classes are not particularly physically demanding, whereas some jobs of a better class position may involve some physical exposure. Although conditions related to control at work certainly vary within classes as well, it is also clear that there is a strong connection between decision authority and class position. Therefore, when the focus is on the combined effects of physical workload and conditions related to control at work, it would be relevant to consider social class position part of the study setting.

Certain issues related to age and gender are also considered in the study. Although there is a considerable body of literature on physical capacities in relation to ageing, there are few studies on whether the work conditions, in fact, remain the same

throughout working life. It is somewhat self-evident that functional problems at work will probably increase with increasing age. However, as some employees are granted disability pensions and some may change to less physically demanding tasks or work environments, it is not clear to what degree those who continue to do the same work suffer from age-related increase in marked incapacity. It has also been suggested that there are gender differences in the contributions of specific work conditions, as well as working life in general, to ill health and related social-class inequalities, and the gender differences in the distribution of many occupations already warrant some investigation in terms of potential differences in the contribution of work conditions to ill health.

The detailed objectives of the study could be defined as follows:

To examine the contribution of physical workload to social-class differences in overall ill health and incapacity, also taking into account the potential contributions of other work conditions including overall job demands and control at work (Substudies I and III).

To test to what extent the contribution of physical workload to social-class differences in overall ill health could be due to musculoskeletal morbidity related to physical workload (Substudy III).

To test whether job decision latitude modifies the association of physical workload with illness and incapacity, and whether the associations of physical work, and decision latitude and their interaction with ill health are similar for all social classes (Substudy IV).

To examine potential gender and age-group differences in the prevalence of physical demands and the interaction effects of physical workload, age and gender on ill health (Substudy II).

This study concerned social inequalities in ill health and their causes in the working population. Although groups outside employment should also be considered in the description and understanding of social inequalities in health and illness in society at large, the aim here was to enhance understanding of inequalities in ill health in the context of working life, an essential element in the life experience of the majority of the population.

Chapter VIII

The methods used in the study

This study is part of a research project on health and welfare among Finnish middle-aged employed men and women, called the Helsinki Health Study. The study population consists of men and women aged 40 to 60 years and employed by the City of Helsinki at baseline. The research project has many data sources, including postal questionnaires, health examinations and register data. Only baseline data from the years 2000, 2001 and 2002 was utilised in this study, and the setting was thus cross-sectional.

On the City of Helsinki

Helsinki is the capital of Finland, and has approximately 500 000 inhabitants in the municipality of Helsinki alone, and one million in the metropolitan area including neighbouring municipalities of Espoo, Vantaa and Kauniainen. The City of Helsinki is the second largest employer in the country, the largest being the state, with approximately 40 000 employees at the time of the baseline survey in 2000-2002. The variety of services covered by the organisation of the city is wide. The biggest employers are the health and social services, 51% of the total personnel employed work in these two departments (City of Helsinki, Kaupunginkanslia 2003). Other major services include education, cultural services, transport, public works, city planning, housing production, emergency services and various administrative bodies. Several departments also employ their own kitchen and cleaning personnel. At the time of the baseline survey bus traffic was part of Helsinki City Transport, but in 2005 it was transferred to a publicly owned business company. Another major organisational change occurred just before the baseline survey in 2000, when special health care services were transferred to the Hospital District of Helsinki and Uusimaa run by the Federation of Municipalities of Uusimaa. At the time of the study the health care services of the city thus consisted of primary health care in Helsinki, although some psychiatric services were also retained in the organisational scope of the city. Public utilities owned by the city include the Helsinki Energy Company, although its personnel were not included in the study.

Mail questionnaires

The study population comprised employees of the City of Helsinki aged 40, 45, 50, 55 or 60 years in 2000, 2001 and 2002. The inclusion criteria in the questionnaire studies also included being in employment with a monthly salary and total income of at least 4000 euro from the City in the previous year. Trainees and those employed on account of short-term government employment subsidies were excluded.

Baseline postal questionnaires were sent by the researchers to eligible employees in 2000, 2001 and 2002. They were sent first to the work address and then to the home address if the letter was returned because the recipient had not been reached. The total number of employees to whom the questionnaire was sent was 13 678. Employees who were retired or dead at the time of the postal questionnaire according to register data updated at the end of the survey year were further deleted from the study population, and thus the final number of eligible employees was 13 344. Of these, 8970 responded, thus resulting in an overall response rate of 67%.

There have been several studies on non-response to the baseline questionnaires of the Helsinki Health Study (Lallukka et al. 2002, Martikainen et al. 2007, Laaksonen et al. 2008). It was possible to retrieve data on sociodemographic factors and sickness absence concerning both respondents and non-respondents from the personnel register of the City. On the whole, sociodemographic factors did affect response activity to some degree, but the resulting bias in the group prevalences of ill health were probably small. Age had some effect on response activity among the men, being higher among the older ones. There were some social-class differences in response activity in both genders, those in the routine work and manual classes having slightly lower crude participation rates than those in the professional and managerial, and the semiprofessional classes. Following adjustment for age, temporary employment and income from the City, only the manual class differed from the other classes in both genders. The difference was larger among the men than among the women, the risk ratios for response in the manual class being 0.76 and 0.93, respectively.

None of the sociodemographic factors were found to have interaction effects with sickness absence in relation to questionnaire-response activity, however. Sickness absence was independently associated with questionnaire non-response among the women, but the association was not clear among the men. However, sickness-

absence rates and class inequalities in sickness absence were found to be similar in the responders and non-responders of both genders.

Health examinations

Data on the study population were also collected from age-group based health examinations under the City's occupational health-care system. The occupational health-care services invite employees reaching the ages of 40, 45, 50, 55 and 60 to a routine health examination. These age-group based health examinations are part of the routine operations of the occupational health-care services, and the practice was not established for the purposes of the study – although some modifications to the protocol were made in order to make the data more suitable for research purposes. The examinations were carried out by qualified occupational-health nurses. Although the target population is, for the most part, the same as for the questionnaire surveys, there are some differences. A group of employees engaged in hourly wage based employment with no regular monthly salary, who were outside the target population for the questionnaire were included in the health examinations. These employees were mainly outdoor workers employed by the Public Works Department. However, only those whose principal employer was the City were invited to the health examinations. Firemen were excluded from these regular check-ups because they covered by a specific statutory health examination practice, whereas all bus drivers were obliged to participate the age-group based examinations. Finally, some employees who had had very recent experience of the occupational health care were not invited, although the overall number of such exclusions was small. The personal identification information of all those invited to the health examinations were not made available, and thus it was impossible to identify all invited individuals.

The data collected during the health examinations included anthropometric measurements, laboratory tests and self-reported information on work conditions, functioning and health. Self-reported data were collected by means of a questionnaire form, which was filled in by the participants and checked through with the occupational health nurse during the examination. This health examination questionnaire was designed by occupational-health-care professionals to provide information predominantly for the purposes of client work. Furthermore, height, weight, waist and hip circumference and blood pressure were measured, and a series

of laboratory tests taken. The anthropometric and laboratory measurements were not used in this study.

During the years 2000, 2001 and 2002 a total of 13 923 employees were invited to attend the age-group based health examinations, and a total of 8458 attended. However, the use of the health-examination data in the study was not tied to attendance and was rather based on informed consent to allow use of the data for research purposes. Of those attending the health examination, 5943 also gave their consent for the data to be used for research purposes. Thus, as far as the health examination data was concerned, the final participation rate amounted to 43% of those invited. Non-response in terms of not attending the health examination amounted to 39% of the target population, whereas non-participation in the study alone amounted to 18%: non-response thus reflected the coverage of the health examination procedure more than non-participation specific to the study.

There have also been studies on non-response to the health examination (Laaksonen et al. 2008). The sociodemographic differences in participation were largely similar to those found for the baseline questionnaire response, although there was no similar association between sickness absence and participation. Older men were somewhat more likely to participate than their younger counterparts, and those in the routine work and the manual classes had somewhat lower participation rates than the professional and managerial and the semiprofessional classes, although adjustment for income from the city and temporary employment abolished the association between social class and participation among the women. Participation was particularly low among those who had very low income from the city. Sickness absence of between four and 14 days during the study year increased participation in the health examination, whereas there was no difference in the crude participation prevalence between those with no sickness absence and sickness absence of above 14 days.

Personnel registers and combined data

The complete personnel registers of the city, including information on salaries and wages, employment-contract type, job title, workplace, termination of and interruptions in employment including sick-leave, and other related information, were available to the researchers. However, it was possible to use this together with the data from the questionnaires and health examinations only with regard to the

participants who gave their written consent to their data being complemented with register sources: consent was given by 73% of the questionnaire respondents and 93% of the health-examination respondents.

The third substudy and some further analyses reported here used a combination of data from the postal questionnaire and the self-reported data from the health examinations. There was further loss of data in this sample, partly because the non-responses in each case were not congruent, and partly because the examination data also included respondents who did not belong to the questionnaire target group. The number of respondents in the combined data set was 3815.

Separate non-response, or rather non-coverage analyses were performed for the combined data set, although the detailed data have not been published. The association between sociodemographic characteristics and data availability were otherwise largely similar to non-response in the simple data sets except for an interaction effect of social class and sickness absence. Sickness-absence spells of longer than three days increased the data availability in the combined data set more in the professional and semiprofessional classes than in the routine-work and manual classes. Thus there was a slight over-representation of professional and semiprofessional class participants with sickness absence in the combined data set.

Social classification

The social classification used in the study was based entirely on occupation title. The data on occupation were derived from the personnel registers, or from the questionnaire responses when the register data could not be used due to a lack of consent to its linkage.

The classification scheme was developed from two previous classifications. The allocation of occupations into classes was based mainly on the scheme used by the City of Helsinki in the personnel registers, which in turn was based on the qualifications required for the job, the supervisory status, and the position of the job in the organisational hierarchy. The classification of employees in the personnel register was not entirely dependent on their occupational title, and varied somewhat between people with same job title. The data were not systematic, however, and there was a lot missing, and so the classification used in the study was adapted from

the personnel registers, each job title being allocated to only one class on the basis of the most common original classification in the register.

The classes used in the study were formed as follows: the professional and managerial class included all occupations that, according to the personnel registers, required university-level qualifications or were classified as managerial positions with subordinates and involving predominantly managerial or supervisory tasks; the semiprofessional class included occupations that required college-level qualifications or were classified as jobs that included both supervisory responsibilities and routine tasks; the routine-work and the manual-work classes included occupations that required vocational training or no specific qualifications, and had no supervisory status.

The distinction between the routine-work and the manual-work classes was based on the social classification of Statistics Finland (Tilastokeskus 1989). No explicit conceptual criteria have been presented for this classification, but in practice the allocation of occupations to the manual class corresponds to the conventions followed by most similar classifications in official as well as research use. A significant feature of the scheme, however, is that all nursing staff as well as childcare, home and personal assistance, and other social welfare personnel are placed in the non-manual classes, whereas some of the occupations in these groups are allocated to the manual classes in the Nordic classification scheme, for example. In this study practical nurses, for example, were placed in the routine-work class and not in the manual class as is the case in the Nordic classification.

Measures of ill health and functioning

The ill-health and functioning measures included single-item self-rated health, a series of items on self-reported musculoskeletal morbidity, the Short Form 36 health inventory and the work-ability index inventory.

Answers to the question How good would you generally say your health is ’from the postal questionnaire data were used to measure self-rated health, the response categories being excellent, very good, good, mediocre and bad. Ratings below good were examined further: the variable was applied as a dichotomy in the analyses. Dichotomous operationalisation was chosen because it represented conceptual clarity in limiting the focus to ill health. It can be fairly safely assumed that

respondents rating their health as mediocre or poor as opposed to good or better are experiencing illness, and that their experience of illness is likely to be more consistent, persistent or severe than the experience of illness of those who rate their health as good, very good or excellent. Furthermore, it was not considered worth addressing the question of whether the distinction between mediocre versus good self-rated health was equivalent to the distinction between good and very good ratings.

Musculoskeletal disorders were measured in terms of self-reported musculoskeletal problems identified in the health examination. There were six items on musculoskeletal disorders in the health examination survey: disorders of the neck and upper back, disorders of the low back, sciatica syndrome, disorders of the limbs, rheumatoid arthritis, and other musculoskeletal disorders. The participants were asked to state whether they were currently experiencing any of these disorders, and whether it had been diagnosed by a physician. The analyses focused mainly on any physician diagnosed disorder. The variable was applied as dichotomous variable signifying any musculoskeletal disorder reported as having been diagnosed by a physician. As the distribution of the number of items indicating disorders was heavily concentrated on zero, continuous application of the variable was out of the question. The cut-off point of any versus no items was chosen mainly because the distinction between those with and without a disorder for which they had sought care was conceptually fairly unproblematic, i.e. it is clear that the former group is more ill with respect to musculoskeletal morbidity than the latter group. A cut-off point of two items might have been chosen on purely numerical grounds, but this distinction is conceptually rather problematic in that it is not clear that those who report several disorders are more severely ill than those who report one only. However, some supplementary analyses were carried out for an optional variable signifying disorder in at least two items of the six areas.

Overall functioning was measured on the Short Form 36 health inventory, which was originally developed for the Medical Outcomes Study in the United States. The aim was to find a measure that was suitable for collecting data on the patient's view of the outcomes of medical care. The conceptual basis of the measure is the notion that the interest of the patient regarding care is in "obtaining effective life and to preserve functioning and well-being" (Ware and Sherbourne 1992). The inventory contains 36 items representing eight different concepts: physical functioning, role limitations due to physical health problems, social functioning, bodily pain, general mental health, role limitations due to emotional problems, vitality and general health perceptions. All the items refer to activities and experiences during the previous four weeks. According to Ware and Sherbourne (1992), concepts of physical

functioning (i.e. performance in simple physical tasks such as carrying bags and walking up and down stairs), role and social functioning, general mental health and health perceptions were chosen because they featured in the literature as dimensions that researchers tended to consider important, whereas vitality and bodily pain were chosen because there was evidence that patients considered these dimensions important. Items representing one of the eight health concepts can be summed by simply adding the scores of the individual items, thus yielding eight scales each comprising a distinct set, the number of items included in a scale varying from two to ten.

Researchers examining the validity of the eight scale constructs have used factor analysis to demonstrate how the scales represent the hypothesised dimensions of physical health and mental health. The results have been found to correspond roughly to how the scales differentiate between groups of clinical somatic disease and clinical mental disorder as opposed to healthy groups (McHorney, Ware and Raczek 1993). A further scoring schema was developed in studies using data from the general population in the U.S. in order to calculate scores representing the physical factor and the mental factor. The eight scales were standardised to a mean of zero and a standard deviation of one, and a rotated factor pattern was used to extract the factor loads for each scale. The summary scores are calculated by adding the standardised scale scores multiplied by the factor loads. For convenience the resulting score is standardised to a mean of 50 and a standard deviation of 20. The two summary scores are called the physical-component summary and the mental-component summary.

It has become customary to use the same 'norm' factor-load coefficients for calculating the summary scores in all studies, although it might be more sensible to calculate new factor loading patterns, representing the normal or general population from which the participants of a given study are a sample, or of which they represent any other kind of limited subgroup. For reasons of convenience, however, this has not become the practice. It is assumed that the relationship of the original items to the two hypothesised underlying factors is similar enough for any studied population so as not to result in a significant degree of non-validity because the estimated factor-loading patterns could have been slightly different for a different population. The advantage of using the norm coefficients is the better comparability across studies when the calculation schema is preserved.

Two outcomes from the Short Form 36 inventory were used in this study. The physical-component summary was used in Substudy IV and in some supplementary

analyses related to Substudy III. Although this score could be regarded as a continuous variable, and it does satisfy the statistical criteria of normalcy, the assumption that the association between the studied determinants and change in the summary score are similar across the whole physical-component range was considered problematic. The studied population was relatively healthy, and the differences in scores near to and above the average are not necessarily similarly related to the determinants as differences between very low and high scores. It should be kept in mind that the measure is a construct, and does not represent an entity on which actual continuous measurements can be made. The interest in this study is on the distinction between poor functioning and normal functioning. Therefore the physical-component summary was applied as a dichotomy signifying the lowest quartile of the summary score. The same cut-off score was used for both genders and all age groups. An additional advantage of the dichotomous application of the variable is the relatively easy interpretation of estimates for the associations. The lowest quartile point for the physical-component summary in this study was 45.1, while the median was 51.3. The corresponding scores in the U.S. general population for men and women between the ages of 45 and 54 were reported by Ware and Kosinski (1994/2001) to be 45.7 for the lowest quartile and 52.6 for the median.

The scale measuring role limitations due to physical health problems was used separately in Substudy II. A purely functional approach was desired, and the latent-factor philosophy related to component summaries was rejected in this substudy. This scale comprises four items indicating limitations caused by physical health problems: whether the respondent has had to limit the time used for work, has achieved less than would have been desired, has had to limit certain activities, and has had difficulties in completing tasks during the previous four weeks. The respondent is asked to consider activities both in their paid work and at home. The majority did not report any limitation. The analyses focused on those reporting at least some limitation as opposed to those reporting none. Supplementary analyses distinguishing the reported limitations indicated on several items were conducted.

Another measure for functioning used in Substudy I was the work-ability index, which was developed at the Finnish Institute of Occupational Health by Tuomi, Ilmarinen and associates. The inventory was compiled for a study of ageing public-sector employees using data from the year 1981. It was originally used to assess the work ability of employees in different occupations with the objective of developing pension policies applicable to occupations with varying functional demands (see Ilmarinen (ed.) 1985 and Tuomi (ed.) 1997). The inventory comprises seven scoring elements, including self-assessed current work ability compared to the lifetime best

(one item), self-assessed work ability in relation to the physical and mental demands of the job (two items), the number of days on sick leave during the previous year (one item), the number of diseases or disorders confirmed by a physician (a list of 34 items), impairment due to diseases (one item), the respondent's own prognosis of work ability two years onward (one item), and mental resources (three items). The choice of items was based on factor loadings from a rotated factor pattern. A calculation schema that was different from shear weighing by factor loading was defined, however. This could have been partly because the work-ability index has also been applied as a tool of everyday patient work in the occupational health services, and for that reason the schema needed to be simple enough not to require machine calculation.

Tuomi et al. also introduced cut-off scores for categorising the work-ability index and for giving interpretation to the score values. The category cut-off scores were originally chosen purely on the basis of the distribution of the index score. Later studies, however, confirmed a low value of the index below the score of 27 to predict disability retirement (Tuomi et al. 1997). Studies carried out after the year 2000, including this one, have reported a marked upwards shift in the index score from that observed by Tuomi, Ilmarinen and associates between 1981 and 1991, the mean value having been higher in later studies conducted by Järvisalo et al. (1997, in Finnish), for example. In this study there were very few respondents with index scores below the cut-off point for poor work ability as proposed by Tuomi et al, and a higher cut-off score was used. The sheer numerical requirements of quantitative study necessitate a certain minimum number of people in the group examined, and it is likely that selecting the same proportion of participants at the low end of the range of scores will still distinguish a group with a higher probability of disability retirement in a similar way as with the earlier categorisation in the older cohorts (i.e. earlier studies).

Measures of physical work conditions

Physical workload was measured separately in the postal questionnaire and in the health examination, and there were some differences between the items used in the two data sources. The baseline postal questionnaire included an inventory of 18 items concerning physical work conditions. The respondents were asked to state whether each of the 18 types of exposure was present in their work and whether it was causing them trouble. The items could be divided into three groups. Physically

Table 1. The number of physically demanding job tasks[1] reported in the questionnaire data.

Number of demands	Women %	Men %
None	10	21
1 item	11	14
2 items	13	14
3 items	23	27
All 4 items	43	24

[1] The demands included difficult working postures, twisting of the back, repetitive movements, strenuous muscular work or lifting and carrying. The data was limited to respondents who provided data in both the questionnaire and the health examination.

demanding tasks, in other words mechanical load, was measured on six items including difficult working postures, twisting of the back, repetitive movements, strenuous muscular work or lifting and carrying, standing, and walking. There were three items reflecting computer-terminal work, including sitting, working at a video display terminal, and using a computer mouse, and nine items on the physical environment, including exposure to noise, vibration, insufficient lighting, detergents and other chemicals, uncomfortable temperatures, dry air, dust and dirt, dampness and mould-damaged premises. The above grouping was confirmed by factor loadings on the rotated factor pattern in the studied data.

The health-examination form included a four-item inventory on physically demanding tasks. The respondents were asked to state how often the four types of exposure recurred in their work. The items were strenuous muscular work, repetitive movements, difficult working postures, and carrying and lifting, and the subjective response categories were never, seldom, moderately, often and very often. Furthermore, there was an eight-item inventory on the physical environment, including exposure to noise, vibration, cold, high temperatures, bad lighting, chemicals, and fibre and other dust, the response categories representing the subjective amount of exposure in terms of none, considerably and a lot.

Several different applications were used for variables representing the load due to physically demanding tasks. The data from the baseline postal questionnaire were problematic in that the inclusion of trouble caused by the exposure on the response

Table 2. The number of physical task demands [1] reported as recurring often or very often in the health-examination data.

Number of demands	Women %	Men %
None	42	57
1 item	21	24
2 items	16	14
3 items	13	3
All 4 items	9	1

[1] The demands included lifting and/or carrying heavy loads, strenuous muscular work, repetitive movements and difficult working postures. The data was limited to respondents who provided data in both the questionnaire and the health examination.

dimension is likely to have made the response partly dependent on functioning. In a cross-sectional setting, in which the time order of the exposure and poor health and functioning outcomes cannot be established, poor health may cause the reporting of trouble with physical exposure. Therefore only information concerning whether the exposure was reported to be present at all or not was used from the questionnaire data. The solution resulted in considerably diminished variation, however, as reports of exposure were quite common. The distribution of the reported number of physical tasks out of four items (excluding standing and walking) is presented in Table 1. Because of the high prevalence of reported exposure, the physical-workload data from the questionnaire were used as a single dichotomous variable indicating the presence of six out of six or four out four task items, the latter option excluding standing and walking.

The data on physical tasks from the health examinations lacked the problematic inclusion of the functional dimension in the response categories. However, the amount of exposure measured by the response categories was interpretational, and not truly quantitative (in terms of time, number of repetitions and weights). For this reason the items were not regarded as truly continuous measurements, and the data from each one were reduced to a dichotomy indicating exposure recurring often or very often. The number of items out of the four indicating such recurring exposure is presented in Table 2. The data on physical workload from the health examinations were represented in the analysis either by a continuous variable for the number of

frequent demands out of four, or by four separate dichotomous variables for each demand item. The use of a continuous variable was considered more sensible than with the questionnaire data because there was no strong ceiling effect for the measure.

Adjustments for physical-environment exposure were also made in Substudy III and in some of the figures presented in this publication. Exposure was used as a continuous variable representing the number of environment factors reported to be present according to the questionnaire data.

Other measures

The contributions of other work conditions to ill health and functioning ,as well as to class inequalities in ill health and poor functioning, were also considered. The work conditions examined included job output demands and decision latitude, as in the Karasek model, from the questionnaire data (Substudies III and IV), and psychosocial stressors, social relations at work and control over work environment and rewards from the health-examination data.

Job Content Questionnaire inventories were used to measure job demands and decision latitude (see Karasek et al. 1998). The items are statements about work conditions with five response categories from fully agree to fully disagree. The five-item version was used for job demands, whereas job decision latitude was comprised nine items. The five-item so-called Framingham version of job demands includes the following items: required to work fast, required to work hard, an excessive amount of work, having enough time to get the work done, and conflicting demands. Items measuring skill discretion include the requirement to learn new things, the use of creativity, a high level of skill required, variety of tasks and repetitive work, whereas those measuring decision authority include making decisions of one's own, deciding how the work is done, and having a say about the work in general. Weighting according to the calculation schema presented by Karasek (1985/1993) was used, skill discretion and decision authority having the same weight in the total score for decision latitude.

Substudy I utilised other inventories of psychosocial stressors and control over work environment derived from the health-examination data. These inventories were more heterogeneous in their contents than the Job Content Questionnaire

inventories for the Karasek dimensions. The items were not used to construct sum variables, however, but were used as individual variables in the regression models. Psychosocial stressors included excess responsibility, time pressure, inconsistent tasks, monotonous and uninteresting work, fear of failure and isolation. The nine-item inventory on the possibilities for control and experience of rewards also included experience of rewards and the perception of meaning related to work, in addition to items similar to decision latitude. A three-item measure of difficulties in social interaction with superiors was also used in Substudy I.

Statistical methods

The main statistical method used in this study was logistic regression modelling. Group prevalences, means and their confidence intervals were used where applicable. Statistical significance was generally taken to be verified if the probability of null hypothesis remaining in effect was below five percent. The SAS software package was used for the calculations, the version available at different times ranging from the sixth to the ninth. Regression models were fitted using the genmod and logistic procedures.

Logistic regression analysis is an adaptation of ordinary linear regression analysis for binomial outcomes. It is not the value of the dependent variable, but the odds of the dependent variable falling into a category of interest rather than another category that is modelled. In logical terms, this could be expressed as modelling the odds for y=1, when y can have only the values of one or zero, corresponding to the category of interest or any other category. The logistic model is constructed as a linear regression model for the logarithm of the odds of interest, in which the error term is presumed to be binomially distributed. It is, however, more common to express the mathematical form of logistic model in terms of probability rather than odds of the dependent falling in the category of interest. The link function that transforms the logarithm of odds into probability is called the logit function.

Logistic regression model can be expressed in the form of the following equation:

$$\text{logit}(p) = \log\frac{p}{1-p} = \alpha + \beta_1 x_1 + \text{K} + \beta_i x_i + \varepsilon \ ,$$

where p is the probability of the dependent variable falling in a category of interest. Note that the expression p/(1-p) is the odds corresponding to probability p. Other elements of the equation are the intercept term α, the independent variable x, and the modelling coefficient β for the effect of x on the modelled probability. The subscript i denotes the i'th independent variable in a model in which there are many independents. The error term, i.e. the difference between the predicted value and the observed value is represented by ε. Assessment of the model fit is based on the assumption that when the probability is above 0.5 (odds above 1), the observed value of the dependent variable should fall in the modelled category of interest. In this study the maximum-likelihood method was used to estimate the β coefficients that provide the best possible fit, i.e. the highest correspondence between the values predicted by the model and those observed.

The strengths of logistic regression for a binomial outcome when compared to ordinary linear regression include the avoidance of certain difficult requirements and assumptions. Using a dichotomous outcome avoids assumptions of continuity or normal distribution in the outcome variable. Furthermore, when the modelled dependent is dichotomous and all the independent variables are categorical, no assumptions concerning the form of the association need to be made. However, if the dependent variable was reduced to a binomial variable from an original measurement with more categories, logistic regression loses all information concerning the differences between the categories that were collapsed. However, if regression assuming linear association is used when the true association is not linear, information is lost as well.

Recently there has been some discussion in the literature on the feasibility of log binomial modelling in preference to logistic models when the modelled outcome is not rare. Proponents of log binomial model are concerned about the misinterpretation of odds ratios as relative risks: with common outcomes odds ratios are generally somewhat higher than the relative risks. The issue, however, is one of interpreting the results, not of the validity of the modelling. Advocates of the log-binomial approach claim that relative risk is easier to understand correctly than the odds ratio, but in my experience differences expressed as probability ratios also seem to be difficult to understand for many people. The correct interpretation of a

relative difference can never be captured without any knowledge of the absolute level of the quantified phenomenon, and with regard to absolute differences, probability ratios may be even more misleading than odds ratios. The value of risks and relative risks is essentially dependent on the choice of which category of the binomial dependent is modelled. A risk ratio for being ill as a function of an exposure is entirely different from the risk ratio for not being ill as a function of not having the exposure. The odds ratio is the same for both.

Elaboration of effect

An approach to studying the potential mediation of the effect of a distal determinant through a more proximal determinant, called 'elaboration of effect' by Valkonen and Martelin (1988), was used in the study. It is essentially a way of interpreting the results from a series of nested regression models, and has been fairly common in social epidemiology.

A base model is fitted to an outcome as a function of a determinant that is the main focus of interest. Subsequent models are fitted, with additional covariates in the model representing other determinants. Differences are observed in the estimates of the association between the main determinant and the outcome between models with and without covariates representing other determinants. If the addition of a new covariate attenuates the association of the main determinant with the outcome, the association observed in the base model can be partly or completely explained by the common variance of the main determinant with the added determinant. Depending on the assumed causal order of the determinants, there are two options for further interpretation: 1. the added determinant mediates part or all of the effect of the main determinant on the outcome; 2. the main determinant does not have a causal effect on the outcome, or the causal effect is weaker than observed in the base model.

The choice between the two interpretations is essentially based on assumptions concerning whether the main determinant could be considered the cause of the added determinant. The first interpretation assumes that it causes the added determinant, at least to some extent, which consequently causes the outcome. If no causal connection between the main determinant and the added determinant is assumed, the second interpretation is chosen, which could sometimes also be referred to as confounding. The choice of interpretation between the two

alternatives has to be based on prior knowledge or assumptions. It will often depend on whether a plausible mediating mechanism could be thought of, and on the known or assumed temporal order of the events measured by the determinant covariates.

The central issue addressed in this study, the question of whether work conditions might explain the effect of social class on ill health, is of the type that corresponds to the above elaboration. Thus this approach to interpreting results from regression models is a focal part of this study.

Chapter IX

The results of the study – statistical models of effects of social class and work conditions on ill health

My aim in this presentation of the main results is to summarise the substudies in a relatively concise way. Furthermore, in some cases I not only reiterate the results already published in the articles, but also repeat the same analyses on larger data sets, such as when the stricter focus in the articles demanded the derivation of all the results from the same data set even when some analyses could have been performed for larger ones. I also report supplementary analyses not included in the original articles. I trust that the footnotes to the tables will clarify the data sources. The social-class inequalities in ill health and limited functioning observed in this study

Table 3. The unadjusted prevalences and age-adjusted odds ratios (OR) and their 95% confidence intervals (CI) for musculoskeletal disorder and less than good self-rated health by gender and occupational social class.

	Musculoskeletal disorder [1]			Less than good self-rated health [2]		
Women	%	OR	95% CI	%	OR	95% CI
Social class						
Professional / managerial	30	1.00		20	1.00	
Semi-professional	32	1.16	0.95-1.40	22	1.25	1.04-1.49
Routine work	38	1.44	1.23-1.68	29	1.72	1.49-1.99
Manual work	41	1.58	1.27-1.96	36	2.20	1.81-2.67
Number of responses used	4 478			6 571		
Men						
Social class						
Professional / managerial	28	1.00		22	1.00	
Semi-professional	32	1.23	0.86-1.74	30	1.58	1.17-2.13
Routine work	36	1.62	0.98-2.69	29	1.71	1.17-2.50
Manual work	43	1.95	1.45-2.63	38	2.38	1.82-3.10
Number of responses used	1 145			1 683		

1 Any disorder reported to have been diagnosed by a physician, data source health examination 2000-2002.
2 Data source mail questionnaire 2000-2002.

are considered before the results concerning the more detailed objectives are covered.

Class inequalities were found for less than good self-rated health, musculoskeletal disorders, low physical functioning (Short Form 36 component summary) and low work ability. The professional and semi-professional classes had lower prevalences of ill health and functional limitation than the routine and manual classes. Among the women the differences in the prevalence of ill health consistently matched the presumed order of privilege attributable to the classes, i.e. higher assumed privilege was invariantly associated with less ill health. Among the men the correspondence was slightly less perfect for low overall physical functioning, as the intermediate semi-professional and routine-work classes had the same point estimate for low Short Form 36 physical-component summary score, but these classes were again sharply contrasted in the low work-ability index scrore. There were no clear class

Table 4. The unadjusted prevalences and age-adjusted odds ratios (OR) and their 95% confidence intervals (CI) for poor physical functioning as measured on the physical-component summary of Short Form 36 and the work-ability index by gender and occupational social class.

	Physical component summary [1]			Work ability index [2]		
Women	%	OR	95% CI	%	OR	95% CI
Social class						
Professional / managerial	19	1.00		6	1.00	
Semi-professional	23	1.42	1.17-1.70	10	2.04	1.45-2.87
Routine work	29	1.87	1.62-2.18	13	2.53	1.92-3.33
Manual work	35	2.35	1.92-2.86	18	3.41	2.43-4.78
Number of responses used	6 349			4 336		
Men						
Social class						
Professional / managerial	14	1.00		9	1.00	
Semi-professional	22	1.77	1.26-2.49	10	1.26	0.72-2.22
Routine work	20	1.77	1.14-2.77	17	3.03	1.49-6.14
Manual work	26	2.34	1.71-3.18	23	3.37	2.17-5.22
Number of responses used	1 632			1 113		

1 The lowest quartile of the physical-component summary score, data source postal questionnaire 2000-2002.
2 Work ability index score below 33, data source health examination 2000-2002.

inequalities in the role limit due to physical health problems scale (a four-item subscale of Short Form 36 inventory) alone. (Tables 3 and 4, substudies I, III and IV.)

The magnitude of the relative class inequalities was roughly similar for less than good self-rated health and limited physical functioning in both genders, the odds ratios for the manual class as compared to the professional and managerial class ranging from 2.20 to 2.38, and those for the routine-work class from 1.71 to 1.87. The relative inequalities in low work ability were somewhat larger than those in self-rated health and low physical functioning. The relative class inequalities in musculoskeletal disorder observed in Substudy III were somewhat narrower than those found for overall ill health, but as Tables 3 and 4 demonstrate, this difference was partly attributable to the more limited data set used in Substudy III. Among the men social-class inequalities in musculoskeletal disorder and overall ill health and incapacity seemed similar, and slightly narrower for musculoskeletal disorder among the women, with odds ratios of 1.44 and 1.58 for the routine-work and the manual classes as compared to the professional and managerial class. The overall prevalence levels of the outcomes were not similar, however. When the absolute class differences were assessed by means of linear binomial models (inequalities estimated as percentage unit differences) the difference in magnitude of inequalities between musculoskeletal disorders and other outcomes was not as clear as for relative inequalities in women either. (Data on linear binomial models have not been published.)

The effect of physical workload on limited functioning with regard to gender, age and decision latitude

A decreasing age trend, with lower prevalence in higher age groups, was found for the dichotomous measure of physically demanding work in the postal questionnaire data, and this trend was more marked for men than for women (Substudy II). A clear age trend was dependent on the physical-demands measure, however, because no corresponding age trend could be demonstrated when physically demanding work was measured in terms of the mean number of physical demands in the health-examination data.

There was an interaction effect of age, physically demanding work and gender on role limitation due to physical health problems. The effect of physically demanding

work measured in the questionnaire data was higher among the older than among the younger female respondents. When age was entered into the model as a categorical variable, the odds ratio for role limitation due to physical health problems for those with physically demanding work ranged from 1.53 among women aged 40 years to 2.27 at the age of 60. The interaction was in the opposite direction in the men, although the decreasing age trend with regard to the effect of physically demanding work on role limitation due to physical health problems was not statistically significant. The interaction of gender, age and physical work load dichotomy on the whole, however, was of borderline statistical significance. (Substudy II)

The age trends in the effect of physical work demands on role limitation were also tested on the physical-demands measurement in the health-examination data. The subsample for this test was smaller, however, because data from both sources was required. A similar age trend was observed in the women, with odds ratios for one-item increments in the number of physical demands of 1.08 at 40 years of age and 1.45 at 60. Contrary to what was found for the association of physically demanding work as measured in the questionnaire data, the age trend in the effect of the number of physical demands seemed to be upwards among the men as well, although the results among the men did not achieve statistical significance. (Results not published)

It is of relevance that, although the dependence of the effect of physically demanding work on age was stronger among the women, the opposite was the case regarding the main effect of physically demanding work. Its effect on role limitation due to physical health problems, as well as a low physical-component summary score and less than good self-rated health, was stronger among the men. The stronger main effect for men was found for both physical-demand measurements. (Substudy II)

We also investigated whether decision latitude could modify the effect of physically demanding work on functioning, the hypothesis being that low decision latitude would be associated with a stronger effect of physical workload than average or high decision latitude. The interaction effect of physically demanding work and job decision latitude on low physical functioning as measured by the lowest quartile of the Short Form 36 physical-component summary was examined for each social class separately. No interaction was found for the routine-work or manual classes, even though the combination of physically demanding work and low decision latitude was much more common than in the more privileged classes.

Statistically significant interactions were found for the professional and managerial and the semi-professional classes: in the semi-professional class the effect of physically demanding work was higher for those with low decision latitude than for those rated above the lowest quartile, while in the professional and managerial class the effect was lower for those with low decision latitude than for others. (Substudy IV)

The contribution of physical workload to class inequalities in ill health and limited functioning

Marked contributions of the physical-workload variables to social-class inequalities in ill health and limited functioning were found. The degree of the association between social class and ill health and limited functioning attributable to physical workload, however, varied somewhat according to the outcome, especially in men. The choice of the physical-workload variable also influenced the degree of contribution to some extent among the men.

The contribution of physical workload to class inequalities in less than good self-rated health, poor functioning and poor work ability were of roughly similar magnitude among the women. On average, the model estimates for other classes compared to the professional and managerial class decreased by about 45% from those not adjusted for physical workload, ranging from -33% to -58% for the different classes. Among the men the contribution of the number of frequent physical demands to low work ability was comparable to that of women for the routine-work and the manual classes, although no contribution was found for the semi-professional class. The contribution to limited functioning observed in men was dependent on the data source and the workload variable used. When class inequalities in limited functioning among the men in the combined data were adjusted for the number of frequent demands measured the in health-examination data, the contribution was of similar magnitude as for women, i.e. it ranged between -43% and -63% (this data is not shown in the table). However, when the adjustment variable was the dichotomous one of physically demanding work from the questionnaire data, the observed contributions were much smaller. Compared to the contribution of physical workload to inequalities in limited functioning and less than good self-rated health among women, the observed contribution to class inequalities in less than good self-rated health among men was very modest. (Table 5, substudies I and III)

Table 5. The contribution of physical workload to social-class inequalities in limited functioning, musculoskeletal disorders and less than good self-rated health by gender as percentage changes (% C) in the model estimates for the effect of social class on the health outcomes (logistic regression) following adjustment for physical workload factors.

	Low physical component summary [1] % C	Low work ability index [2] % C	Musculo-skeletal disorder [3] % C	Less than good self-rated health [4] % C
Women				
Social class				
Professional / managerial [5]				
Semi-professional	-56	-47	-86	-43
Routine work	-45	-51	-92	-50
Manual work	-42	-47	-86	-33
Men				
Social class				
Professional / managerial [5]				
Semi-professional	-6	32	-32	-5
Routine work	-28	-44	-28	-15
Manual work	-19	-76	-94	-15

1 The lowest quartile of the physical-component summary score, following adjustment for the dichotomous physically-demanding-work variable, data source questionnaire 2000-2002.

2 Work-ability index score below 32, following adjustment for four workload demands as four individual dichotomous variables, data source health examination 2000-2001.

3 Any disorder reported having been diagnosed by a doctor, following adjustment for the number of physical workload demands, data limited to respondents who had data in both the questionnaire and the health examination in 2000-2002.

4 Adjustment by number of physical workload demands, data limited to respondents who had data in both the questionnaire and the health examination in 2000-2002.

5 The professional / managerial class is the reference category.

The physical-workload contribution to class inequalities in musculoskeletal disorders was considerable. Among women adjustment for the number of frequent physical demands resulted in the complete disappearance of class inequalities in musculoskeletal disorders. Among men the difference between the manual and the professional and managerial classes was completely attributable to the number of frequent physical demands, whereas the attenuation of the odds ratios for routine-work and semi-professional classes were smaller. (Table 5, substudy III.)

The possibility of the effect of physical workload on less than good self-rated health being mediated through musculoskeletal morbidity was tested by subsequently adjusting the models for self-rated health with musculoskeletal disorder and physical workload. When social-class differences in less than good self-rated health were adjusted for musculoskeletal morbidity, the observed reductions in class inequalities were comparatively small. The contribution attributable to musculoskeletal disorders was clearly smaller than the effect of physical workload on class inequalities in self-rated health among the women, and among the men a contribution to inequalities in less than good self-rated health was found only in the routine-work class. This weak contribution was not explained by the lack of association between musculoskeletal disorder and self-rated health as such, however, which was fairly strong. (Substudy III)

We further examined whether the observed contribution of physical workload to class inequalities in ill health might have been attributable to psychosocial or physical environmental conditions at work to the extent that there was common variance with physical workload. Psychosocial work conditions measured as output demands and decision latitude according to the Karasek job-demand model were found to have very little if any effect on the findings concerning the contribution of physical workload to class inequalities in ill health and limited functioning. The changes in the model estimates for the beta coefficients for the social classes when the physical-workload variables were added were compared across models that had been previously adjusted only for age, models previously adjusted for age and job decision latitude, and ones previously adjusted for age, job output demands and decision latitude. The differences were negligible, thus showing that previous adjustment for the two psychosocial-work-condition dimensions had no effect on the contribution found for the physical-workload variables. (Table 6, substudy III)

When similar comparisons were made between models previously adjusted for age only and those adjusted for age and physical environmental conditions, the changes in the social-class estimates when physical workload variables were added were

Table 6. The comparison of changes in the model estimates for low physical component summary as a function of social class when physical-workload factors are added between models previously adjusted for age only, for psychosocial work conditions and age, and for physical environmental conditions and age. The figures show differences in the beta-coefficient estimates from logistic regression models.

Previous adjustments	Age	Age and decision latitude	Age and psychosocial dimensions [2]	Age and environment conditions
	Change [1]	Change	Change	Change
Women				
Social class				
Professional / managerial [3]				
Semiprofessional	-0.20	-0.20	-0.19	-0.14
Routine work	-0.28	-0.29	-0.28	-0.20
Manual work	-0.36	-0.37	-0.35	-0.21
Men				
Social class				
Professional / managerial [3]				
Semiprofessional	-0.04	-0.05	-0.05	-0.00
Routine work	-0.16	-0.20	-0.18	-0.08
Manual work	-0.16	-0.21	-0.18	-0.03

[1] Absolute changes in the model estimates, not percent changes.
[2] Karasekian dimensions of decision latitude and output demands.
[3] The professional / managerial class is the reference category.

found to be smaller when the previous models included physical environmental conditions in addition to age. The difference was particularly marked in men, and somewhat smaller in women. Thus the results showed that part of the contribution attributable to physical-workload variables might also have been attributable to physical environmental conditions, especially in men. (Table 6, substudy III)

Chapter X

Discussion on the findings and methods

There has been increasing research attention to social inequalities in health during the last thirty years, and it has become generally accepted that differences in ill health and mortality between groups in different socioeconomic positions in society are universal. The macrosocial economic structure affects and defines the lives of individuals in many fundamental ways, and thus also many explanations have been proposed for social inequalities in health. The aim in this study was to contribute to the discussion on explanations of social-class inequalities in ill health and morbidity by examining the dependence of ill health on work conditions in a sample of the employed middle-aged Finnish population. The study differs from the majority of research on inequalities and work conditions in its focus on physical work conditions, particularly physically demanding tasks. The interest was mainly in overall health status as manifested in functional capacity and self-rated health. Morbidity from musculoskeletal disorders was also considered, however, largely because such disorders could be expected to be associated with physical work conditions in particular, and might be especially relevant causes of functional disadvantage.

The magnitude of the observed class inequalities in ill health

The social-class differences in overall ill health observed in this study were in accordance with those reported in previous studies. The relative class differences in poor self-rated health were similar to those observed by Manderbacka et al. (2001) in the Finnish population. They also correspond, by and large, with those reported for several different European countries by Cavelaars et al. (1998), as well as to national findings reported by Lundberg et al. (2001), Power et al. (1996), Borg and Kristensen (2000) and Borrell et al. (2000), for example. It is more difficult to evaluate the findings on functional limitation with respect to earlier studies because the literature varies in terms of how limited functioning is measured, and inquiry into social class and functional disability have been less common than into self-rated health. Some studies that are the closest in approach, including Hemingway et al. (1997) have reported social-class inequalities with similar magnitudes of difference as those found in this study.

It is also of note how the findings of this study indicate similar social-class differences in functioning and in self-rated health. The similarity of the inequalities for these measurements may point to the fundamental similarities in the health concepts they reflect. Definitions of functional limitation for operationalisation into measurements vary, and the conceptual relatedness is likely to concern inventories that summarise several different aspects of functional capacity or incapacity. The narrower definition of work-related functioning compared with overall functioning is likely to explain why the observed inequalities in the former were somewhat larger. With regard to work-related definition, the context in which ill health is evaluated also differs somewhat among the social classes. It is perhaps worth mentioning, that this is essentially an issue concerning the meaning of illness, rather than one of a simple measurement validity.

The results also indicated that musculoskeletal disorders are unequally distributed across the social classes, the socioeconomically underprivileged suffering from higher morbidity. Research into inequalities in musculoskeletal disorder has been complicated by the lack of generally accepted, clear and uncontroversial definitions and measurements for the common disorders and for the overall morbidity associated with musculoskeletal disorders. The evidence available has generally confirmed the existence of socioeconomic inequalities, as concluded in a review carried out by Dionne et al. (2001) and in studies by Kaila-Kangas et al. (2006) and Hagen et al. (2000), for example. A recent Finnish study by Kaila-Kangas (editor, 2007) and colleagues has examined self-reported as well as clinically confirmed musculoskeletal disorders by length of education. Relative educational-group differences in clinically confirmed back disorder tended to be somewhat steeper than in self-reported back disorder, for example. There were educational-group inequalities in all of the musculoskeletal measures examined, including disorders of the neck and shoulders and osteoarthritis of the knee and hip, although in the rarer conditions such as lateral epicondylitis they did not always reach statistical significance.

Among women, the relative class inequalities in musculoskeletal morbidity observed in this study were somewhat narrower than those found for overall ill health and limited functioning. This could, to some extent, reflect the fact that the measure included a wide variety of mild conditions, and it is likely that inequalities in more severe and long-lasting disorders would be wider. Furthermore, it may not be completely sensible to compare relative inequalities across measures that have very different overall prevalence levels. Measured in absolute percentage unit differences, the potential difference between inequalities in musculoskeletal disorder and in overall ill health in women did not seem clear. Recognition of this difference in the

results of this study may be necessary for the further interpretation of the more detailed findings, however.

The contribution of physical workload to class inequalities in ill health

The results of this study confirm that physically demanding work tasks make a marked contribution to social-class inequalities in overall ill health among employed middle-aged men and women. However, the contributions were much larger among the women, with approximately half of the inequalities in overall ill health being attributable to physically demanding work. The contribution to class inequalities was lower among the men despite the association between physical demands and ill health as such being somewhat stronger than among the women. Furthermore, the contribution of physically demanding work to inequalities in overall ill health and functioning did not seem to vary among the women according to the different data sources and different variables used for physical demands, but it did vary across data sets and measures among the men. There are three ways in which the study setting and methods may have contributed to this gender difference. Firstly, the study population consisted of municipal employees and was dominated by women. Given the extent of gender segregation in many jobs associated with underprivileged class position, this could mean that physically demanding occupations predominantly carried out by men are not well-represented in the data. Secondly, it is possible that the somewhat crude measurements of physical work demands used captured the relevant variance in physical demands more accurately among the women than among the men. Finally, there are far fewer men than women in the sample, and therefore more statistical uncertainty concerning the results among the men.

Although the variety of different work conditions accounted for in the substudies was limited, and the contributions of so-called psychosocial conditions were not the main focus, account was taken of overall output demands, mental stressors, job decision latitude, possibilities for development and personal fulfillment, social interaction in the work community and factors affecting the physical environment. In all cases the contribution of physically demanding work tasks to class inequalities in ill health was found to be clearly larger than that of the other work factors. Similar results were reported by Borg and Kristensen (2000), who found that ergonomic exposure made the highest contribution to class inequalities in the worsening of self-rated health out of the eleven different work-condition factors assessed, although the contribution of physically demanding work found in this

study was even larger. Schrijvers et al. (1998) also found that physical work conditions accounted for a considerable proportion of class differences in less than good self-rated health, although their results indicated contributions of a similar magnitude for job decision latitude as well. Lundberg (1991) also found that physical work conditions contributed to class inequalities in illness more strongly than any other condition he studied, and the results of Warren et al. (2004) were at least not contradictory, although their study does not differentiate between physical and other work conditions. It seems likely that exposure to physically demanding tasks and a physically hazardous work environment is a major determinant of social-class inequalities in overall ill health among the employed population.

The main focus of this study was on physical or biomechanical exposure on account of the actions the individual performs at work, i.e. actions requiring the exertion of muscle force in some form, including maintaining certain postures. The physical work environment as a whole naturally also includes other potentially detrimental factors. Conditions such as dampness, noise, dust, air pollutants, as well as handling chemicals and any environmental characteristics causing an increased risk of accidents may cause worse health in exposed working people. Some characteristics of the physical environment were measured in this study, and the results suggest that all physical work conditions taken together, including physically demanding tasks and environmental characteristics, may even make a somewhat higher contribution to class inequalities in ill health than physically demanding work alone. Some of the contribution of physically demanding work tasks especially among the men, however, could have been related to common variance with the characteristics of the physical environment. In this study setting it is not possible to establish the dominating cause of the health effect, exposure to muscle work or a hazardous physical environment, in that the effects seem to be at least partly overlapping.

Physically straining work conditions are widely reported to be associated with excess musculoskeletal morbidity, although the extent to which this reflects the causal effect of work conditions on tissue damage and degeneration, rather than increased limitation and difficulties in coping with a physical disorder because of work demands, is still to some extent unresolved. The strength of scientific evidence varies considerably depending on the exact work factors and measures of morbidity examined (see e.g. Bernard ed. 1997, Hoogendoorn et al. 1999, Maetzel et al. 1997). Given the amount of evidence confirming dependence between the physical workload and musculoskeletal disorders, it may be justified to ask to what extent the effect of physical workload on class inequalities in overall morbidity might reflect functional disadvantage and the suffering caused by musculoskeletal disorders.

Social-class differences in musculoskeletal morbidity itself seemed to be almost completely attributable to physical work exposure in the data in question. Thus it is possible that class inequalities in at least the most common musculoskeletal disorders among employed people are almost entirely caused by physical work conditions. Specific disorders or diseases, such as rheumatoid arthritis, may be exceptions, although there is so far no evidence to rule out the contribution of work conditions to the severity of such disorders either. Although overweight may be somewhat more common in the underprivileged classes (see e.g., Heliövaara and Rissanen 2007), at least among women (Laaksonen et al. 2004, Utriainen et al. 2006), the data of this study gave no evidence that differences in overweight contributed to social-class differences in musculoskeletal disorders. Many studies have examined physical work conditions as determinants of common musculoskeletal disorders such as back pain (e.g., Vingård et al. 2000, Hartvigsen et al. 2001, Hoogendoorn et al. 2002), shoulder pain (e.g., Hoozemans et al. 2002a and b, Harkness et al. 2003) or osteoarthritis (e.g., Coggon et al. 2000, Manninen et al. 2002), and found some contribution, but none of these studies concerned class inequalities in disorders. Further studies strenghtening the conclusion that physical workload is a source of social-class inequalities in musculoskeletal disorders are thus warranted.

The findings of this study may also add some insight to support the importance of physical work conditions as risk factors for musculoskeletal disorder in general: disorders of the back, for example, are common in all occupational groups and all social classes. The results of this study, in turn, confirm that physical work conditions have a marked effect on such morbidity. Although it is impossible to determine to what extent the effect is caused by increased permanent tissue damage, and to what extent by increased dysfunction on account of degenerative changes related to ageing, for example, I do not think either interpretation really justifies the claim that the effect should not be considered causal. Even if pain caused by physical exposure does not correlate with observable morphological abnormality in tissues, this does not necessarily make its effect less causal, let alone less of a cause for concern. Differentiation between the two possible mechanisms does not seem to be practically relevant either, as in both cases reduced physical exposure could be expected to result in reduced morbidity.

Nevertheless, no support was found for the hypothesis that a major proportion of the effect of physical work conditions on social-class differences in overall illness could be mediated by musculoskeletal disorder. The lower relative class differences in musculoskeletal disorders than in overall ill health in women already narrows the possibility of a marked contribution. Statistical models built in order to test the contribution of musculoskeletal disorder to social-class differences in overall ill

health further diminished the likelihood that such a hypothesis would hold. It seems likely that at least a part of the effect of physical work exposure on overall ill health and related social-class differences are independent of musculoskeletal disorders.

It has long been a matter of concern in social epidemiology whether the effect of social conditions on health should be understood in terms of specific biological agents affecting the development of specific disorders, or whether the conditions can cause general susceptibility to disease. Cassel (1974 and 1976) and Syme and Berkmann (1976, see also Berkman and Kawachi 2000), for example, developed the concept of general susceptibility in the 1970s, whereas lately neuroendocrinology and the psychosocial stress framework of social epidemiology have investigated issues related to it (see e.g. Cohen and Herbert 1996, Marmot 2005, Brunner and Marmot 2006). General susceptibility could be understood as the capability of many forms of social and environmental burden to cause changes in physiology that will make the individual more liable to develop a wide variety of disorders, perhaps almost any disorder. A specific aetiological approach, in contrast, would rather require explanation of the mediating mechanism that is specific to the disorder in question.

It is possible to interpret the effect of physical work conditions on overall illness as a tendency of physically strenuous or straining conditions potentially to aggravate the symptoms of many different kinds of disorders or diseases. There is, for example, a fairly widely spread belief among lay people and professionals alike that rest is beneficial in terms of bringing about improvement in a worsened health state, by and large independently of the specific biological deviation in question. This line of reasoning suggests that socially-determined conditions may alter the prognosis of almost any organic disorder. The physiological mechanism by which this effect happens will be mediated not by any single biological agent, but potentially by an array of many different agents capable of causing widespread changes in complex physiological systems. However, an attempt could be made, to apply the logic of the effect on prognosis to more specific factors. For example, physically strenuous work tasks may put higher demands on the cardiovascular system, and elevation in blood pressure might contribute to several circulatory conditions. Finally, in principle we might also assume that physical workload causes psychological distress at least when the individual has difficulties coping with the demands. However, reverting to stress theory introduces much more problematic assumptions concerning mediating mechanisms than is necessary in considering the effect of physical task exposure on musculoskeletal morbidity.

Interaction of physical demands with decision latitude, age and gender

Whether physical activation is detrimental to health depends on the potentially complex pattern of utilised force as a function of time in different parts of the body. It is plausible to assume that similar work tasks and functions could be organised into different patterns of final physical exposure depending on what kind of work methods are used, and on the pace of work and other related ways of organising the functions to be performed. In some cases it might be possible to organise similar tasks in a way that makes them less detrimental to health. Indeed, this is certainly to some extent the case. If two people lift a package the exposure level is obviously lower than if one worker lifts it alone. It may then be justified to ask whether the possibility of influencing one's own work conditions could be a factor affecting the effect of physically demanding work on employee health. There are many studies on the effect on health of job decision latitude and its interaction with overall output demands, but so far no attention has been directed to decision latitude and physical work conditions.

The results of this study did not give consistent support to the hypothesis that high decision latitude may alleviate the health-detrimental effects of physically demanding work, however. The interpretation of this result may be tied to an understanding of what decision latitude as assessed on standard inventories in fact means and measures, and what it does not measure. It may be that being able to control the work pace in terms of what gets done during certain work day or to decide on one's work shifts does not reflect the possibility of modifying the working methods that are relevant to the effect of physical exposure. It may be, on the other hand, that for several reasons the control potential is often not exploited so as to protect from health-detrimental exposure. There may be low motivation for adopting slower working methods, for example, even when they might be physically somewhat less strenuous. Many aspects of the work culture could contribute to such phenomena.

The findings also indicated that increasing health problems related to the physical workload came with an increase in age particularly in women, and not to the same extent in men. It was not possible in this study setting to examine this gender difference much further, but it may be that differences in exit from work with high physical demands helped to generate it. Related results were reported by Torgén and Kilbom (2000), who found that the physical workload reduced for men across a twenty three year follow-up, but not so much for women. Hytti (1993), for example, reported that granted disability pensions were more common among men than

women in Finland, but according to recent official statistics the gender difference in this respect is not particularly large and has not been observed every year (Eläketurvakeskus 2005, 2006 and 2007).

Causality in the observed associations and potential selection effects

The foremost causality consideration with regard to an observed association generally concerns whether it might reflect the effect of a common determinant rather than a causal dependence between the conditions studied. As far as the main findings of this study are concerned, such a determinant should meet three criteria: 1) it should have an effect on health; 2) it should have an association with physical workload independently of social class (i.e. physical workload should be a closer estimation for this factor than social class); and 3) it should not be caused by physical workload. The most likely candidates would be other adverse work conditions. As noted above, to the extent that other work conditions could be examined in this study, these were not the source of such an effect.

It seems difficult to find any plausible alternative factor explaining the contribution of physical workload to class inequalities in ill health when other adverse work conditions have been excluded. Unhealthy habits, for example, might be hypothesised to covary with work conditions. If those with a high physical work load smoked more than those in the same social-class stratum doing less strenuous work, the contribution of physical workload to class inequalities in illness could in principle be partly attributable to smoking (although we might face some serious empirical challenges in attempting to test epidemiologically which was the true causal agent). According to other work within the Helsinki Health Study, however, this does not seem to be the case. Lallukka et al. (2004, see also Lallukka et al. 2007 and Lallukka 2008) found only weak and inconsistent associations between work conditions and behavioural patterns. Furthermore, should such an association between workload and smoking explain part of the contribution, this could in principle also be because a heavy physical workload causes smoking. This may sound dubious, but adding yet another factor to explain why those with a high physical workload might smoke more is certainly not easy either.

Belonging to an underprivileged social class may also cause illness through a potential effect of the standard of living on the development of illness. However, given the lack of research on the exact material conditions determined by wealth

and income that would mediate this effect (a bank account in credit can hardly, as such, be a biological agent) it is difficult to speculate on the contribution of the standard of living. According to the relative deprivation approach, the effect of economic welfare should be understood in terms of social anxiety that a lack of material welfare may cause. However, it is very difficult to see how either concrete material deprivation or relative deprivation could be related to physical workload when the contribution of class position is already accounted for. As noted several times earlier, not all jobs held by people belonging to underprivileged classes are physically straining, and there are many low-paid jobs that are not particularly physically demanding. I find it somewhat counter-intuitive to assume that physical work is associated with a lack of status over and above one's position in work hierarchy and financial rewards.

Another potential issue to address is whether ill health can cause social conditions. As discussed in Chapter III, I find it hard to accept that any directly unobservable health-sustaining potential would affect the position of people in society, and thus I am inclined to reject any theories suggesting that future ill health may affect social position before the illness is manifest. I will limit further discussion to the effects that evident illness may have. It would seem to be very unlikely that ill health could cause physical exposure at work to a marked extent. If people have to change jobs or positions due to physical illness, this cannot sensibly be assumed to happen in the direction that would be likely to increase physical demands and thus increase social problems caused by the illness. Individuals with physical health problems are likely to avoid employment in physically strenuous jobs. Furthermore, deterioration in health might result in conscious attempts to modify the working conditions so as to minimise exposure within the same job. It is much more likely that occupational mobility or changes in work tasks within the same occupation will decrease the observed association between physical work conditions and ill health rather than cause them.

A specific issue is exit from employment. Unemployment and disability retirement move individuals out of the economically active population. Naturally, there is mortality in the working-age population, too. Disability retirement and death are obviously related to ill health, and ill health may also increase the risk of unemployment (see e.g., Leino-Arjas et al. 1999). Overall, ill people are more likely to exit employment than the healthy. Consequently, it is impossible to observe the gravest potential consequences of work exposure that is detrimental to health in cross-sectional data. If exposure caused deteriorating health, and deteriorating health caused exit from the studied population, an observed cross-sectional association between current work conditions and ill health could be an

underestimation of the true causal effect. The stronger the true effect, the more likely it is to be underestimated in cross-sectional data. It is likely that some degree of underestimation may have occurred in this study as well, especially among the oldest age group.

Overall, the plausible directions of causation seem to be fairly straightforward. This reasoning may meet with empirical challenges, however, if the measurements are not all independent of each other. The measurements in this study were based on self-reports, and there is the possibility that different individual conditions influenced the respective ratings when the measurements were taken at the same point in time. The validity of the findings of this cross-sectional study, then, is subject to measurement bias rather than speculation about the direction of causation. Potential measurement bias is further discussed below.

Issues of social classification

As indicated in Chapter II, the concept of social class in this study is mainly a reflection of the class-theoretical approach proposed by Goldthorpe (1980). According to this approach differences in class position could be described in relation to two ideal types of class: the professional specialist class, which he called service class, and the contract-labour class. These classes correspond to two ideal types of employment, the service relationship and contract labour, which differ with regard to the labour-market situation (monetary compensation, employment security, career options) and the work situation (authority and supervision). So far few studies have examined whether the differences described in Goldthorpe's theory are properly captured by any classification scheme currently in use, including the Erikson-Goldthorpe-Portocarero scheme. Erikson and Goldthorpe (1993) presented some prestige scales for the scheme they used, but these scales were not systematically based on Goldthorpe's theory. In this respect the theory and its associated classification scheme has received much less research attention than Wright's neo-Marxist approach (Wright 1985, Blom et al. 1984).

The study population was composed entirely of people in employment, and thus questions regarding the relationship of the self-employed and entrepreneurs to those in employment in the social classification are avoided. Furthermore, the participants were all employed by the same organisation, thus probably diminishing the variation in terms of employment between those in the same occupation. The classification

reflects the educational qualifications required for the job and the possible supervisory status of the job. The classification used, by and large, groups occupations in a similar fashion as the Erikson-Goldthorpe-Portocarero scheme, collapsing the manual-work classes into one. However, some individual occupations may be classified differently, especially in classes I and II in the Erikson-Goldthorpe-Portocarero scheme and the professional and semi-professional classes in this study. There are some occupations for which the most appropriate allocation in terms of labour-market advantage can clearly be brought into question. Occupations in education, for example, tend to require high qualifications although the labour-market situation as described in Goldthorpe's theory is not necessarily obviously advantageous, as with elementary school teachers (classified as professional in this study) and pre-school teachers (classified as semi-professional).

Another issue concerning the classification is whether the division into the routine-work class and the manual-work class can be trusted to reflect advantages in the labour market and the work situation. The distinction in this study is derived from the official Finnish classification and mainly reflects the tradition of allocating jobs in manufacturing and transportation to the traditional working class, and jobs in the service sector to low-ranking white-collar groups. The manual-work class mainly comprised kitchen and cleaning staff, transportation workers (e.g., drivers, mechanics, port workers), as well as porters and caretakers. It may be relevant to note that there are many low-status jobs that fall within the routine-work class in health and social care, such as reception assistants, laboratory assistants and child carers, for which it may not be certain that their position is necessarily more advantageous than that of the aforementioned manual workers.

The literature on social-class inequalities in ill health sometimes refers to consistent social gradients in health. The idea of a 'consistent gradient' is a problematic one when used in connection with social class, however: even when we can observe a consistent hierarchy of health advantage, we have seldom observed that the classification is ordered according to a consistent gradient of socioeconomic advantage. According to the classic theories of both Marx and the Weber, there is no ordered range of classes. Assuming that the two Goldthorpe ideal types are opposites, we could in principle order classes on a unitary continuum. I have shown above, however, how even in a fairly homogenous working population such as the one in this study, the exact allocation of occupations into such a continuum is far from obvious. Certain occupations placed in this study in the higher professional class might in other instances be placed in a lower occupational class. There is the chance that such classification issues affected the consistency of the observed gradient. Discussion on gradients is thus, to some extent, problematic.

Another deceptive feature of the traditional social classification is the use of the terms manual and non-manual work. The results of this study, for their part, confirm that physical exposure is not limited to the jobs assigned to the manual-work class. There are many jobs in the routine-work class involving a marked degree of physical exposure, especially those predominantly occupied by women. The degree of non-correspondence between these terms and the reality of the working conditions should not be mistaken for a social classification problem, however. Social classification by definition does not reflect physical exposure as such, although it does reflect other employment and work characteristics that are partly associated with it. Thus it is a question of not presuming that the classes are completely discriminated according to physical exposure at work even if the terminology commonly used implies that they are.

Measures of work conditions

This study focused on the effects of physically demanding work tasks, i.e. actions requiring the exertion of muscular force in order to maintain working postures, to manipulate objects or to move around. There is a somewhat implicit prerequisite that such muscular work needs to be forceful clearly beyond a 'sedentary' state, and enough to cause an experience of strenuous activity. After all, logically all conscious interaction with the environment necessitates some kind of motor activation, thus the definition of physically demanding work is not as self-evident as it may at first seem. Although there has been an extensive amount of ergonomic research on objectively measured exposure and physiological reaction, and some studies on long-term health outcomes, it does not seem possible to establish clear limits beyond which work is physically strainful and risky for health, and below which it is not strainful and is safe.

The data available for this study were based on subjective ratings of whether the job required certain types of tasks in considerable or extensive quantities. The data acquired by means of the items used are obviously crude, as the quantification of exposure cannot be expressed in any unit of objective definition. This is also reflected in the operationalisation of the variables for the analyses. Some substudies used only a simple two-way division of the studied population, exposed vs. non-exposed, whereas others also used a measure incorporating several levels. In the latter case as well, however, the roughness of the quantification prevented the valid examination of a truly consistent dependence of illness probability on the amount of

exposure. It is not clear whether the measure was truly scaled, and if each unit increase in score could be interpreted to denote equal differences. This somewhat weakens the power of the results to confirm a causal relationship, as the dependence of outcome probability on the exact amount of exposure is sometimes taken as an indication of true causality.

Self-ratings of work conditions may always be susceptible to bias related to differences in how individuals perceive their conditions. When work exposure and health status are measured at the same point in time there is the possibility that ill health will negatively affect the evaluation of other conditions. Demands imposed on the individual by their social conditions might be rated differently because of difficulties in coping with these conditions related to a decreased health status. There have been attempts in previous studies to examine the extent to which health status may contribute to bias in the self-evaluation of physical work conditions, but the results have been inconsistent. Viikari-Juntura et al. (1996) found some support for the notion that poor health results in somewhat increased reporting of physical exposure, while Wiktorin et al. (1999) and Torgén et al. (1999) did not find notable contributions. Hansson et al. (2001), however, found neck and shoulder complaints somewhat increased the reporting of repeated movements. Given the simplicity and the easily rateable content of the measures of physical conditions used in this study, however, it is unlikely that the extent of potential bias covers a marked proportion of the entire variance measured in these conditions. While poor health might in some case increase the tendency to overestimate how often lifting and carrying is required, for example, it is unlikely to cause misclassification in terms of whether such tasks are required at all.

Measurement inaccuracy could also result in the underestimation of the contribution of physical work conditions to ill health and to social-class inequalities in ill health. When the measurement is rough, random error, i.e. differences in rating unrelated to any observable respondent characteristics, will diminish the variation in the measured conditions between individuals and between social groups. Decreased variation will, in turn, cause weaker observed associations. Furthermore, there may be a specific tendency for those with low demands to overestimate and those with high demands to underestimate their exposure, and the results of Hansson et al. (2001) supported such a hypothesis. The extent to which the work environment, including the work of others at the same work place and all connected contexts, contains certain conditions may influence the tendency to perceive these conditions as normal, and the amount of attention the respondent directs towards them. Some physically strenuous activity in an otherwise non-demanding environment may subjectively seem to be more demanding than the same exposure in a more

demanding environment, again resulting in the underestimation of both variation in exposure and association with ill health. While the presence of the latter kind of bias could be questioned, measurement inaccuracy is most likely to have caused some underestimation in the association of physical work conditions with ill health in this study.

Measures of ill health

The focus of this study was predominantly on overall ill health, measured as perceptions of ill health and as functional disability. It is not entirely self-evident either that health or ill health could be defined and measured as a unitary condition and as one coherent quantity. The concept of deteriorated health is tied to that of organic abnormality, and abnormalities vary considerably in nature. No overall quantification of 'degree of organic deviance' is possible. However, as discussed in the context of von Wright's (1963/1972) philosophical account of health in Chapter III, ill health always entails a certain amount of suffering or incapacity. The idea of overall ill health must be based more or less on the assumption that suffering and incapacity are somewhat comparable regardless of the biological nature of the deviant organic condition that causes them.

Functioning refers to the capability of the individual to cope with the ordinary demands of daily life. Sometimes the term health-related functioning is used to indicate functional disadvantage in terms of incapacity that is assumed to be related to health problems, i.e. is partly caused by an organic condition. Functioning was understood in this study as primarily physical, as opposed to mental functioning. With regard to mental health, emotional dysfunction and social functioning, the distinction between what is considered ill health and what is not is particularly difficult to make. Incapacity related to somatic disorder and manifest in physical limitations and pain is somewhat more straightforward. Pain in itself is often understood as an indication of the presence of an organic condition, although the extent to which it satisfies the criterion of abnormality is somewhat more subject to question.

Inventories of functioning, such as the Short Form 36 health inventory used in this study, attempt to combine limitations and incapacity in somewhat coherent quantity. The physical-component summary score used is a construct assumed to measure an underlying factor of overall physical capacity for normal functioning.

Whether this factor is, in fact, "underlying" in the sense that it could precede and cause individual functional problems, rather than reflect deteriorating welfare as a consequence of individual functional problems, is not necessarily practically relevant to the validity of the measure. The author's position, however, reflects more the latter type, supporting the assumption that specific individual limitations are the preceding condition, and the overall lack of normal functioning and the perception of deteriorating welfare are the consequence.

The physical-component summary of the Short Form 36 inventory is a scale constructed on the basis of a somewhat complicated calculation schema from 36 items on subjective functioning ratings. Whether a unit of such a constructed scale has a constant interpretation throughout the whole theoretical range of the quantity, i.e. whether the quantity is truly scaled rather than ordinal, is somewhat disputable. Given the suggestion in the earlier conceptual discussion that 'health' in itself has no gradation, only 'severity of illness' does, it seems that differences between scores near to the population mean of relatively healthy may have an entirely different meaning than the difference between scores near to the mean and those markedly deviating downwards. The analyses in this study mainly concerned a class of respondents with a low physical-component summary score, although some supplementary analyses were also carried out on the continuous score. A similar rationale applied to the work-related functioning measure, the work-ability index.

Somewhat wider inequalities in work-related functioning were found than for overall functioning. There may, however, be a relevant conceptual difference between incapacity in the work context and overall incapacity. It may be that functional capabilities assessed with reference to work are more dependent on specific characteristics of the individual's social environment (related to work and employment) than on more generic functioning and health concepts that could be more dependent on expectations of a more universal nature. People generally expect to be without severe pain irrespective of the social environment, for example. Thus a more generic functioning measure is more reflective of health against general norms, whereas a clearly work-related measure may rather be assessed against particular conditions: in other words there is more variation in norms concerning work-related incapacity than overall incapacity.

The application of the functioning measure as a dichotomy naturally introduces the problem of choosing a cut-off value. The lowest quartile was chosen for the Short Form 36 physical-component summary partly because it has been used in previous studies (e.g., by Martikainen et al. 1999), and some population data on

quartile scores are also available for comparison. The lowest quartile point for the physical-component summary in this study was similar to the U.S. population norm for men and women of a similar age reported by Ware and Kosinski (1994/2001). There were also practical statistical reasons for the choice, as a low cut-off value increases the statistical uncertainty of the estimates. Observed social-class differences may have been affected by the choice of cut-off point to some extent. Analyses of the different cut-off points as well as of the different health measures revealed a tendency for measures of more severe illness to display wider relative class inequalities. The lower the overall prevalence in the population, the wider are the relative inequalities that tend to be found. This may also explain why the observed inequalities in the low work-ability index were somewhat wider than for the physical-component summary among women.

The cut-off point chosen for the work-ability index was markedly higher than the one recommended by the developers of the measure. This was because the scores were markedly higher in this study than in Finnish studies on ageing municipal employees conducted in the 1980s (see Ilmarinen editor 1985 and Tuomi editor 1997). Other later studies, such as the one conducted by Järvisalo et al. (1997), also reported higher scores, indicating a real change either in how this measure works, or in the extent of work-related functional problems in employed middle-aged people. A decrease in functional problems could be related either to a better health status or to changes in the work environment. In any case, the difference is likely to be related to the whole life history of the cohorts in question, as many of the employees examined in the studies in which the measure was developed were born prior to World War II.

Apart from overall ill health, specific attention was directed to musculoskeletal disorders. All conditions of the musculoskeletal system the respondent was currently experiencing and had sought medical assistance for were considered without particular limitation to the exact medical diagnosis of the condition. The majority of such morbidity is also likely to be of an uncertified biomedical nature. Recurrent or long-lasting pain in the shoulder and neck region or the low back is common, and biomedical certification of pathophysiological changes in such disorders is usually not possible. Nerve-root compression and arthrosis in the lower limb may be among the most common biomedically specific disorders. Respondents suffering from rheumatoid arthritis were also included, but their number in the data was very low. The majority of musculoskeletal morbidity examined was practically certain to concern disorders of which there was scant biomedical knowledge of the aetiology and little strong epidemiological evidence concerning the risk factors.

Data on the duration of the disorder was not available, and thus the musculoskeletal morbidity examined potentially varied somewhat widely in terms of severity of disorder. As the maximum time from seeking medical consultation was not specified, the respondents may also have over-reported the current presence of the disorder to some extent. The high overall prevalence of musculoskeletal morbidity reflects the probably wide range of severity. Limitation to more severe cases might also have affected the magnitude of the observed social-class inequalities. Given a lower overall prevalence, absolute social-class differences are naturally highly likely to be smaller, but relative class inequalities, in contrast, may be wider than those found for more common disorders. According to the review conducted by Dionne et al. (2001), relative socioeconomic inequalities in the prognosis of back pain may be more consistent than in its onset. Such a difference may indicate that the relative inequalities are more consistent and marked in severe than in mild cases. The results reported by Kaila-Kangas and colleagues (editor, 2007) indicated wider relative inequalities for back disorders with clinically certified findings than for total self-reported back disorder. This may thus indicate a tendency for more severe disorders to be more unequally distributed among the social classes. However, as the absolute differences in the numbers of people suffering from somewhat less severe disorders are higher between the social classes, it may be questionable to assume that inequalities in less severe disorders are much less important than those in more severe cases, and certainly they are no less real differences in morbidity.

There is, at least in principle, the possibility that limiting the analysis to severe rather than fairly common disorders might have affected the observed contribution of musculoskeletal disorder to functioning and overall ill health. On the one hand, more severe disorders could be expected to cause more functional limitations: in fact, a severe degree of functional limitation is always part of the definition of a severe condition. On the other hand, however, the lower prevalence of a more severe disorder might also limit the potential contribution to functioning and overall ill health on the level of the whole population. Consideration of overall ill health was not limited to particularly severe illness, as very severely ill people are obviously often not in paid work either, but included more common dysfunction and illness with overall prevalences varying between 12 to 25 percent in the studied population. It is not likely that the contribution of fairly rare conditions to such morbidity would be particularly high, even though the presence of a severe condition could explain more fully severe overall dysfunction in a smaller group of those who are particularly ill.

The data collection and statistical methods

Non-response is often thought of as a potential source of bias in survey data. There are often sociodemographic differences in study participation, which may give some groups excess weight in determining population prevalence in the studied conditions, for example. Socioeconomically disadvantaged groups generally participate somewhat less than advantaged groups, and the ill participate somewhat less than the healthy. If the potential determinants of response activity act independently of each other, however, they should not affect between-group relative differences in a studied condition markedly. In other words, if the ill are equally less active in both socioeconomically advantaged and disadvantaged groups, this should not cause marked bias in the observed relative differences in ill health between the advantaged and the disadvantaged, although the exact value of any statistical estimate of the relative difference may be slightly affected.

This study was based on data from a postal questionnaire survey designed for the Helsinki Health Study, as well as data on health examinations conducted by the occupational health care services of the City of Helsinki. The questionnaire survey had a response rate of 67%, and the health-examination data was available for 43% of the employees originally invited to the examination. The non-response in both data sets was analysed using register data from the City of Helsinki (Lallukka et al. 2002, Martikainen et al. 2007, Laaksonen et al. 2008). Analysis of the influence of sickness absence on response activity, and of sociodemographic differences in sickness absence among participants and non-participants has suggested that non-response is unlikely to cause considerable bias in the between-group relative differences in the studied conditions. However, if there was bias it would be likely to underestimate rather than overestimate social-class inequalities in ill health and the association between physical work exposures and ill health. It seems unlikely that such bias would explain the main findings of this study.

Analyses of the participants who were both questionnaire respondents and contributors to the health-examination data were especially vulnerable to problems with the data-set construction. Further loss in the combined data was caused by the individual non-response in both data sets. The combined data were slightly more representative of employees with sickness-absence spells in the professional and semiprofessional classes than in the manual and routine-work classes. The potential bias in this case is also more likely to underestimate rather than overestimate class inequalities in ill health.

A method of building sequential regression models and observing changes in the model estimates when the adjusting covariates are added was used in this study. The method has been widely used in the literature on social epidemiology. Nevertheless it has a clear statistical disadvantage: conclusions are drawn from a calculatory variable for which no statistical significance can be derived, i.e. changes in the beta coefficients, or the odds ratios derived from them, between the modelling steps. So far no clear solution to the problem has been offered. In some cases, when all the modelled variables are scaled, structural equation models may be a potential alternative to regression methods. Such study settings are not common, however.

In my view, it is unlikely that the marked contributions of physical work conditions to ill health and social-class inequalities in ill health observed in this study could sensibly be considered to have been attributable to the fact that a large number of individuals with a co-occurring high physical workload, an underprivileged class position and ill health just happened to be found in the data. If this were the case, the observed class inequalities in ill health should also have been for the most part statistically non-significant to begin with. When observed contributions are small, it may be due to chance rather than to true systematic dependence. However, particularly among the women in the manual-work and routine-work classes, and regarding musculoskeletal disorders among the men in the manual class, changes in the model estimates when physical workload was added into the model were considerable. It seems slightly counter-intuitive to assume that such contributions would be observed by chance. Similar problems of formal statistical inference are found almost universally in epidemiological studies on causes of socioeconomic inequalities in health, and at least the results of this study are no more uncertain in this respect than those of the great majority of other studies.

Studied entities, in principle, need to be free of any noteworthy error if their association is to be estimated with accuracy by the means of any statistical method. Perfect measurements are, of course, impossible. Problems with regression results may arise if the covariates have very different degrees of error. Accurately measured determinants are, of course, likely to manifest stronger observed associations with the outcome than inaccurately measured determinants if both have some extent of real association with the outcome. In this study, if there is any noteworthy difference between the different work conditions in their potential for measuring error, it seems most likely that psychosocial conditions would have been measured somewhat more accurately than physical work conditions. Therefore potential differences in measurement error are unlikely to explain the stronger contributions found for physical work exposure.

Generalisability of the findings

The studied population consisted of middle-aged municipal employees in Helsinki, the capital of Finland. The findings as such apply to employed men and women between 40 and 60 years old. The examined ill-health outcomes, however, are generally likely to reflect persistent and longstanding health status rather than transient problems related to a certain limited time in life. Although the findings do not directly concern inequalities in ill health in younger or older people, nevertheless it is sensible to assume that the inequalities found have a history as well as a future. On the one hand, the current health status has probably been affected by conditions earlier in life, and on the other, current inequalities are likely to persist in the future unless there is any causal agent altering them. The findings concerning employed people from the approximate middle point of their economically active life to near retirement are relevant in shaping our overall picture of health inequalities in relation to the life span.

The study was limited to public-sector employees, and especially in terms of working conditions, the absence private-sector employees from the population could limit generalisation to the labour force at large to some extent. This limitation is likely to be more relevant with regard to men than to women. Jobs in the organisation of the City of Helsinki are more representative of women in working life, including care workers and different kinds of service employees, although excluding retail sales and some consumer services. The lack of jobs in manufacturing and construction may affect representativeness concerning men. A higher contribution of the physical workload to social-class inequalities in ill health might thus be observed for men in data that is more representative of the whole working population. The variation in jobs and working conditions in the studied population, however, is likely to be sufficient to demonstrate the general dependence between work conditions and ill health in women, and whereas a more complete picture would be obtained from studies covering the whole labour force, it seems reasonable to expect very similar results to those obtained in this study.

The findings of this study concerned a Finnish employed cohort. Evidence in the literature, however, tends to indicate that socioeconomic inequalities in both morbidity and mortality are, by and large, similar throughout Western Europe: similar inequalities in overall mortality have been reported by Kunst et al. (1998 b), and in self-reported health by Cavelaars et al. (1998) and Kunst et al. (2005). Although between-country differences in certain diseases have been found, most notably inequalities in ischemic heart disease tend to be wider in northern than in

southern countries (see Kunst et al. 1998 c), the overall picture of inequalities in ill health is fairly uniform. Given the similarity in economic and political structure as well as in the standard of living in Western European societies, it is logical to expect the effects of the social structure on public health to be markedly similar. I seems to me that this is particularly likely with regard to the effect of working conditions on inequalities in ill health. It seems much more plausible to expect cultural differences between countries in the distribution of unhealthy dietary and substance-use habits than in the distribution of adverse work conditions. The overall structure of production in industrial societies evidently allows for much less variance in distribution of working conditions than in differences in behaviour that does not, by definition at least, follow from differentiated positions in paid work.

There is no good-quality data available on which to assess whether there are any notable differences in physical work conditions between European countries. What is available from European work-condition surveys reported by Paoli and Merllié (2001) and Parent-Thirion et al. (2007) does not suggest that we should expect marked differences between Western European countries. As differences in occupational structure are not likely to be large enough to alter the effects of the social structure on public health in general, it seems plausible to expect the effect of physical work conditions on social-class inequalities in ill health to be roughly similar at least in Western Europe. Whether differences in social conditions between Eastern and Western European countries are reflected in social inequalities in ill health is not completely clear.

Conclusions

This study appears to provide support for the notion that social-class inequalities in health and illness are primarily attributable to differences in material conditions between the privileged and underprivileged strata in society. There was strong support suggesting that physical work conditions are a major contributing cause of class inequalities in ill health. Physical work conditions are likely to contribute markedly to decreased functional capacity and overall morbidity, as well as to individual disorders. Although physically straining work tasks are likely to be particularly strong causes of social-class differences in musculoskeletal morbidity, the effect of such conditions may not be limited to musculoskeletal disorders and related functional disadvantage, but seems to contribute to illness and social-class differences in illness in other ways as well.

Various interrelationships among work characteristics and their effects on health are sometimes suggested. No clear support for the existence of interaction effects on ill health for a combination of exposure to adverse physical conditions and the contribution of other working conditions, including general output demands and job decision latitude was found in this study. Issues concerning interrelationships between such conditions are methodologically difficult, however, and advances in understanding and measuring different dimensions of work conditions, as well as more accurate data on physical work conditions, might yet challenge these results. Observed gender differences in the dependence of the effect of physical workload on age may indicate potential differences in the work situations of ageing men and women in jobs with high physical exposure. Issues related to ageing and gender, however, require more research.

Material and physical conditions were influential as assumed causes of social inequalities in ill health in the early development of enquiry into class inequalities in illness and mortality. Recent research, however, has predominantly failed to address these conditions as major causes of inequalities in ill health. Physical work conditions in particular have received little attention, and although the effect of income level on illness and mortality has been addressed, attempts to further explain the why standard of living is potentially related to ill health have mostly been related to theories of psychological reactions to inequality of distribution, not to material disadvantage or advantage as such. Decreased interest in physical and material conditions may be partly related to the so-called threshold hypothesis, i.e. the assumption that once a certain minimum level of material welfare has been achieved, these conditions cease to have an effect on health and mortality. I do not find very strong arguments to defend the threshold hypothesis: it seems to me that the limit for improving longevity at least has not been reached so far. If improvement in material and physical conditions on the level of whole population does result in improved public health, then what is the rationale for assuming that the distribution of these conditions does not affect differences in health? This seems somewhat illogical.

As far as physical work conditions in particular are concerned, I do not think it is very logical to assume that the division between the magnitude of exposure that has health effects and exposure that does not could be defined. Empirically it could be claimed that once differences in detrimental work conditions between the social classes have become sufficiently narrow, the resulting differences in ill health attributable to these conditions could be so small that they are practically unobservable. The results of this study, however, indicate that such equality in working conditions has not been achieved. I do not think it is warranted to expect

that it will be achieved in the near future, either. Available studies do not even support the assumption that the contribution of physical work conditions to social inequalities in ill health is on the decrease.

There is room for substantial improvement in the data on material and physical conditions as causes of inequalities in ill health. There is a need for longitudinal studies, particularly since only one follow-up study on physical work conditions as a cause of inequalities in ill health has been published (Borg and Kristensen 2000). The major weakness in the research so far, however, is the unsatisfactory measuring of material and physical conditions. It is necessary first of all to define with sufficient accuracy the specific conditions that are hypothesised to cause deterioration in health, and to devise items that measure them in survey studies as accurately as possible. Some of these conditions may be very difficult or virtually impossible to measure reliably in questionnaire or interview surveys involving large population samples, but certainly not all are completely beyond the scope of large surveys, and significant improvements to the data that has been collected and utilised so far could be made.

I noted in the introduction to this work that since this study is not on intervention or policy, I do not think it is completely warranted to draw conclusions concerning potential practical interventions for effectively reducing class inequalities in ill health. However, the results certainly point to the importance of physical work conditions. If exposure to adverse physical conditions among the underprivileged social classes could be reduced, it should have a significant effect on class inequalities in illness, although the magnitude of such effect is likely to depend on what choices are made in terms of conceptualising and measuring illness.

I believe there are two primary ways in which the working conditions of large numbers of people could, in principle, change. Firstly, there could be changes in the economy and in production that could change the demand for different kinds of work. Should these changes be large enough, there may even be changes in occupational structure – and ultimately in the macrosocial structure of stratification. However, I do not think it would be very warranted to place much hope in such a revolutionary outcome. Even if some form of economic change will undoubtedly continue, it seems that the demand for work in physically strenuous conditions will not disappear. It has been argued several times in this work that we cannot be very certain about whether such demand is on the decrease at all in Western society. The instrumental use of the human body continues to be a part of the production of ordinary goods and services.

Secondly, focused action to specifically change the conditions in which certain work tasks are carried out could be pursued. Such actions tend to have limits, however, as the requirements for productivity and the simple need to get the work done by any technological means that are applicable limit the possibilities for change. Identifying policy changes through which a reduction in physical exposure at work could be achieved, and which will be practically possible to realise in the present economic order, is a challenging task. Policy-oriented research, intervention studies and ergonomic development may open up opportunities for making some improvements. Should actions directed to specific work-place exposure affect a significant proportion of the working population, it might result in a reduction in social inequalities in health. It is at least certain that negligence of the contribution of physical work conditions is not likely to help in understanding if, and how social inequalities in ill health can be reduced.

Acknowledgements

This study was carried out within the Helsinki Health Study research group at the Department of Public Health of the University of Helsinki. The Helsinki Health Study is financed by the Academy of Finland and the Finnish Work Environment Fund. The author has been further financially supported by Doctoral Programs in Public Health, the Finnish Work Environment Fund, and the University of Helsinki Research Funds. I wish to acknowledge all the senior researchers who have contributed to the financing of my work from project funds at their disposal, including Eero Lahelma, Ossi Rahkonen, Pekka Martikainen and Mikko Laaksonen.

It has been a privilege to work as a student of Professor Eero Lahelma, who is not only an experienced and proficient scholar in social epidemiology and the sociology of health, but is also a devoted teacher. I am grateful that I always received the help and advice I needed. I have also been lucky to benefit from working with several seasoned researchers: Pekka Martikainen, Ossi Rahkonen, Päivi Leino-Arjas and Eva Roos have all shared their own particular specialties and approaches, and provided support at different stages of the work. I am also happy about the general open-minded attitude of my supervisors, which has permitted me to work in ways that I found suitable for myself.

The thesis was reviewed by Professor Seppo Pöntinen and Dr Pekka Virtanen, whom I thank for accepting the assignment and reviewing this lengthy paper in due time. Joan Nordlund M.A. revised the language of the summary part, and I thank her for the corrections she made.

This study, among others done in the Helsinki Health Study group, has been possible thanks to all those who have worked in the research group. Many people participated in the designing of the research project and in the data collection, processing and management in one way or another, some making crucial contributions and others working on more detailed tasks. It has also been a pleasure to work in a community that is engaged in a lively informal discussion on research ideas and methodological issues to complement the chat about life and society in general.

I wish to thank all members of the group, in particular my long-term collaborators at the Department of Public Health including, in addition to those mentioned above, Karoliina Harkonmäki, Elina Laaksonen, Mikko Laaksonen, Tea Lallukka, Kustaa

Piha, Peppiina Saastamoinen, Sirpa Sarlio-Lähteenkorva and Karri Silventoinen. I am also grateful to those with other affiliations, including Sakari Karvonen, Kristiina Manderbacka, Netta Mäki and Petteri Sipilä, as well as to more recent members of the group and those who left to take up other activities, including Laura Haapala, Risto Kaikkonen, Katariina Kivelä, Jouni Lahti, Tomi Mäkinen, Olli Pietiläinen, Susanna Pulkkinen, Aino Salonsalmi, Kirsi Talala, Terhi Tuominen, Inka Utriainen and Jan-Erik Wiens. Furthermore, I would like to thank Ulla Broms, Eeva Pyörälä and Salla-Maarit Volanen for their part in the informal life of the group. Finally, I owe special thanks to Tea for helping with the formalities involved in getting the thesis registered and printed.

In collecting of the health-examination data we also required the contribution of the occupational health-care services of the City of Helsinki, and I thank the personnel of these services, especially the occupational-health nurses, for their efforts.

I wish to thank the administrative and computer systems personnel at the Department of Public Health, Sirkka Koskinen and Pirkko Särkijärvi in particular, for their efforts concerning financial administration.

It has been a pleasure to participate in the discussion at the post-graduate seminar organised by the Väestön terveys ja elinolot-doctoral program, and I would like to thank all senior researchers and doctoral students who have taken part in the seminar, as well as the program coordinator Netta Mäki. I would also like to thank the organisers of and participants in the doctoral student meetings held jointly with the Centre for Health Equity Studies of the Stockholm University and Karolinska Institutet: these scientific meetings were a delight.

I thank my family and friends for their support, and in particular my partner Sanni for her tolerance when my work extended to unconventional hours, and for allowing books and papers to occupy an unlimited space in our apartment.

Bibliography

Alison S Scott (1842). On the diseases, conditions, and habits of the collier population of East Lothian. In a report by Frank R F from the Children's Employment Commission on the East of Scotland District, 1842.

Available at Scottish Mining Villages, http://www.mining-villages.co.uk/241.html

Allardt Erik (1981). Experiences from the comparative Scandinavian Welfare Study, with bibliography of the project. European Journal of Political Research 1981; 9(1): 101-111.

Alterman T, Shekelle RB, Vernon SW and Burau KD (1994). Decision latitude, psychologic demand, job strain, and coronary heart disease in the Western Electric Study. American Journal of Epidemiology 1994; 139(6): 620-627.

Antonovsky Aaron (1985). Healt, stress and coping. San Francisco, Jossey-Bass, 1985.

Armstrong Thomas J, Buckle Peter, Fine Lawrence J, Hagberg Mats, Jonsson Bengt, Kilbom Åsa, Kuorinka Ilkka AA, Silverstein Barbara A, Sjogaard Gisela, Viikari-Juntura Eira RA (1993). A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scandinavian Journal of Work, Environment and Health 1993; 19(2): 73-84.

Barondess Jeremiah A et al; Panel on musculoskeletal disorders and the workplace (2001). Musculoskeletal disorders and the workplace. Low back and upper extremities. Washington DC, National Academy Press, 2001.

Available at National Academy Press, www.nap.edu/books/0309072840/html/

Bartley Mel and Plewis Ian (1997). Does health selective social mobility account for socioeconomic differences in health? Evidence from England and Wales 1971 to 1991. Journal of Health and Social Behavior 1997; 38(4): 376-86.

Belkic Karen L, Landsbergis Paul A, Schnall Peter L and Baker Dean (2004). Is job strain a major source of cardiovascular risk? Scandinavian Journal of Work, Environment and Health 2004; 30(2): 85-128.

Bengtsson C, Nordmark B, Klareskog L, Lundberg I, Alfredsson L and the EIRA study group. Socioeconomic status and the risk of developing rheumatoid arthritis: results from the Swedish EIRA study. Annals of the Rheumatic diseases 2005; 64(11): 1588-1594. doi:10.1136/ard.2004.031666

Ben-Shlomo Yoav and Kuh Diana (2002). A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives. International Journal of Epidemiology 2002; 31(2): 285-293.

Berkman Lisa F and Kawachi Ichiro (2000). A historical framework for social epidemiology. In: Berkman Lisa F and Kawachi Ichiro, editors. Social epidemiology. Oxford/NewYork, Oxford University Press, 2000.

Bernard Bruce P, editor (1997). Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. Cincinnati (OH), US Department of Health and Human Services, National Institute for Occupational Safety and Health, 1997.

Blane D, Bartley M and Davey Smith G (1997). Disease etiology and materialist explanations of socioeconomic mortality differentials. European Journal of Public Health 1997; 7(4): 385-391.

Blane D, Harding S and Rosato M (1999). Does social mobility affect the size of the socioeconomic mortality differential?: evidence from the Office for National Statistics Longitudinal Study. Journal of Royal Statistical Society, Series A 1999; 162(1): 59-70.

Blau Peter M and Duncan Otis Dudley (1967). The American Occupational Structure. New York, Wiley & Sons, 1967.

Blaxter Mildred (1989). A comparison of measures of inequality in morbidity. In: Fox John, editor. Health inequalities in European Countries. Aldershot/Brookfield, Gower, 1989.

Blaxter Mildred (2004). Health. Cambridge, Polity, 2004.

Blom Raimo, Kerkelä Heikki, Kivinen Markku, Melin Harri, Järvelä Marja, Rantalaiho Liisa, Nikula Jouko, Tyrkkö Arja, Keinänen Pirjo, Julkunen Pertti and Jähi Rita (1984). Suomalaiset luokkakuvassa. Luokkaprojekti. Tampere, Vastapaino, 1984.

Boorse Christopher (1977). Health as a theoretical concept. Philosophy of Science 1977; 44(4): 542-573.

Borg Vilhelm and Kristensen Tage S (2000). Social class and self-rated health: can the gradient be explained by differences in life style or work environment? Social Science and Medicine 2000; 51(7): 1019-1030.

Borrell Carme, Rue Montserrat, Pasarín M Isabel, Rohlfs Izabella, Ferrando Josep and Fernandez Esteve (2000). Trends in social class inequalities in health status, health-related behaviors, and health services utilization in a Southern European urban area (1983–1994). Preventive Medicine 2000; 31(6): 691-701. doi:10.1006/pmed.2000.0751

Bornehag CG, Blomquist G, Gyntelberg F, Jarvholm B, Malmberg P, Nordvall L, Nielsen A, Pershagen G and Sundell J (2001). Dampness in buildings and health. Nordic interdisciplinary review of the scientific evidence on associations between exposure to "dampness" in buildings and health effects. Indoor Air 2001; 11(2): 72-86.

Bosma H, Marmot MG, Hemingway H, Nicholson AC, Brunner E and Stansfeld SA (1997). Low job control and risk of coronary heart disease in Whitehall II (prospective cohort) study. BMJ 1997; 314(7080): 558-565.

Bosma H, Peter R, Siegrist J and Marmot M (1998). Two alternative job stress models and the risk of coronary heart disease. American Journal of Public Health 1998; 88(1): 68-74.

Bourdieu Pierre (1984). Distinction. A social critique of the judgement of taste. London, Routledge & Kegan Paul, 1984.

Brekke Mette, Hjortdahl Per, Thelle Dag S, Kvien Tore K (1999). Disease activity and severity in patients with rheumatoid arthritis: relations to socioeconomic inequality. Social Science and Medicine 1999; 48(12): 1743-1750.

Brewer Richard I (1986). A note on the changing status of the registrar general's classification of occupations. British Journal of Sociology 1986; 37(1): 131-140.

Brunner EJ, Marmot MG, Nanchahal K, Shipley MJ, Stansfeld SA, Juneja M and Alberti KGMM (1997). Social inequality in coronary risk: central obesity and the metabolic syndrome. Evidence from the Whitehall II study. Diabetologia 1997; 40(11): 1341-1349.

Brunner Eric and Marmot Michael (2006). Social organisation, stress, and health. In: Marmot Michael and Wilkinson Richard, editors. Social determinants of health. 2nd edition. Oxford/New York, Oxford University Press, 2006.

Cavelaars AEJM, Kunst AE, Geurts JJM, Helmert U, Lundberg O, Mielck A, Matheson J, Mizrahi Ar, Mizrahi A, Rasmussen N, Spuhler T, Mackenbach JP (1998). Morbidity differences by occupational class among men in seven European countries: an application of the Erikson-Goldthorpe social class scheme. International Journal of Epidemiology 1998; 27(2): 222-230.

Cassel J (1974). An epidemiological perspective on psychosocial factors in disease etiology. American Journal of Public Health 1974; 64(11): 1040-1043.

Cassel J (1976). The contribution of the social environment to host resistance: the Fourth Wade Hampton Frost Lecture. American Journal of Epidemiology 1976; 104(2): 107-123.

Chadwick Edwin (1842/1965). Flinn MW, editor. The sanitary condition of the labouring population of Gt. Britain. Edinburgh, Edinburgh University Press, 1965.

City of Helsinki, Kaupunginkanslia (2003). Henkilöstöraportti 2002. Helsinki, Helsingin kaupunki, 2003.

Cohen Sheldon and Herbert Tracy B (1996). Psychological factors and physical disease from the perspective of human psychoneuroimmunology. Annual Review of Psychology 1996; 47: 113-142.

Coggon D, Croft P, Kellingray S, Barrett D, McLaren M and Cooper C (2000). Occupational physical activities and osteoarthritis of the knee. Arthritis and Rheumatism 2000; 43(7): 1443-1449.

Cummins Steven J, McKay Laura and Macintyre Sally (2005). McDonald's restaurants and neighborhood deprivation in Scotland and England. American Journal of Preventive Medicine 2005; 29(4): 308-310.

Dahl Espen and Elstad Jon Ivar (2001). Recent changes in social structure and health inequalities in Norway. Scandinavian Journal of Public Health 2001; 29 suppl 55: 7-17.

Dahrendorf Ralf (1959). Class and class conflict in industrial society. London, Routledge & Kegan, 1959.

Devereux JJ, Vlachonikolis IG and Buckle PW (2002). Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb. Occupational and Environmental Medicine 2002; 59(4): 269-277. doi:10.1136/oem.59.4.269

Dionne C E, von Korff M, Koepsell T D, Deyo R A, Barlow W E and Checkoway H (2001). Formal education and back pain: a review. Journal of Epidemiology and Community Health 2001; 55(7): 455-468. doi:10.1136/jech.55.7.455

Dijk van FJH, van Dormolen M, Kompier MAJ, Meijman TF (1990). Herwaardering model belasting-belastbaarheid. Tijdschrift voor Sociale Gezondheidszorg 1990; 68: 3-10.

Ellaway Anne and Macintyre Sally (1998). Does housing tenure predict health in the UK because it exposes people to different levels of housing related hazards in the home or its surroundings? Health and Place 1998; 4(2): 141-150.

Elstad Jon Ivar (2000). Social inequalities in health and their explanations. Nova Rapport 9/00. Oslo, NOVA - Norwegian Social Research, 2000.

Eläketurvakeskus ja Kansaneläkelaitos (2005). Tilasto Suomen eläkkeensaajista 2004. Helsinki, Eläketurvakeskus ja Kansaneläkelaitos 2005.

Eläketurvakeskus ja Kansaneläkelaitos (2006). Tilasto Suomen eläkkeensaajista 2005. Helsinki, Eläketurvakeskus ja Kansaneläkelaitos 2006.

Eläketurvakeskus ja Kansaneläkelaitos (2007). Tilasto Suomen eläkkeensaajista 2006. Helsinki, Eläketurvakeskus ja Kansaneläkelaitos 2007.

Engels Friedrich (1845/1971). Henderson WO and Chaloner WH, translators and editors. The condition of the working class in England. Oxford, Basil Blackwell, 2nd edition 1971.

Eriksen W, Bruusgaard D and Knardahl S (2004). Work factors as predictors of intense or disabling low back pain; a prospective study of nurses' aides. Occupational and Environmental Medicine 2004; 61( ): 398-404. doi: 10.1136/oem.2003.008482

Erikson Robert and Goldthorpe John H (1993). Constant flux – a study of class mobility in industrial societies. Oxford, Clarendon – Oxford, 1993.

Evans Julie, Hyndman Sophie, Stewart-Brown Sarah, Smith David and Petersen Sophie (2000). An epidemiological study of the relative importance of damp housing in relation to adult health. Journal of Epidemiology and Community Health 2000; 54(9): 677-686. doi:10.1136/jech.54.9.677

Flinn MW (1965). Introduction. In: Chadwick Edwin (1842/1965) The sanitary condition of the labouring population of Gt. Britain. Edinburgh, Edinburgh University Press, 1965.

Fulford KWM (1993). Praxis makes perfect: illness as a bridge between biological concepts of disease and social conceptions of health. Theoretical Medicine and Bioethics 1993; 14(4): 305-320.

Galton Francis (1901). The possible improvement of the human breed under the existing conditions of law and sentiment. Nature 1901; 64(1670): 659-665.

Available at galton.org, http://galton.renoster.com/essays/1900-1911/

Galton Francis (1908). Memories of my life. Methuen, 1908.

Available at galton.org, http://www.galton.org/books/

Galobardes Bruna, Shaw Mary, Lawlor Debbie A, Lynch John W and Davey Smith George (2006 a). Indicators of socioeconomic position (part 1). Journal of Epidemiology and Community Health 2006; 60(1): 7-12. doi: 10.1136/jech.2004.023531

Galobardes Bruna, Shaw Mary, Lawlor Debbie A, Lynch John W and Davey Smith George (2006 b). Indicators of socioeconomic position (part 2). Journal of Epidemiology and Community Health 2006; 60(2): 95-101. doi: 10.1136/jech.2004.028092

Goldthorpe John H (1980). Social mobility and class structure in modern Britain. Oxford, Clarendon Press – Oxford, 1980.

González Monica Alonso, Artalejo Fernando Rodríguez and del Rey Calero Juan (1998). Relationship between socioeconomic status and ischaemic heart disease in cohort and case-control studies: 1960-1993. International Journal of Epidemiology 1998; 27(3): 350-358.

Graunt John (1665). Natural and political observations mentioned in a following index, and made upon the bills of mortality.

Available at European Cultural Heritage Online, http://nausikaa2.mpiwg-berlin.mpg.de/cgi-bin/toc/toc.x.cgi?dir=Graunt_1665&step=thumb

Gubéran Etienne and Massimo Usel (1998). Permanent work incapacity, mortality and survival without work incapacity among occupations and social classes: a cohort study of ageing men in Geneva. International Journal of Epidemiology 1998; 27(6): 1026-1032.

Faggiano F, Partanen T, Kogevinas M and Boffetta P (1997). In (pp. 65-176): Kogevinas M, Pearce N, Susser M and Boffetta P, editors (1997). Social inequalities and cancer. IARC Scientific Publications no. 138. Lyon, International Agency for Research on Cancer, 1997.

Hagen Kåre B, Holte Hilde H, Tambs Kristian and Bjerkedal Tor (2000). Socioeconomic factors and disability retirement from back pain. A 1983–1993 population-based prospective study in Norway. Spine 2000; 25(19): 2480-2487.

Hagen Knut, Zwart John-Anker, Svebak Sven, Bovim Gunnar and Stovner Lars Jacob (2005). Low socioeconomic status is associated with chronic musculoskeletal complaints among 46,901 adults in Norway. Scandinavian Journal of Public Health 2005; 33(4): 268-275.

Hammar N, Alfredsson L and Johnson JV (1998). Job strain, social support at work, and incidence of myocardial infarction. Occupational and Environmental Medicine 1998; 55(8): 548-553.

Hansson GÅ, Balogh I, Unge Byström J, Ohlsson K, Nordander C, Asterland P, Sjölander S, Rylander L, Winkel J, Skerfving S (2001). Questionnaire versus direct technical measurements in assessing postures and movements of the head, upper back, arms and hands. Scandinavian Journal of Work, Environment and Health 2001; 27(1): 30-40.

Harkness EF, Macfarlane GJ, Nahit ES, Silman AJ and McBeth J (2003). Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers. Occupational and Environmental Medicine 2003; 60(11): 850-857. doi:10.1136/oem.60.11.850

Hartvigsen Jan, Bakketeig Leiv S, Leboeuf-Yde Charlotte, Engberg Marianne and Lauritzen Torsten (2001). The association between physical workload and low back pain clouded by the "healthy worker" effect. Spine 2001; 26(16): 1788-1793.

Heistaro S, Jousilahti P, Lahelma E, Vartiainen E and Puska P (2001). Self rated health and mortality: a long term prospective study in eastern Finland. Journal of Epidemiology and Community Health 2001; 55(4): 227-232.

Heliövaara M, Aho K, Aromaa A, Knekt P and Reunanen A (1993). Smoking and risk of rheumatoid arthritis. Journal of Rheumatology 1993; 20(11): 1815-1816.

Heliövaara Markku (1999). Work load and back pain. Scandinavian Journal of Work, Environment and Health 1999; 25(5): 385-386.

Heliövaara Markku and Rissanen Aila (2007). Lihavuus ja painonhallinta. In: Prättälä Ritva and Paalanen Laura (editors). Elintavat ja niiden väestöryhmäerot Suomessa. Terveys 2000 –tutkimus. Publications of National Public Health Institute B2/2007. Helsinki, Kansanterveyslaitos – National Public Health Institute, 2007.

Hemingway Harry, Nicholson Amanda, Stafford Mai, Roberts Ron and Marmot Michael (1997). The impact of socioeconomic status on health functioning as assessed by the SF-36 questionnaire: the Whitehall Study. American Journal of Public Health 1997; 87(9): 1484-1490.

Hemingway Harry and Marmot Michael (1999). Evidence based cardiology. Psychosocial factors in the etiology and prognosis of coronary heart disease: systematic review of prospective cohort studies. BMJ 1999; 318(7196): 1460-1467.

Hofmann Bjørn (2005). Simplified models of the relationship between health and disease. Theoretical Medicine and Bioethics 2005; 26(5): 355-377. doi: 10.1007/s11017-005-7914-8

Hofmann Bjørn (2002). On the triad disease, illness and sickness. Journal of Medicine and Philosophy 2002; 27(6): 651-673. doi: 10.1076/jmep.27.6.651.13793

Hooftman Wendela E, van Poppel Mireille NM, van der Beek Allard J, Bongers Paulien J and van Mechelen Willem (2004). Scandinavian Journal of Work, Environment and Health 2004; 30(4): 261-278.

Hoogendoorn Wilhelmina E, van Poppel Mireille NM, Bongers Paulien M, Koes Bart W and Bouter Lex M (1999). Physical load during work and leisure time as risk factors for back pain. Scandinavian Journal of Work, Environment and Health 1999; 25(5): 387-403.

Hoogendoorn WE, Bongers PM, de Vet HCW, Ariëns GAM, van Mechelen W and Bouter LM (2002). High physical work load and low job satisfaction increase the risk of sickness absence due to low back pain: results of a prospective cohort study. Occupational and Environmental Medicine 2002; 59(5): 323-328.

Hoozemans Marco JM, van der Beek Allard J, Frings-Dresen Monique HW, van Dijk Frank JH, van der Woude Luc HV (1998). Pushing and pulling in relation to musculoskeletal disorders: a review of risk factors. Ergonomics 1998; 41(6): 757-781.

Hoozemans Marco JM, van der Beek Allard J, Frings-Dresen Monica HW, van der Woude Luc HV, van Dijk Frank JH (2002a). Low-back and shoulder complaints among workers with pushing and pulling tasks. Scandinavian Journal of Work, Environment and Health 2002; 28(5): 293-303.

Hoozemans MJM, van der Beek AJ, Frings-Dresen MHW, van der Woude LHV, van Dijk FJH (2002b). Pushing and pulling in association with low back and shoulder complaints. Occupational and Environmental Medicine 2002; 59(10): 696-702.

Hopkins Eric (1982). Working hours and conditions during the industrial revolution: a re-appraisal. The Economic History Review, New Series 1982; 35(1), 52-66.

Hopkins Eric (2000). Industrialisation and society. A social history, 1830-1951. London/New York, Routledge, 2000.

Hunt Sonja M and McEwen James (1980). The development of a subjective health indicator. Sociology of Health and Illness 1980; 2(3): 231-246.

Hunt Sonja M, McEwen James and McKenna SP (1985). Social inequalitites and perceived health. Effective Health Care 1985; 2(4): 151-160.

Hytti Helka (1993). Työkyvyttömyyseläkkeelle siirtymisen yhteiskunnalliset taustatekijät. Kansaneläkelaitoksen julkaisuja M:87. Helsinki, Kansaneläkelaitos, 1993.

Idler Ellen L (1979). Definitions of health and illness and medical sociology. Social Science and Medicine 1979; 13A: 723-731.

Idler Ellen L and Benyamini Yael (1997). Self-rated health and mortality: a review of twenty-seven community studies. Journal of Health and Social Behavior 1997; 38(1): 21-37.

Illsley Raymond and Svensson Per-Gunnar, editors (1984). The health burden of social inequities. Copenhagen, World Health Organisation, Regional Office for Europe, 1984.

Illsley Raymond and Svensson Per-Gunnar, editors (1990). Health inequities in Europe. Social Science and Medicine 1990; 31(3): 223-420.

Ilmarinen Juhani, editor (1985). Työ, terveys ja eläkeikä kunta-alalla. Työterveyslaitoksen tutkimuksia 1985 nro 2. Helsinki, Työterveyslaitos, 1985.

Ishizaki Masao, Martikainen Pekka, Nakagawa Hideaki, Marmot Michael and the Japan Work Stress and Health Cohort Study Group (2001). Influence of socioeconomic status and job control on plasma fibrinogen responses to acute mental stress. Scandinavian Journal of Work, Environment and Health 2001; 27(4): 287-291.

Jarvis Martin J and Wardle Jane (2006). Social patterning of individual health behaviour: the case of cigarette smoking. In: Marmot Michael and Wilkinson Richard G, editors. Social determinants of health. Second edition. Oxford/New York, Oxford University Press, 2006.

Jordan Z A (1971). Introductory essay: Karl Marx as a philosopher and a sociologist. In: Marx Karl; Jordan Z A, editor (1971). Karl Marx: Economy, Class and Social Revolution. 2nd reprint; London, Nelson, 1972.

Jylhä Marja, Volpato Stefano and Guralnik Jack M (2006). Self-rated health showed a graded association with frequently used biomarkers in a large population sample. Journal of Clinical Epidemiology 2006; 59(5): 465-471.

Järvisalo Jorma, Bergström Monica and Kaleva Simo (1997). Työkykyindeksin vaihtelua selittävät tekijät pientyöpaikkaohjelman aineistossa. In: Bergström Monica, Huuskonen Matti S, Koskinen Kari, Kaleva Simo, Ahonen Guy, Järvisalo Jorma, Forss Simo, Järvikoski Aila and Vuorio Ritva. Työkyky yksilön, pienyrityksen ja yhteiskunnan menestystekijänä. Työ ja ihminen tutkimusraportti 10. Helsinki, Työterveyslaitos, 1997.

Kaila-Kangas L, Keskimäki I, Notkola V, Mutanen P, Riihimäki H and Leino-Arjas P (2006). How consistently distributed are the socioeconomic differences in severe back morbidity by age and gender? A population based study of hospitalisation among Finnish employees. Occupational and Environmental Medicine 2006; 63(4): 278-282. doi: 10.1136/oem.2005.021642

Kaila-Kangas Leena, editor (2007). Musculoskeletal disorders and diseases in Finland. Results of the Health 2000 Survey. Publications of the National Public Health Institute B25/2007. Helsinki, Kansanterveyslaitos, 2007.

Available at National Publich Health Institute, http://www.ktl.fi/portal/2920

Kalimo Raija (1980). Stress in work. Conceptual analysis and study on prison personnel. Scandinavian Journal of Work, Environment and Health 1980: 6 supplement 3.

Kaplan George A and Keil Julian E (1993). Socioeconomic factors and cardiovascular disease: a review of the literature. Circulation 1993; 88(4): 1973-1998.

Kaprio Jaakko, Sarna Seppo, Fogelholm Mikael and Koskenvuo Markku (1996). Total and occupationally active life expectancies in relation to social class and marital status in men classified as healthy at 20 in Finland. Journal of Epidemiology and Community Health 1996; 50(6): 653-660.

Karasek Robert A Jr (1979). Job demands, job decision latitude, and mental strain: implications for job redesign. Adminstrative Science Quarterly 1979;24(2):285-307.

Karasek R, Baker D, Marxer F, Ahlbom A, Theorell T (1981). Job decision latitude, job demands, and cardiovascular disease: a prospective study of swedish men. Am J Public Health 1981;71:694-705.

Karasek Robert (1985/1993). Job content questionnaire and user's guide.

Document available from Job Content Questionnaire Center.

Karasek Robert, Brisson Chantal, Kawakami Norito, Houtman Irene, Bongers Paulien and Amick Benjamin (1998). The job content questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. Journal of Occupational Health Psychology 1998; 3(4): 322-355.

Karisto Antti (1981). Sosiaalilääketiede ja yhtieskunta. Katsuaus suomalaiseen terveyden sosiaalisia eroja koskevaan tutkimustoimintaan autonomian ajalta 1930-luvulle. Helsinki, Helsingin yliopisto, sosiaalipolitiikan laitos, tutkimuksia 3/1981.

Karisto Antti (1984). Hyvinvointi ja sairauden ongelma. [Welfare and the problem of illness] Helsinki, Kansaneläkelaitoksen julkaisuja M:46, 1984.

Karisto Antti, Notkola Veijo and Valkonen Tapani (1978). Socioeconomic status and health in Finland and the other Scandinavian countries. Social Science and Medicine 1978; 12C(3/4): 83-88.

Kauppinen Timo, Heikkilä Pirjo, Lehtinen Suvi, Lindström Kari, Näyhä Simo, Seppälä Anne, Tolkkanen Jouni and Tossavainen Antti (2000). Työ ja terveys Suomessa v. 2000. Helsinki, Työterveyslaitos, 2000.

Available at Finnish Institute of Occupational Health, http://www.ttl.fi/Internet/Suomi/Aihesivut/Tyoterveyshuolto/Tiedonlahteet/Kirjallisuus/tyo+ja+terveys.htm

Kauppinen Timo, Hanhela Rauno, Heikkilä Pirjo, Lehtinen Suvi, Lindström Kari, Toikkanen Jouni and Tossavainen Antti (2004). Työ ja terveys Suomessa 2003. Helsinki, Työterveyslaitos, 2004.

Available at Finnish Institute of Occupational Health, same url as for Kauppinen et al. 2000.

Kauppinen Timo, Hanhela Rauno, Heikkilä Pirjo, Kasvio Antti, Lehtinen Suvi, Lindström Kari, Toikkanen Jouni and Tossavainen Antti (2007). Työ ja terveys Suomessa 2006. Helsinki, Työterveyslaitos, 2007.

Available at Finnish Institute of Occupational Health, same url as for Kauppinen et al. 2000.

Kerr Clark, Dunlop John T, Harbison Frederick H and Myers Charles A (1962). Industrialism and industrial man. London and Edinburgh, Heinemann, 1962.

Kerr Clark (1983). The future of industrial societies – convergence or continuing diversity. Cambridge (Mass.), Harvard University Press, 1983.

Kestilä Laura, Koskinen Seppo, Martelin Tuija, Rahkonen Ossi, Pensola Tiina, Pirkola Sami, Patja Kristiina and Aromaa Arpo (2006). Influence of parental education, childhood adversities, and current living conditions on daily smoking in early adulthood. European Journal of Public Health 2006; 16(6): 617-626. doi:10.1093/eurpub/ckl054

Kjeldsen Sverre E, Knudsen Karl, Ekrem Gunhild, Fure Tormod O, Movinckel Petter and Erikssen Jan E (2006). Is there an assoication between severe job strain, transient rise in blood pressure and increased mortality? Blood Pressure 2006; 15(2): 93-100.

Kogevinas M and Porta M (1997). Socioeconomic differences in cancer survival: a review of the evidence. In (pp. 177-206): Kogevinas M, Pearce N, Susser M and Boffetta P, editors (1997). Social inequalities and cancer. IARC Scientific Publications no. 138. Lyon, International Agency for Research on Cancer, 1997.

Kogevinas M, Pearce N, Susser M and Boffetta P, editors (1997). Social inequalities and cancer. IARC Scientific Publications no. 138. Lyon, International Agency for Research on Cancer, 1997.

Krieger Nancy (2001). A glossary for social epidemiology. Journal of Epidemiology and Community Health 2001; 55(10): 693-700. doi:10.1136/jech.55.10.693

Krieger N, Williams DR and Moss NE (1997). Measuring social class in US public health research: concepts, methodologies, and guidelines. Annual Review of Public Health 1997; 18: 341-378.

Krokstad Steinar, Johnsen Roar and Westin Steinar (2002). Social determinants of disability pension: a 10-year follow-up of 62 000 people in a Norwegian county population. International Journal of Epidemiology 2002; 31(6): 1183-1191.

Koos Earl Lomon (1954/1967). The health of Regionville: what the people thought and did about it. New York and London, Hafner, 1954, reprinted 1967.

Koskimies Akseli (1916). Mitä ovat sosiaalihygienia ja sosiaalimedisiina? Duodecim 1916; 32(3): 133-147.

Kuh Diana and Ben-Shlomo Yoav, editors (1997). A life course approach to chronic disease epidemiology. Oxford, Oxford University Press, 1997.

Kunitz Stephen J (2002). Holism and the idea of general susceptibility to disease. International Journal of Epidemiology 2002; 31(4): 722-729.

Kunst Anton E, del Rios Marina, Groenhof Feikje and Mackenbach Johan P (1998 a). Socioeconomic inequalities in stroke mortality among middle-aged men: an international overview. Stroke 1998; 29(11): 2285-2291.

Kunst Anton E, Groenhof Feikje, Mackenbach Johan P and the EU Working Group on Socioeconomic Inequalities in Health (1998 b). Mortality by occupational class among men 30-64 years in 11 European countries. Social Science and Medicine 1998; 46(11): 1459-1476.

Kunst Anton E, Groenhof Feikje, Mackenbach Johan P and the EU Working Group on Socioeconomic Inequalities in Health (1998 c). Occupational class and cause specific mortality in middle aged men in 11 European countries: comparison of population based studies. BMJ 1998; 316(7145): 1636-1642.

Kunst Anton E, Bos Vivian, Lahelma Eero, Bartley Mel, Lissau Inge, Regidor Enrique, Mielck Andreas, Cardano Mario, Dalstra Jetty AA, Geurts José JM, Helmert Uwe, Lennartsson Carin, Ramm Horun, Spadea Teresa, Stronegger Willibald J and Mackenbach Johan P (2005). Trends in socioeconomic inequalities in self-assessed health in 10 European countries. International Journal of Epidemiology 2005; 34(2): 295-305. doi:10.1093/ije/dyh342

Kuorinka Ilkka and Lina Forcier, scientific editors; Hagberg Mats, Silverstein Barbara, Wells Richard, Smith Michael J, Hendrick Hal W, Carayon Pascale and Pérusse Michel (1995). Work related musculoskeletal disorders (WMSDs): a reference book for prevention. London, Taylor & Francis, 1995.

Kuper H and Marmot M (2003). Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study. Journal of Epidemiology and Community Health 2003; 57(2): 147-153. doi:10.1136/jech.57.2.147

Laaksonen Mikko, Sarlio-Lähteenkorva Sirpa and Lahelma Eero (2004). Multiple dimensions of socioeconomic position and obesity among employees: the Helsinki Health Study. Obesity Research 2004; 12(11): 1851-1858.

Laaksonen Mikko, Aittomäki Akseli, Lallukka Tea, Rahkonen Ossi, Saastamoinen Peppiina, Silventoinen Karri and Lahelma Eero (2008). Register-based study among employees showed small nonparticipation bias in health surveys and check-ups. Journal of Clinical Epidemiology, available online 20 May 2008. doi:10.1016/j.jclinepi.2007.09.010

Lahelma Eero and Arber Sara (1994). Health inequalities among men and women in contrasting welfare states. Britain and three Nordic countries compared. European Journal of Public Health 1994; 4(3): 213-226.

Lahelma Eero, Manderbacka Kristiina, Rahkonen Ossi and Karisto Antti (1994). Comparisons of inequalities in health: evidence from national surveys in Finland, Norway and Sweden. Social Science and Medicine 1994; 38(4): 517-524.

Lahelma Eero, Karisto Antti and Rahkonen Ossi (1996). Analysing inequalities. The tradition of socioeconomic public health research in Finland. European Journal of Public Health 1996: 6(2): 87-93. doi: 10.1093/eurpub/6.2.87

Lahelma Eero, Lundberg Olle, Manderbacka Kristiina and Roos Eva (2001). Changing health inequalities in the Nordic countries? Scandinavian Journal of Public Health 2001; 29 suppl 55: 1-5. doi:10.1080/14034940175028569 2.

Lahelma Eero, Martikainen Pekka, Laaksonen Mikko and Aittomäki Akseli (2004). Pathways between socioeconomic determinants of health. Journal of Epidemiology and Community Health 2004; 58(4): 327-332. doi:10.1136/jech.2003.011148

Lallukka Tea, Aittomäki Akseli, Piha Kustaa, Roos Eva, Kivelä Katariina and Silventoinen Karri (2002). Postikyselyn vastanneiden edustavuus sosioekonomisten tekijöiden ja sairauspoissaolotietojen mukaan: Helsingin kaupungin henkilöstön terveystutkimus. Sosiaalilääketieteellinen aikakauslehti 2002; 39(3): 164-171.

Lallukka Tea, Sarlio-Lähteenkorva Sirpa, Roos Eva, Laaksonen Mikko, Rahkonen Ossi, Lahelma Eero. Working conditions and health behaviors among employed women and men: the Helsinki Health Study. Preventive Medicine 2004; 38(1): 48-56.

Lallukka Tea, Lahelma Eero, Rahkonen Ossi, Roos Eva, Laaksonen Elina, Martikainen Pekka, Head Jenny, Brunner Eric, Mosdol Annhild, Marmot Michael, Sekine Michikazu, Nasermoaddeli Ali and Kagamimori Sadanobu (2008). Associations of job strain and working overtime with adverse health behaviors and obesity: evidence from the Whitehall II Study, Helsinki Health Study, and the Japanese Civil Servants Study. Social Science and Medicine 2008; 66(8): 1681-1698.

Lallukka Tea (1998). Associations among working conditions and behavioral risk factors: the Helsinki Health Study with international comparisons. Publications of Public Health M 191:2008. Helsinki, University of Helsinki, 2008.

Electronic version available at University of Helsinki,
http://ethesis.helsinki.fi/en/

Leino-Arjas Päivi, Liira Juha, Mutanen Pertti, Malmivaara Antti and Matikainen Esko (1999). Predictors and consequences of unemployment among construction workers: prospective cohort study. BMJ 1999; 319(7210): 600-605.

Leino-Arjas Päivi, Kaila-Kangas Leena, Kauppinen Timo, Notkola Veijo, Keskimäki Ilmo and Mutanen Pertti (2004). Occupational exposures and inpatient hospital care for lumbar intervertebral disc disorders among Finns. American Journal of Industrial Medicine 2004; 46(5): 513-520. doi:10.1002/ajim.20084

Liberatos Penny, Link Bruce G and Kelsey Jennifer K (1988). The measurement of social class in epidemiology. Epidemiologic Review 1988; 10(1): 87-121.

Lissau Inge, Rasmussen Niels Kristian, Moss Hesse Nina and Hesse Ulrik (2001). Social differences in illness and health-related exclusion from the labour market in Denmark from 1987 to 1994. Scandinavian Journal of Public Health 2001; 29 suppl 55: 19-30. doi:10.1080/140349401750285719.

Lundberg Olle (1986). Class and health: comparing Britain and Sweden. Social Science and Medicine 1986; 23(5): 511-517.

Lundberg Olle (1991). Causal explanations for class inequality in health: An empirical analysis. Social Science and Medicine 1991; 32(4): 385-393.

Lundberg Olle, Diderichsen Finn and Åberg Yngve Monica (2001). Changing health inequalities in a changing society? Sweden in the mid-1980s and mid-1990s. Scandinavian Journal of Public Health 2001; 29 suppl 55: 31-39. doi:10.1080/140349401750285728.

Lynch John W, Kaplan George A and Salonen Jukka T (1997). Why do poor people behave poorly? Variation in adult health behaviours and psychosocial characteristics by stages of the socioeconomic lifecourse. Social Science and Medicine 1997; 44(6): 809-819.

Lynch John and Kaplan George (2000). Socioeconomic Position. In: Berkman Lisa F and Kawachi Ichiro, editors. Social Epidemiology. Oxford/New York, Oxford University Press, 2000.

Lynch John and Davey Smith George (2005). A life course approach to chronic disease epidemiology. Annual Review of Public Health 2005; 26: 1-35. doi: 10.1146/annurev.publhealth.26.021304.144505

Macintyre Sally (1986). Health and illness. In: Burgess Robert G, editor. Key variables in social investigation. London/Boston/Henley, Routledge & Kegan Paul, 1986.

Macintyre Sally (1997). The Black report and beyond what are the issues? Social Science and Medicine 1997; 44(6): 723-745.

Mackenbach Johan P, Simon Jeanette G, Looman Caspar WN and Joung Inez MA (2002). Self-assessed health and mortality: could psychosocial factors explain the association? International Journal of Epidemiology 2002; 31(6): 1162-1168.

Mackenbach Johan P, Bos Vivian, Andersen Otto, Cardano Mario, Costa Giuseppe, Harding Seeromanie, Reid Alison, Hemström Örjan, Valkonen Tapani and Kunst Anton E (2003). Widening socioeconomic inequalities in mortality in six Western European countries. International Journal of Epidemiology 2003; 32(5): 830-837.

Maetzel Andreas, Mäkelä Matti, Hawker Gillian and Bombardier Claire (1997). Osteoarthritis of the hip and knee and mechanical occupational exposure – a systematic overview of the evidence. Journal of Rheumatology 1997; 24(8): 1599-607.

Manderbacka Kristiina (1998 a). Examining what self-related health question is understood to mean by respondents. Scandinavian Journal of Social Medicine 1998; 26(2): 145-53.

Manderbacka Kristiina (1998 b). Questions on survey questions on health. Stockholm, Swedish Institute for Social Research, 1998.

Manderbacka Kristiina, Lahelma Eero and Rahkonen Ossi (2001). Structural changes and social inequalities in health in Finland, 1986-1994. Scandinavian Journal of Public Health 2001; 29 suppl 55: 41-54. doi: 10.1080/14034940175028573 7.

Manner Viktor (1916). Kuolinsyyt ja keski-ikä erinäisissä ammateissa Helsingissä 1896-1915. Duodecim 1916: 32(4-5): 183-206.

Manninen Pirjo, Heliövaara Markku, Riihimäki Hilkka and Suomalainen Olavi (2002). Physical workload and the risk of severe knee osteoarthritis. Scandinavian Journal of Work, Environment and Health 2002; 28(1): 25-32.

Marmot MG, Bosma H, Hemingway H, Brunner E and Stansfeld S (1997). Contribution of job control and other risk factors to social variations in coronary heart disease incidence. Lancet 1997; 350(9073): 235-239.

Marmot Michael (2005). Status syndrome. How your social standing directly affects your health and life expectancy. London, Bloomsbury, 2005.

Marmot Michael, Siegrist Johannes and Theorell Tores (2006). Health and the psychosocial environment at work. In: Marmot Michael and Wilkinson Richard G, editors. Social determinants of health. Second edition. Oxford/New York, Oxford University Press, 2006.

Marshall Gordon (1990). John Goldthorpe and class analysis. In: Clark Jon, Modgil Celia and Modgil Sohan (editors). John H. Goldthorpe Consensus and Controversy. London, Falmer, 1990.

Martikainen Pekka, Stansfeld Stephen, Hemingway Harry and Marmot Michael (1999). Determinants of socioeconomic differences in change in physical and mental functioning. Social Science and Medicine 1999; 49(4): 499-507.

Martikainen Pekka, Valkonen Tapani and Martelin Tuija (2001). Change in male and female life expectancy by social class: decomposition by age and cause of death in Finland 1971-95. Journal of Epidemiology and Community Health 2001; 55(7): 494-499.

Martikainen Pekka, Lahelma Eero, Marmot Michael, Sekine Michikazu, Nishi Nobuo and Kagamimori Sadanobu (2004). A comparison of socioeconomic differences in physical functioning and perceived health among male and female employees in Britain, Finland and Japan. Social Science and Medicine 2004; 59(6): 1287-1295. doi:10.1016/j.socscimed.2004.01.005

Martikainen Pekka, Laaksonen Mikko, Piha Kustaa and Lallukka Tea (2007). Does survey non-response bias the association between occupational social class and health? Scandinavian Journal of Public Health 2007; 35(2): 212-215.

Marx Karl and Engels Friedrich (1848/1955); Moore Samuel, translator. Manifesto of the Communist Party. Chicago, Encyclopaedia Britannica, 1955.

Marx Karl; Jordan Z A, editor (1971). Karl Marx: Economy, Class and Social Revolution. 2nd reprint; London, Nelson, 1972.

Marx Karl (1867/1971); Moore Samuel and Aveling Edward, translators (1887); Engels Friedrich, editor. Capital – A Critical Analysis of Capitalist Production. After 3rd german revision. 4th reprint; London, George Allen & Unwind Ltd, 1971.

Marx Karl (1867/1974); Louhivuori O V, translator (Finnish, 1957); Engels Friedrich, editor. Pääoma – Kansantaloustieteen arvostelua. Moscow, Kustannusliike Edistys, 1974.

McHorney Colleen A, Ware John E Jr and Raczek Anastasia E (1993). The MOS 36-item Short-Form survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. Medical Care 1993; 31(3): 247-263.

Meklin T, Putus T, Pekkanen J, Hyvärinen A, Hirvonen M-R and Nevalainen A (2005). Effects of moisture-damage repairs on microbial exposure and symptoms in schoolchildren. Indoor Air 2005; 15 supplement 10: 40-47.

Muntaner Carles and O'Campo Patricia J (1993). A critical appraisal of the demand/control model of the psychosocial work environment: epistemological, social, behavioural and class considerations. Social Science and Medicine 1993; 36(11): 1509-1517.

Månsson Nils-Ove, Råstam Lennart, Eriksson Karl-Fredrik and Israelsson Bo (1998). Socioeconomic inequalities and disability pension in middle-aged men. International Journal of Epidemiology 1998: 27(6): 1019-1025.

National Institute for Occupational Health and Safety (2007). NIOSH Pocket Guide to Chemical Hazards. Third printing. DHHS (NIOSH) Publication No. 2005-149.

Available at National Institute for Occupational Health and Safety, information resources, http://www.cdc.gov/niosh/npg/

Nihtilä Elina and Martikainen Pekka (2007). Household income and other socio-economic determinants of long-term institutional care among older adults in Finland. Population Studies 2007; 61(3): 299-314.

Paoli Pascal (1992). First European survey on the work environment 1991-1992. Dublin/Luxembourg, European Foundation for the Improvement of Living and Working Conditions, 1992.

Available at European Foundation for the Improvement of Living and Working Conditions, http://www.eurofound.europa.eu/publications/htmlfiles/ef9211.htm

Paoli Pascal (1997). Second European survey on working conditions. Dublin, European Foundation for the Improvement of Living and Working Conditions, 1997.

Available at European Foundation for the Improvement of Living and Working Conditions, http://www.eurofound.europa.eu/publications/htmlfiles/ef9726.htm

Paoli Pascal and Merllié Damien (2001). Third European survey on working conditions 2000. Dublin/Luxembourg, European Foundation for the Improvement of Living and Working Conditions, 2001.

Available at European Foundation for the Improvement of Living and Working Conditions, http://www.eurofound.europa.eu/publications/htmlfiles/ef0121.htm

Parent-Thirion Agnés, Macías Enrique Fernández, Hurley John and Vermeylen Greet (2007). Fourth European working conditions survey. Dublin/Luxembourg, European Foundation for the Improvement of Living and Working Conditions, 2007.

Available at European Foundation for the Improvement of Living and Working Conditions, http://www.eurofound.europa.eu/publications/htmlfiles/ef0698.htm

Parsons Talcott (1940/1954). An analytical approach to the theory of social stratification. In: Talcott Parsons (1954). Essays in sociological theory (revised edition). Glencoe, The Free Press, 1954. Pp. 69-88.

Parsons Talcott (1951/1991). The Social System. London, Routledge, 1991.

Parsons Talcott and Fox Renée (1952). Illness, therapy and the modern urban American family. Journal of Social Issues 1952; 8(4): 31-44.

Paul Jeannette A, van Dijk Frank JH, Frings-Dresen Monique HW (1994). Work load and musculoskeletal complaints during pregnancy. Scandinavian Journal of Work, Environmant and Health 1994;20:153-159.

Pedersen Merete, Jacobsen Søren, Klarlund Mette and Frisch Morten (2006). Socioeconomic status and risk of rheumatoid arthritis: a danish case-control study. The Journal of Rheumatology 2006; 33(6): 1069-1074.

Pensola Tiina (2000). The classification of social class after 1975: Differentiating skilled manual from unskilled manual workers. A memo.

Available at University of Helsinki, http://blogs.helsinki.fi/populationru/socioeconomic-classification/

Perkiö-Mäkelä Merja, Hirvonen Maria, Elo Anna-Liisa, Ervasti Jenni, Huuhtanen Pekka, Kandolin Irja, Kauppinen Kaisa, Kauppinen Timo, Ketola Ritva, Lindström Kari, Manninen Pirjo, Mikkola Jutta, Reijula Kari, Riala Riitta, Salminen Simo, Toivanen Minna and Viluksela Marja (2006). Työ ja terveys - haastattelututkimus 2006. Taulukkoraportti. [Work and health interview study in year 2006. Table report.] Helsinki, Työterveyslaitos, 2006.

Piirainen Helena, Elo Anna-Liisa, Kankaanpää Eila, Laitinen Heikki, Lindström Kari, Luopajärvi Tuulikki, Mäkelä Pentti, Pohjanpää Kirsti and Riala Riitta (1997). Työ ja terveys -haastattelututkimus v. 1997. Taulukkoraportti. [Work and health interview study in year 1997. Table report.] Helsinki, Työterveyslaitos, 1997.

Piirainen Helena, Elo Anna-Liisa, Hirvonen Maria, Kauppinen Kaisa, Ketola Ritva, Laitinen Heikki, Lindström Kari, Reijula Kari, Riala Riitta, Viluksela Marja and Virtanen Simo (2000). Työ ja terveys -haastattelututkimus v. 2000. Taulukkoraportti. [Work and health interview study in year 2000. Table report.] Helsinki, Työterveyslaitos, 2000.

Piirainen Helena, Hirvonen Maria, Elo Anna-Liisa, Huuhtanen Pekka, Kandolin Irja, Kauppinen Kaisa, Ketola Ritva, Lindström Kari, Salminen Simo, Reijula Kari, Riala Riitta, Toivanen Minna, Viluksela Marja and Virtanen Simo (2003). Työ ja terveys -haastattelututkimus 2003. Taulukkoraportti. [Work and health interview study in year 2003. Table report.] Helsinki, Työterveyslaitos, 2003.

Power Chris, Matthews Sharon and Manor Orly (1996). Inequalities in self rated health in the 1958 birth cohort: lifetime social circumstances or social mobility? BMJ 1996; 313(7055): 449-453.

Purola Tapani (1972). A systems approach to health and health policy. Medical Care 1972; X(5): 373-379.

Ramazzini Bernardino (1713/1940); Wright Wilmer Cave, translator. De Morbis Artificum Diatriba. Chicago, University of Chicago Press, 1940.

Ramazzini Bernardino (1713/2001). An extract from De Morbis Artificum Diatriba. American Journal of Public Health 2001; 91(9): 1380-1381.

Relander Konrad (1885). Kuolevaisuus keuhkotaudin vaikutuksesta. Duodecim 1885; 1(11): 131.

Relander Konrad (1892/1992). Terveyshoidollisia tutkimuksia Haapajärven piirilääkäripiiristä. I. Terveyteen vaikuttavien olosuhteiden ja tapojen ynnä yleisen terveyskannan valaisemiseksi Haapaveden kunnassa. Helsinki, Kustannus Oy Duodecim, 1992.

Ricardo David (1817). On the Principles of Political Economy and Taxation. London, John Murray, 1817.

Available at The Library of Economics and Liberty, http://www.econlib.org/LIBRARY/Ricardo/ricP.html

Rohmert W (1984). Das Belastungs-Beanspruchungs-Konzept. Zeitschrift für Arbeitswissenschaft 1984;38:193-200.

Sapolsky Robert M, Romero L Michael and Munck Allan U (2000). How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory and preparative actions? Endocrine Reviews 2000; 21(1): 55-89. doi: 10.1210/er.21.1.55

Schnall Peter L, Landsbergis Paul A and Baker Dean (1994). Job strain and cardiovascular disease. Annual Review of Public Health 1994; 15: 381-411.

Schrijvers Carola TM, van de Mheen H Dike, Stronks Karien and Mackenbach Johan P (1998). Socioeconomic inequalities in health in the working population: the contribution of working conditions. International Journal of Epidemiology 1998; 27(6): 1011-1018.

Selye Hans (1946). The general adaptation syndrome and the diseases of adaptation. Journal of Clinical Endocrinology and Metabolism 1946; 6(2): 117-230.

Selye Hans (1956). The stress of life. New York/Toronto/London, McGraw-Hill Book Company, 1956.

Siegrist Johannes (1996). Adverse health effects of high-effort/low-reward conditions. Journal of Occupational Health Psychology 1996; 1(1): 27-41.

Silventoinen Karri, Zdravkovic Slobodan, Skytthe Axel, McCarron Peter, Herskind Anne Maria, Koskenvuo Markku, de Faire Ulf, Pedersen Nancy, Christensen Kaare and Kaprio Jaakko (2006). Association between height and coronary heart disease mortality: a prospective study of 35,000 twin pairs. American Journal of Epidemiology 2006; 163(7): 615-621. doi: 10.1093/aje/kwj081

Sooman A, Macintyre S and Anderson A (1993). Scotland's health – a more difficult challenge for some? The price and availability of healthy foods in socially contrasting localities in the west of Scotland. Health Bulletin 1993; 51(5): 276-284.

Stafford Mai and McCarthy Mark (2006). Neighbourhoods, housing, and health. In: Marmot Michael and Wilkinson Richard, editors. Social determinants of health. 2nd edition. Oxford/New York, Oxford University Press, 2006.

Steptoe Andrew, Kunz-Ebrecht Sabine, Owen Natalie, Feldman Natalie J, Rumley Ann, Lowe Gordon DO and Marmot Michael (2003). Influence of socioeconomic status and job control on plasma fibrinogen responses to acute mental stress. Psychosomatic Medicine 2003; 65(1): 137-144.

Steptoe Andrew and Willemsen Gonneke (2004). The influence of low job control on ambulatory blood pressure and perceived stress over the working day in men and women from the Whitehall II cohort. Journal of Hypertension 2004; 22(5): 915-920.

Syme Leonard S and Berkman Lisa F (1976). Social class, susceptibility and sickness. American Journal of Epidemiology 1976; 104(1): 1-8.

Szreter Simon RS (1984). The genesis of the Registrar-General's social classification of occupations. British Journal of Sociology 1984; XXXV(4): 522-546.

Takala Esa-Pekka and Virtanen Simo (2004). Fyysiset kuormitustekijät. In: Kauppinen Timo, Hanhela Rauno, Heikkilä Pirjo, Lehtinen Suvi, Lindström Kari, Toikkanen Jouni and Tossavainen Antti. Työ ja terveys Suomessa 2003. Helsinki, Työterveyslaitos, 2004.

Tilastokeskus (1989). Sosioekonomisen aseman luokitus 1989. Käsikirjoja 17. Helsinki, Tilastokeskus, 1989.

Thomson Hilary, Petticrew Mark and Morrison David (2001). Health effects of housing improvement: systematic review of intervention studies. BMJ 2001; 323(7306): 187-190.

Torgén M, Winkel J, Alfredsson L and Kilbom Å (1999). Evaluation of questionnaire-based information on previous physical work loads. Scandinavian Journal of Work, Environment and Health 1999; 25(3): 246-254.

Torgén Maria, Kilbom Åsa (2000). Physical work load between 1970 and 1993 – did it change? Scandinavian Journal of Work, Environment and Health 2000; 26(2): 161–8.

Townsend Peter and Davidson Nick, editors (1982/1983); Black Douglas sir, Morris JN, Smith Cyril, Townsend Peter. Inequalities in health. The Black report. Harmondsworth/New York, Penguin Books, 1982. Reprinted 1983.

Tuomi Kaija, Ilmarinen Juhani, Järvinen Erkki, Wägar Gustav, Eskelinen Leena, Suurnäkki Timo and Huuhtanen Pekka (1985). Eläkeiän perusteiden tutkimuksen tausta, viitekehys ja osat. In: Ilmarinen Juhani, editor. Työ, terveys ja eläkeikä kunta-alalla. Työterveyslaitoksen tutkimuksia 1985 nro 2. Helsinki, Työterveyslaitos, 1985; pp. 85-94.

Tuomi Kaija, editor (1997). Eleven-year follow-up of aging workers. Scandinavian Journal of Work, Environment and Health 1997; 23 suppl 1.

Tuomi Kaija, Ilmarinen Juhani, Seitsamo Jorma, Huuhtanen Pekka, Martikainen Rami, Nygård Clas-Håkan and Klockars Matti (1997). Summary of the Finnish research project (1981-1992) to promote the health and work ability of aging workers. Scandinavian Journal of Work, Environment and Health 1997; 23 suppl 1: 66-71.

Twaddle Andrew C and Hessler Richard M (1977). A sociology of health. Saint Louis, C. V. Mosby Company, 1977.

Twaddle Andrew (1994). Disease, illness and sickness revisited. In: Twaddle Andrew and Nordenfelt Lennart. Disease, illness and sickness: three central concepts in the theory of health. Studies on Health and Society, 18. Linköping, Linköping University, 1994.

Upmark M, Lundberg I, Sadigh J, Bigert C (2001). Conditions during childhood and adolescence as explanations of social class differences in disability pension among young men. Scandinavian Journal of Public Health 2001; 29(2): 96-103.

Utriainen Inka, Sarlio-Lähteenkorva Sirpa, Aittomäki Akseli and Lahelma Eero (2006). Lihavuus ja keskivartalolihavuus Helsingin kaupungin henkilöstön keskuudessa. Tutkimuskatsauksia 2006:1. Helsinki, Helsingin kaupungin tietokeskus, 2006.

Valkonen Tapani and Martelin Tuija (1988). Occupational class and suicide: an example of the elaboration of a relationship. Helsingin yliopiston Sosiologian laitoksen tutkimuksia No. 222. Helsinki, Helsingin yliopisto, sosiologian laitos, 1988.

Valkonen Tapani, Martelin Tuija and Rimpelä Arja (1990). Socio-economic mortality differences in Finland in 1971-1985. Tilastokeskus, tutkimuksia 176. Helsinki, Tilastokeskus, 1990.

Valkonen Tapani, Martikainen Pekka, Jalovaara Marika, Koskinen Seppo, Martelin Tuija and Mäkelä Pia (2000). Changes in socioeconomic inequalities in mortality during an economic boom and recession among middle-aged men and women in Finland. European Journal of Public Health 2000; 10(4): 274-280.

Vesalius Andreas (1568/1725). Chirurgiae magnae libri VII. In: Vesalius Andreas; Boerhaave Herman, Albinus Bernhard Siegfried, editors. Andrea Vesalii Opera omnia anatomica & chirurgica, Tomus Secundus. Lugdunum Batavorum, 1725.

Available at European Cultural Heritage Online, http://echo.mpiwg-berlin.mpg.de/content/lifesciences/physiology

Videman Tapio and Battié Michele C (1999). The influence of occupation on lumbar degeneration. Spine 1999; 24(11): 1164-1168.

Viikari-Juntura E, Rauas S, Martikainen R, Kuosma E, Riihimaki H, Takala EP and Saarenmaa K (1996). Validity of self-reported physical work load in epidemiologic studies on musculoskeletal disorders. Scandinavian Journal of Work, Environment and Health 1996; 22(4): 251–259.

Vilho S (1887). Suomen lääkäriseuran 11 yleinen kokous. Duodecim 1887; 3(8): 141-155.

Villermé Louis René (1830). De la mortalité dans ’les divers quartiers de la ville de paris, et des causes qui la rendent tres differente dans plusieurs d ènträe eux, ainsi que dans les divers quartiers de beaucoup de grandes villes. Annales d hygiene publique 1830; 3: 294-341.

Available at Gallica collection of Bibliothéque nationale de France, http://gallica.bnf.fr/ark:/12148/bpt6k81421x.pdf

Villermé Louis René (1840). Tableau de l état physique et moral des ouvriers employés dans les manufactures de coton, de laine et de soie. Paris, Jules Renouard et cié, 1840.

Available at Gallica collection of Bibliothéque nationale de France, http://gallica.bnf.fr/ark:/12148/bpt6k6503b.pdf

Vingård Eva, Alfredsson Lars, Hagberg Mats, Kilbom Åsa, Theorell Töres, Waldenström Måns, Wigaeus Hjelm Ewa, Wiktorin Christina, Hogstedt Christer and the MUSIC-Norrtälje Study Group (2000). To what extent do current and past physical and psychosocial occupational factors explain care-seeking for low back pain in a working population?: results from the musculoskeletal intervention Center-Norrtälje Study. Spine 2000; 25(4): 493-500.

Vågerö Denny (1991). Inequality in health – some theoretical and empirical problems. Social Science and Medicine 1991; 32(4): 367-371.

Walker-Bone K and Cooper C (2005). Hard work never hurt anyone: or did it? A review of occupational associations with soft tissue musculoskeletal disorders of the neck and upper limb. Annals of Rheumatic Diseases 2005; 64(10): 1391–1396. doi:10.1136/ard.2003.020016

Ware John E Jr and Sherbourne Cathy Donald (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Medical Care 1992; 30(6): 473-481.

Ware John E Jr and Kosinski Mark (1994/2001). SF-36 physical and mental health summary scales: a manual for users of version 1, second edition. Lincoln, Rhode Island, QualityMetric Incorporated, 2001.

Warren John Robert, Hoonakker Peter, Carayon Pascale and Jennie Brand (2004). Job characteristics as mediators in SES-health relationships. Social Science and Medicine 2004; 59(7): 1367-1378.

Weber Max (1904/1970); Gerth H H and Wright Mills C, editors and translators (1948). From Max Weber Essays in Sociology. 7th reprint; London, Routledge and Kegan, 1970.

Weber Max (1914/1978); Roth Guenther and Wittich Claus editors (1968), various translators. Economy and society I. 2nd printing; Berkeley/Los Angeles/London, University of California Press, 1978.

West Patrick (1991). Rethinking the health selection explanation for health inequalities. Social Science and Medicine 1991; 32(4): 373-384.

Westgaard RH and Winkel J (1996). Guidelines for occupational musculoskeletal load as a basis for intervention: a critical review. Applied Ergonomics 1996;27(2):79-88.

Wiktorin Christina, Vingård Eva, Mortimer Monica, Pernold Gunilla, Wigaeus-Hjelm Ewa, Kilbom Åsa and Alfredsson Lars (1999). Interview versus questionnaire for assessing physical loads in the population-based MUSIC-Norrtälje Study. American Journal of Industrial Medicine 1999; 35(5): 441-455.

Wilkinson Richard G (1999). Health, hierarchy, and social anxiety. Annals of the New York Academy of Sciences 1999; 896(1): 48-63. doi:10.1111/j.1749-6632.1999.tb08104.x

Williams Simon J (1995). Theorising class, health and lifestyles: can Bourdieu help us? Sociology of Health and Illness 1995; 17(5): 577-604.

Williams Simon J (1998). Capitalising 'on emotions? Rethinking the inequalities in health debate. Sociology 1998; 32(1): 121-139.

Winkel Jørgen and Mathiassen Svend Erik (1994). Assessment of physical work load in epidemiological studies: concepts, issues and operational considerations. Ergonomics 1994; 37(6): 979-988.

Winkel J and Westgaard R (1992). Occupational and individual risk factor for shoulder-neck complaints: Part II. The scientific basis (literature review) for the guide. International Journal of Industrial Ergonomics 1992; 10: 85-104.

Wright Erik Olin (1985). Classes. London, Verso, original publication 1985, 3rd impression 1989.

von Wright Georg Henrik (1963/1972). The varieties of goodness. London, Routledge & Kegan Paul, 1972.

Young J T (2004). Illness behaviour: a selective review and synthesis. Sociology of Health and Illness 2004; 26(1): 1-31.

Zwart de Bart CH, Frings-Dresen Monique HW, van Dijk Frank JH (1995). Physical work load and the ageing worker: a review of the literature. International Archives of Occupational and Environmental Health 1995;68(1):1-12.

Östergren Per-Olog, Hanson Bertil S, Balogh Istvan, Ektor-Andersen John, Isacsson Agneta, Örbaek Palle, Winkel Jörgen, Isacsson Sven-Olof and the Malmö Shoulder Neck Study Group (2005). Journal of Epidemiology and Community Health 2005; 59(9): 721-728. doi:10.1136/jech.2005.034801

Previous Publications of public health M:

M 191/08 Lallukka Tea. Associations among working conditions and behavioral risk factors: The Helsinki Health Study with international comparisons.

M 192/08 Saarni Suoma. Obesity, smoking and dieting.

M 193/08 Broms Ulla. Nicotine dependence and smoking behavior. A genetic and epidemiological study.

M 194/08 Pitkäniemi Janne. Statistical analysis of the association of hereditary factors with the risk of type 1 diabetes and diabetic nephropathy based on the familial data collected through ascertainment from population-based registers.

ISBN 978-952-10-1381-2
ISBN 978-952-10-1382-9 (pdf)
ISSN 0355-7979

Helsinki University Print - Yliopistopaino
Helsinki 2008