Work-Related Inequalities in Health

Studies of income, work environment, and sense of coherence

by

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To the memory of Lauri
ABSTRACT

Morbidity and mortality are unevenly distributed across different groups in society, with the disadvantaged groups displaying higher rates of ill health than the more advantaged groups. The overall aim of the thesis is to study work-related inequalities in health, and to focus on how income, aspects of the physical and psychosocial work environment, and sense of coherence, individually or jointly, generate inequalities in a number of health outcomes in the Swedish working population. The studies are based on survey data and national registers during the period 1990-2003.

For cardiovascular disease (CVD) prevalence and mortality, the impact of income was stronger than that of work environment factors. The psychosocial work environment (women and men) and income (men only) were associated with psychological distress. Income (women) and the psychosocial work environment (men) were associated with musculoskeletal pain. To conclude, income and the work environment have an independent impact on CVD, psychological distress and musculoskeletal pain. Consequently, both factors are important in generating poor health in the working population.

A strong sense of coherence (SOC) moderated the effect of physical demands on musculoskeletal pain in both genders. A strong SOC slightly moderated the effect of job strain on psychological distress in women. Thus, SOC moderates, yet not consistently, the impact of adverse working conditions on psychological distress and musculoskeletal pain. Hence, the results do not fully support the hypothesis that sense of coherence is a global health-protective factor. However, differential vulnerability in terms of the strength of SOC contributed to poor health.

The risk of stroke was higher for women and men in occupations with low job control than for those with high job control. The relative risk of intracerebral hemorrhage was highest in women in low job-control occupations, while low job control did not significantly increase the risk of brain infarction in women. Job control was significantly related to mortality from stroke in women, but not in men. The effect of job control on stroke mortality in women was consistent in all classes except for upper non-manuals.
SAMMANFATTNING

Ojämlikhet i hälsa innebär systematiska skillnader i hälsa mellan olika grupper i samhället. Förekomsten av ohälsa är högre bland lägre socioekonomiska grupper jämfört med högre. Syftet med denna avhandling är att studera arbetsrelaterad ojämlikhet i hälsa med fokus på hur inkomst, arbetsmiljö och känsla av sammanhang, var för sig eller tillsammans, skapar ojämlikhet i hälsa bland de arbetande i Sverige.

Låg inkomst hade starkare effekt på hjärtkärlsjukdomar (prevalens och dödlighet) än arbetsmiljöpåfrestningar. Arbetsmiljön förklarade en liten del av inkomstskillnader i hjärtkärlsjukdomar. Den psykosociala arbetsmiljön (för kvinnor och män) och inkomst (för män) hade samband med psykiskt välbefinnande. Inkomst (för kvinnor) och den psykosociala arbetsmiljön (för män) hade samband med värk i muskler och leder. Inkomst och arbetsmiljöfaktorer har en självständig effekt på hjärtkärlsjukdomar, psykiskt välbefinnande och värk i muskler och leder. Således är både inkomst och arbetsmiljön viktiga bestämningsfaktorer för ohälsa bland den arbetande befolkningen.

En stark känsla av sammanhang (KASAM) buffrade den skadliga effekten av hög fysisk belastning och minskade således risken för värk i muskler och leder. En stark KASAM tycktes även buffra den skadliga effekten av psykosocial stress på arbetet, och minskade risken för nedsatt psykiskt välbefinnande för kvinnor. Sammanfattningsvis, en stark KASAM buffrar mot arbetsmiljöpåfrestningar, dock inte helt förenligt med teorin om KASAM som ser KASAM som en allmän hälsofrämjande faktor.

Risken för stroke (slaganfall) var högre för kvinnor och män i yrken med lågt beslutsutrymme än för dem med högt beslutsutrymme. Den relativa risken för hjärnblödning var högst bland kvinnor med lågt beslutsutrymme, medan lågt beslutsutrymme inte ökade risken för hjärninfarkt (propp) för kvinnor. Beslutsutrymme hade samband med dödlighet i stroke för kvinnor, men inte för män. Effekten av lågt beslutsutrymme på stroke-dödlighet var konsekvent i samtliga yrkesklasser förutom bland högre tjänstemän.
LIST OF PUBLICATIONS

The thesis is based on the following papers:


II. Toivanen, S. Work stress and wages in relation to psychological distress and musculoskeletal pain: results from the Swedish Level of Living Survey. (Submitted) 2007

III. Toivanen, S. Work stress and health: is the association moderated by sense of coherence? In Fritzell J & Lundberg O (Eds.), *Health Inequalities and Welfare Resources: Continuity and Change in Sweden*. Bristol: The Policy Press. 2007;87-107

IV. Toivanen, S. Job control and risk of incident stroke in the working population in Sweden. (Under revision) 2007

V. Toivanen, S and Hemström, Ö. Is the impact of job control on stroke independent from socioeconomic status? A large-scale study of the Swedish working population. *Stroke*; accepted 2007

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<table>
<thead>
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<th>Abbreviation</th>
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<tr>
<td>BI</td>
<td>Brain (cerebral) Infarction</td>
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<tr>
<td>CVD</td>
<td>Cardiovascular Disease</td>
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<tr>
<td>95% CI</td>
<td>95% Confidence Interval</td>
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<td>CHD</td>
<td>Coronary Heart Disease</td>
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<tr>
<td>DCM</td>
<td>Demand-Control Model</td>
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<td>DCQ</td>
<td>The Swedish Demand-Control Questionnaire</td>
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<td>ERI</td>
<td>Effort-Reward Imbalance Model</td>
</tr>
<tr>
<td>HPA</td>
<td>Hypothalamo-Pituitary-Adrenocortical axis</td>
</tr>
<tr>
<td>HR</td>
<td>Hazard Ratio</td>
</tr>
<tr>
<td>ICD</td>
<td>International Classification of Diseases</td>
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<td>ICH</td>
<td>Intracerebral Hemorrhage</td>
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<td>JEM</td>
<td>Job Exposure Matrix</td>
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<td>LNU</td>
<td>Level of Living Survey</td>
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<td>MSD</td>
<td>Musculoskeletal Disorder</td>
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<td>OR</td>
<td>Odds Ratio</td>
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<td>RR</td>
<td>Rate Ratio</td>
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<td>SAM</td>
<td>Sympatho-Adrenal-Medullary system</td>
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<td>SES</td>
<td>Socioeconomic status</td>
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<td>SOC</td>
<td>Sense of Coherence</td>
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<td>ULF</td>
<td>Survey of Living Conditions</td>
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<td>UND</td>
<td>Undetermined pathological type of stroke</td>
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INTRODUCTION

This thesis is dedicated to the study of work-related inequalities in health. Generally, work provides structure and meaning in life, and it certainly contributes to the health and well-being of individuals, and to the wealth of societies. Work is the basis of an individual’s status position in a society (Goldthorpe, 2000, pp. 206-229), and status position has an impact on health in humans and other primates (Marmot, 2004; Sapolsky, 2004). However, some aspects of work may pose a threat to human health. For instance, occupational hazards contribute 2-3% to the global burden of deaths (Murray & Lopez, 1997), it has been suggested that working conditions cause 20-30% of morbidity in the Nordic countries (Meldorf Hansen, 1993), and poor working conditions cause losses as high as 2-4% to the gross domestic product (The Nordic Council of Ministers, 2004).

Social inequalities in population health are avoidable and therefore unfair, and the reduction of such unfair health inequalities is on the agenda of most societies (Evans et al., 2001a). Previous studies of work-related factors as a source of social inequalities in health have focused on health differentials by occupation (e.g. Vahtera et al., 1999), or whether adverse work environment contributes to the health gradient by occupational class (e.g. Marmot & Theorell, 1988). The present thesis, however, chose to highlight income and work environment as sources of work-related inequalities in health. The aim of the thesis is to add to our understanding of how income and work environment factors generate health inequalities in the working population.

In investigating work-related inequalities in health, this thesis sought to combine three strands of research in relation to employees’ health: research into income differences, research into the physical and psychosocial work environment, and research into individual characteristics in terms of sense of coherence. We know from previous research that income, work environment, and sense of coherence all have an impact on health. However, these factors are seldom investigated simultaneously. For instance, people tend to

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1 Work environment comprises a multitude of both physical (ergonomic) and psychosocial factors associated with employees’ health. This thesis focuses on physical workload, i.e. how physically demanding a job is, and on the demand-control model and the effort-reward imbalance model as indicators of psychosocial exposures.
possess a variety of health-protective resources that may provide a buffer against ill health. One such resource may be a high income. There is a clear association between people’s income and their health (Fritzell et al., 2004). Another individual resource believed to be protective of health is a strong sense of coherence, a way of seeing our inner and outer world in a coherent way which helps us to cope successfully with complex stressors of daily life (Antonovsky, 1987a). Studies of the work environment and employees’ health tend to focus either on physical or psychosocial factors at work. Yet for many people, the work environment comprises both physical and psychosocial exposures. Accordingly, in order to increase our understanding of the adversity of the work environment, physical and psychosocial exposures should preferably be studied simultaneously.

Where work-related health is concerned, some diseases are of primarily occupational origin, and elimination of the adverse exposure at the workplace will result in a reduced disease rate. For instance, some lung diseases and dermatological conditions are associated with specific occupational exposures such as dust or contact with chemical substances (Garcia & Checkoway, 2003). Even if occupational diseases contribute to the burden of work-related ill health, it would not make sense to study occupational diseases in the whole working population as in most cases only specific occupational groups have such adverse exposures. Conversely, the work-related factors under study in the present thesis, i.e. physical and psychosocial exposures, are common across the whole working population. Work-related ill health may manifest itself in a number of diseases and symptoms. Instead of focusing on specific occupational groups, or on a specific health outcome, the present thesis analyzed work-related inequalities in the whole working population, or in representative samples of it. Several health outcomes, such as cardiovascular disease, stroke, psychological distress and musculoskeletal pain, were studied.
AIM OF THE THESIS

The overall aim of the thesis is to study work-related inequalities in health, and to focus on how income, aspects of the physical and psychosocial work environment, and sense of coherence, individually or jointly, generate inequalities in a number of health outcomes in the Swedish working population.

Specifically,

- to investigate the associations between income and physical and psychosocial work environment in relation to cardiovascular disease, psychological distress and musculoskeletal pain (Studies I & II)

- to investigate the associations between sense of coherence and physical and psychosocial work environment in relation to psychological distress and musculoskeletal pain (Study III)

- to investigate the associations between job control and stroke (Studies IV & V)
Definitions of health, ill health and work-related ill health

The World Health Organization defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1948). This comprehensive approach, usually called the social model of health, suggests that many factors, both environmental and individual, contribute to the state of complete well-being (Black et al., 1992). To operationalise and measure health as a state of complete well-being may be a complex task. Thus, studies of population health tend to define health outcomes as conditions deviating from health, and indicators such as mortality rates, prevalence or incidence of morbidity, and sickness-absence rates are used to measure population health. In addition, rates of non-fatal or fatal accidents or injuries at work are used to measure the impact of work on health in working populations (Garcia & Checkoway, 2003). Deviations from health are defined as ill health which comprises medically diagnosed disease, self experienced illness, and the social role of ill health defined as sickness. These different aspects of ill health are related in a complex way, and they often, yet not necessarily, overlap (Wikman et al., 2005).

Where work-related ill health is concerned, some diseases are of primarily occupational origin. For instance, some lung diseases and dermatological conditions are associated with specific occupational exposures such as dust or contact with chemical substances (Garcia & Checkoway, 2003). In addition to occupational diseases and work accidents and injuries, the term work-related ill health comprises all non-occupational diseases to whose aetiology work contributes (WHO, 2002). According to the most restrictive definition of work-relatedness applied by workers compensation funds, a causal relation between the work exposure and the health outcome is deemed necessary (Boedeker & Kreis, 2003). The broadest definition is the assessment made

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2 For a thorough discussion of health, its definitions, constructions and measurements, and of its relation to social circumstances, see for instance Blaxter (1990; 2004).
by working people themselves on the work-relatedness of ill health. Their assessment may, however, be influenced by negative affectivity, in other words ill people may be more prone to see their work environment as a potential cause of their illness. As employees typically cannot relate their work environment to specific diseases, self-reporting allows us to study general health outcomes. Another commonly used method of assessing work-relatedness is to analyse health outcomes by occupation or branch of industry. A higher disease frequency in certain occupations or branches may be an indication that there is an association between the work environment of these occupations or branches and the health outcome under study. To estimate the strength of an association between a work exposure and a health outcome, one can compare employees with a certain adverse work exposure with employees without this exposure. The resulting relative-risk estimate then indicates the strength of the association under study (ibid.).

Social inequalities in health in relation to work

The distribution of ill health is socially patterned, which results in a systematic variation in ill health across different groups in society (Lundberg, 1990; Erikson, 2001; Lahelma, 2001). This systematic variation, referred to as social inequality in health, is avoidable and therefore unfair (Whitehead, 1992; Kawachi et al., 2002; Braveman & Gruskin, 2003; Lahelma, 2006). Social inequalities in health are commonly reported by various dimensions of social stratification in society such as educational system, occupational structure, income distribution, gender and ethnicity. Systematic differences in opportunities and resources within these structures play a part in determining a person’s socioeconomic status (SES). Socioeconomic status comprises economic, social, political, cultural and individual factors that influence a person’s status position in the stratification systems of a society. Social status, according to Weber, rests on mode of living, education, or prestige of birth, and on the positive or negative privileges associated with these factors (Worsley, 1970, p.392). While social status may be based on class status directly, or related to it in complex ways, it is not determined by class status alone. For instance, the class status of an officer, a civil servant and a student, defined according to their income level, may differ greatly but their social status may remain the same, because they maintain the same mode of living because of their common education (ibid.).

Of the traditional indicators of socioeconomic status – educational level, occupational class, and income level (Braveman et al., 2005; Geyer et al., 2006; Galobardes et al., 2007) – the latter two are features of work. In fact, employment relations, manifested as differences in status at work and the opportunity to exercise control and to use initiative and skills, are some of
the main features by which occupational class is defined (Goldthorpe, 2000, pp. 206-229). According to studies applying a life career perspective, the chronological order of the different indicators of socioeconomic status typically goes from educational level to occupational class and finally to income (Cavelaars et al., 1998; Lahelma, 2001; Lahelma et al., 2004). Lahelma et al. (2004) investigated the causal interdependencies between the different socioeconomic indicators. They found that for women half of the inequalities in limiting longstanding illness by education were mediated through occupational class and household income. Inequalities by occupational class were largely explained by education. Yet, only a small part of the inequalities by income were explained by education and occupational class. The results for men were similar to those of women for inequalities by education or by occupational class. However, for men, two thirds of the inequalities by income were explained by education and occupational class (ibid.). Geyer et al. (2006, p. 804) point out that even if education, occupational class and income are related, they measure different underlying phenomena and tap into different causal mechanisms in relation to health, and they should therefore not be used interchangeably as indicators of a hypothetical latent social dimension in studies of social inequalities in health. In theory, the choice of indicator of socioeconomic status should depend on how one assumes socioeconomic status is linked to health inequalities (Bartley et al., 2000; Lynch & Kaplan, 2000).

There is still much to be learned about the mechanisms by which socioeconomic status influences population health. According to Marmot and co-workers, the accumulating evidence about the inverse socioeconomic gradient in health “is the major unsolved public health problem of the industrialized world” (Marmot et al., 1997a, p.901). Explanations based on health selection and social causation have been proposed for the pervasive relationship between socioeconomic status and health (Lundberg & Vågerö, 1988; Lundberg, 1990; Townsend & Davidson, 1992; Elstad, 2000; Pensola, 2003). Health selection (or reversed causation) implies that health influences the ability to attain education, to achieve an occupation and to earn income. In contrast, social causation suggests that socioeconomic status influences health via materialist, psychosocial and behavioral/lifestyle pathways. For instance, the materialist pathway sees socioeconomic status as a powerful determinant of the probability of health damaging exposure, and of possessing specific health enhancing resources (Lynch & Kaplan, 2000). To describe the psychosocial pathway, a seminal quote by Richard Wilkinson serves as a vivid example:

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3 For a comprehensive presentation of social inequalities in health and their explanations, see e.g., Elstad (2000).
"To feel depressed, cheated, bitter, desperate, vulnerable, frightened, angry, worried about debts or job and housing insecurity; to feel devalued, useless, helpless, uncared for, hopeless, isolated, anxious and a failure: these feelings can dominate people’s whole experience of life, colouring their experience of everything else. It is the chronic stress arising from feelings like these, which does the damage. It is the social feelings which matter, not exposure to a supposedly toxic material in the environment." (Wilkinson, 1996, p.215)

The behavioral/lifestyle pathway suggests that health behaviors, such as cigarette smoking, alcohol consumption, physical activity, diet and sleep are unevenly distributed across different groups in a society so that the disadvantaged groups display more of the health-damaging and fewer of the health-promoting behaviors (Macintyre, 1986).

Although there is some evidence that individuals with poor health are more likely to move down and less likely to move up the social scale, it has been suggested that the effect of health selection on the socioeconomic gradient in health is only modest and that it cannot be regarded as a major explanation for inequalities in health (Manor et al., 2003). Nevertheless, ill health may influence a person’s choice of occupation (Lahelema & Koskinen, 2001), and thus partly determine an individual’s income (Benzeval et al., 1996). However, empirical evidence has favoured social causation as the explanation for social inequalities in health. For instance, childhood circumstances (Lundberg, 1993; Vågerö & Leon, 1994; Lundberg, 1997a), present working conditions, economic and psychosocial factors, risk behaviors such as smoking and alcohol abuse, adverse diet and physical inactivity, and access to health services (Lahelema & Rahkonen, 1994) have been found to contribute to health inequalities. Many factors are simultaneously active and the effects tend to accumulate over the life course (Marmot et al., 1998).

Based on either absolute or relative measures, the relationship between socioeconomic status and health is well-established; the socioeconomically better-off score better on most measures of health outcome (Antonovsky, 1967; Vågerö & Lundberg, 1989; Lundberg, 1990; Feinstein, 1993). There are some exceptions, however. For instance, breast cancer mortality shows a reversed socioeconomic gradient, indicating that those with a higher education have a higher risk of mortality from breast cancer than those with a lower education (Strand et al., 2007).

Studies of work-related factors as sources of health inequalities have focused on health differentials between occupations (e.g. Vahtera et al., 1999), or whether work-related factors contribute to the health gradient by occupational class (e.g. Marmot & Theorell, 1988). Workplaces contribute to health inequalities measured as differences in sickness absence between occupa-
tions (Vahtera et al., 1999). According to a number of studies, work environmental exposures contribute to the health gradient by occupational class (Marmot & Theorell, 1988; Lundberg, 1990; Marmot et al., 1997b; Schrijvers et al., 1998; Borg & Kristensen, 2000; Aittomäki et al., 2003), and to the health gradient by income (Hemström, 2005a; Toivanen & Hemström, 2006; Orpana et al., 2007). Yet, the actual size of the contribution seems to depend on the socioeconomic indicator, the specific work related exposure in question, and the specific health outcome (cf., Aittomäki et al., 2003).

In the present thesis, income and work environment factors are examined as primary origins of work-related inequalities in health. In addition to being an indicator of socioeconomic status, income from work is a work-related factor per se, and as such income and work environment are closely related. Moreover, income is correlated with positive job attributes (Blau & Kahn, 2006). Yet, it is more common in studies of the work environment and health to adjust for occupational class than for income, and only a few previous studies have focused on the simultaneous effects of income and work environment on health (for exceptions, see Lynch et al., 1997a; Lynch et al., 1997b; Hemström, 2005a, 2005b).

The factors under study in this thesis operate mainly in adult life in people of working age. However, from an intergenerational and lifecourse perspective, it is important to bear in mind that work-related advantages and disadvantages tend to accumulate over a lifetime and that they are also transferred from one generation to another (Diderichsen et al., 2001). For instance, maternal working conditions are found to contribute to the higher proportion of disadvantageous birth outcomes in manual workers than in non-manual workers (Gisselmann, 2007).

**Studying work-related inequalities in health**

Work-related factors with a potential impact on employees’ health operate in a complex way on different levels in society (e.g., Härenstam et al., 2006, p.38). The aim of Figure 1 is to demonstrate in a simplified way how work-related factors may be grouped according to their level of operation. The macro level is represented by the labour market which comprises a broad set of economic, social, political and cultural work-related factors (cf., Hadden et al., 2007). Some risk factors for work-related ill health are not characteristics of the working person; they are rather collective characteristics of the work force on the labour market. Consequently, labour market position is associated with risks to work-related health. For instance, being employed or unemployed, working in the private or public sector or in a certain industrial
branch, or belonging to a certain occupational class are all associated with health differentials in the working population (Westerlund, 2005).

![Diagram of Levels of Work-Related Factors](image)

Figure 1. Levels of work-related factors in relation to work-related ill health

The meso level encompasses work organisations, and workplaces embedded within the organisations (cf., Muntaner et al., 2006a, 2006b). The distinction between the organisational and the workplace level is not always clear in previous literature. The psychosocial work environment in particular is sometime treated as an organisational factor (e.g. Cooper, 1999; Cooper et al., 2001). Factors such as the downsizing and re-organisation of companies are clearly organisational, with consequences for employees’ health (Westerlund, 2005). On the workplace level, both physical (e.g., Dahlberg, 2005) and psychosocial exposures (Karasek & Theorell, 1990; Siegrist, 1996) constitute risk factors for health.

The micro level represents the working person with individual determinants such as age, gender, and health-related risk-factors. Individual characteristics need also to be taken into account when discussing work-related health. Individual susceptibility to disease varies according to biological predisposition (e.g. sex, age, and genes), personality, behavioural (e.g. sense of coherence) and lifestyle factors, and environmental exposures. The differences between women’s and men’s health, for example, may depend on individual factors as well as structural factors on the labour market and differences in women’s and men’s working conditions. Different factors may be of importance for women’s and men’s health (Denton & Walters, 1999). It is, however, difficult to draw a clear distinction between the micro level and the collective macro and meso levels because behaviors and lifestyles are embedded in social structures and cultures (such as workplaces, organisations, and labour market positions) and they are restricted or promoted by a variety of factors (such as income, work environment, opportunities).
For instance, studies of total workload indicate that working life and private circumstances, and the interplay between them, needs to be taken into account if we are to curb stress-related ill health in both women and men (Krantz et al., 2005). Double exposure in terms of heavy domestic responsibility and job strain was associated with a high level of common illness symptoms in a sample of working women in Sweden (Krantz & Östergren, 2001). However, working overtime was associated with lower sickness absence, and a double-exposure situation did not increase the risk of sick leave in a sample of white collar women and men in Sweden (Krantz & Lundberg, 2006). Contrary to what is normally seen, the conflict between work and private life demands emerged as a risk factor for sickness absence for white collar men, but not for women (ibid.). However, the situation may be the opposite for more disadvantaged occupational classes. Another study indicated a clear gender difference in the factors that predicted sickness absence, but found no interaction between job strain and life events in relation to sickness absence rate (Suominen et al., 2007). The strongest association between psychosocial work stress, as measured by overcommitment, and myocardial infarction was found in women working in male-dominated occupations (Peter et al., 2006). Family stress such as separation, divorce, and a stressful relationship with a spouse were stronger predictors for heart disease in women than psychosocial work stress (Orth-Gomer et al., 1997; Orth-Gomer et al., 2000).

The macro, meso and micro levels are in constant and dynamic contact with each other, and changes on one level most likely influence factors on other levels. For example, legislation (macro level) that regulates working conditions is put into practice by organisations and workplaces (meso level), and the potential effects are experienced by the employee (micro level). Thus, grouping the work-related factors according to their level of operation visualizes the multiple causes of work-related ill health, that both societal, environmental as well as individual levels with their specific determinants are included in the web of causation of work-related ill health (Krieger, 1994). The direction between the different levels (macro, meso, micro) and work-related ill health may go both ways. For instance, studies on occupational health selection in terms of the healthy worker effect indicate that ill health influences individuals’ entrance onto or exit from the labour market, and mobility between occupations (Östlin, 1989).

As a comparison to Figure 1, a conceptual framework of work-related factors with potential consequences for the health of working people is presented by Sauter (2002) and his co-workers in their influential NIOSH report The changing organization of work and the safety and health of working
The framework consists of a three-level model of organization of work that distinguishes between (1) the external context (broad economic and public policy forces at the national/international level), (2) the organizational context (management structures, supervisory practices, production methods, and human resource policies), and (3) the work context (job characteristics and conditions at the workplace). There is continuity between the three contexts. For instance, global economic pressure (external context) may lead to restructuring and downsizing by companies (organizational context) which may consequently lead to increased workload and reduced job security for workers (work context). Yet, this elegant model seems to pay little attention to the workers themselves, because the model does not include an individual level (cf. Figure 1). The main focus of the report by Sauter et al. (2002) is, however, on the changing organization of work in the new economy and its consequences for workers’ safety and health.

Combining work-related factors from different levels in studies of work-related health may require data from different levels and the use of statistical methods suitable for analysing such multilevel data (e.g., Härenstam et al., 2006). In the present thesis, a person’s position in the income hierarchy is seen as a characteristic of the labour market. Physical and psychosocial exposures, depending on the method of assessment, are either characteristics of the workplace or of occupations (for more information on assessment, see Data, Variables and Methods, p.43). Sense of coherence operates mainly on the individual level. The possible mechanisms linking these factors and ill health are discussed next.

Social mechanisms linking work-related factors and health

In discussing how work-related factors generate health inequalities, I have chosen the framework introduced by Diderichsen and Hallqvist (1998) as a point of departure (Figure 2). According to this framework, four main mechanisms – social stratification (I), differential exposure (II), differential vulnerability (III), and differential consequences (IV) – play a role in generating health inequalities (Diderichsen et al., 2001). Stratification takes place within the social context (Mechanism I). Power, wealth and risks are distributed by various systems of social stratification such as educational system, occupational structure, income distribution, gender and ethnicity. Individuals are defined partly by their relationship to the social context, and by their position in the stratification systems of a society. Exposure to health hazards varies between social groups, and exposures seem to cluster within certain groups (Mechanism II). For instance, a lower occupational class may be associated with poorer conditions at work, and poorer lifestyle, and may thus

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4 The report can be found at www.cdc.gov/NIOSH/pdfs/02-116.pdf
contribute to differential exposure between social groups. However, the impact of these unhealthy exposures depends on differences in vulnerability between social groups (Mechanism III).

![Diagram of mechanisms affecting health outcomes](image)

Figure 2. A framework for the pathways from the social context to health outcomes and for introducing policy interventions. Source: Diderichsen and Hallqvist (1998)

Social groups that are exposed to many risk factors may be more vulnerable to the effect of one specific risk factor than social groups that are exposed to fewer risk factors. Differential consequences (Mechanism IV) refer to the impact that ill health may have on people’s lives and socioeconomic circumstances. Needless to say, the consequences of ill health are more severe for disadvantaged social groups which have fewer resources for dealing with ill health (ibid.).

The framework by Diderichsen and Hallqvist (1998) is well-known for providing policy options for reducing social inequalities in health. Figure 2 shows the potential entry points (A-D) for policy interventions. Social inequalities in health may be fought against by influencing social stratification (A), reducing both differential exposure (B) and vulnerability (C), and preventing the unequal consequences of ill health (D). However, focusing on
policy options for influencing work-related inequalities in health is outside the scope of the present thesis.

Applying the work-related factors under study in this thesis to Diderichsen and Hallqvist’s framework (1998) is helpful for identifying the pathways between income, work environment, sense of coherence, and work-related ill health (Figure 3).

Stratification on the labour market is expressed by grouping individuals according to their position in the income hierarchy (Mechanism I). A lower position in the income hierarchy is associated with a clustering of health-related risk factors such as smoking (Mechanism II, see Figure 4). Work-environment exposures also vary according to position in the income hierarchy (see Figure 5). Differential vulnerability is represented by sense of coherence (Mechanism III). Depending on the individual strength of sense of coherence, people are differently equipped to deal with daily hassles, and it is suggested that those with a strong sense of coherence are better able to cope with adverse exposures at work (see Figure 6). The differential conse-
quences of work-related ill health vary according to position in the income hierarchy, and what type of ill health is manifested (Mechanism IV).

As shown in Figure 4, in a sample of employed women and men in Sweden, the proportion of people reporting smoking, not being able to run a short distance, feeling tired, and having sleep disturbances is higher in the lowest income quartile than in the highest quartile, with a gradient for the intermediate income quartiles.

Moreover, people in a lower position in the income hierarchy may be more exposed to an adverse work environment than people in higher income positions. Figure 5 illustrates the distribution of high physical workload, high psychological demands, and low job control by income quartiles (see further Toivanen & Hemström, 2006). Among people in the lowest income quartile, the proportions of all the three work environment exposures are relatively similar (32-33%). While the proportion of people with high psychological demands increases with increasing income, the proportions of people with high physical workload and low job control decrease with increasing income.5

5 Figures 4 and 5 are based on ULF data in Paper I, and Figure 6 is based on LNU data in Paper II
Figure 5. Distribution of work-environment factors by income quartiles. Sample of employed women and men (aged 40-64) in Sweden, 1998-1999 (ULF data)

Figure 6. Distribution of a weak sense of coherence (SOC) by income quartiles. Sample of employed women and men (aged 19-64) in Sweden, 2000 (LNU data)

Figure 6 shows that the proportion of people with a weak sense of coherence varies with level of income. The proportion is higher in the lowest income quartile than in the highest quartile. The two intermediate income quartiles have a similar proportion of people with a weak sense of coherence.
To sum up, people in a disadvantaged position in the income hierarchy have a higher proportion of health-related risk factors and adverse work-environment exposures. In addition, a weak sense of coherence is more common in lower income quartiles, which implies that people in lower income quartiles are less well equipped to cope with daily stressors (e.g. financial problems or high levels of work stress) of which they may have more than those who are higher up the income hierarchy (e.g., Taylor, 1998a; Cohen, 2000). With these facts in mind, it is not difficult to imagine that the social consequences of work-related ill health do indeed differ according to position in the income hierarchy, and also according to type of ill health. For instance, suffering a stroke may force people to leave the labour market and consequently influence their future position in the income hierarchy.

The relation between income and health

Compared to occupational class, which rests on a number of theoretical assumptions (Wright, 1985; Erikson & Goldthorpe, 1992; for a review, see e.g., Hauser & Warren, 1997), income is an exact measure of people’s socio-economic status. Income can be measured on a continuous scale, and grouped into quartiles, quintiles or other comparable strata; it is a truly hierarchical measure (Stewart, 2002). On the one hand, (absolute) income is a dynamic measure of socioeconomic status because it connects directly to the material conditions that may affect health - in other words income level influences health because of what money can buy (Lynch & Kaplan, 2000). On the other hand, it is the relative income and status in a society that makes a difference to health, rather than absolute material living standard (Wilkinson, 1997). Yet, a mix of absolute and relative processes seems to be of importance for the income and health relation (e.g., Åberg Yngwe, 2005; Elstad et al., 2006).

Impaired health can directly cause a fall in income, suggesting that the causal relationship may run from poor health to low income rather than, or at least as much as, vice versa (Benzeval et al., 1996). However, longitudinal studies suggests that there is a causal relationship between low income and poor health (Benzeval & Judge, 2001). It has been suggested that the strong relationship between income and health could be due to the low share of labour force participants in the low income strata, implying that ill health is more prevalent in lower income groups (Benzeval et al., 1996; Stronks et al., 1997). Alternatively, poor health may reduce the numbers of hours spent in

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6 It has been suggested that income inequality on a contextual level, indicated by the gap in income between the rich and the poor in a given society, is associated with population health (Kennedy et al., 1999; cf. Lynch et al., 2004; Dahl et al., 2006; Wilkinson & Pickett, 2006). For a thorough presentation of research on income inequality and health, see e.g. Kawachi et al. (1999)
paid work because of sick leave or disability pension (ibid.). Without doubt, income is strongly connected to the work role, and work-related rewards in the form of wages are of central importance in giving individuals a status position in society (Hemström, 2005a). Health differentials by income are reported for cardiovascular disease (Toivanen & Hemström, 2006), psychological distress and musculoskeletal pain (Lundberg & Fritzell, 1994), and self-rated health (Hemström, 2005a; Orpana et al., 2007).

The measurement of income is intricate: absolute or relative, individual or family disposable income can be measured, and family income can be adjusted for family size. Income and poverty levels can be compared; sources other than wages can be included in income, and even wealth including total assets can be measured (Kaplan & Keil, 1993). A small number of studies have used an absolute income measure. These studies tend to find a curvilinear relationship between income and health. In other words, the health returns of an improved income are greatest at very low levels of income, and they tend to diminish at very high levels (Backlund et al., 1996; Ecob & Davey Smith, 1999; Der, 2001; Fritzell et al., 2004; Fritzell, 2005). Most studies of income and health tend to use an income measure based on the income distribution in the data such as quartiles, quintiles or other comparable strata (Lynch et al., 1996; Hemström, 2005a). Some analyses have used annual individual earnings as a measure of income (Fritzell & Lundberg, 1994; Lynch et al., 1996; Geyer & Peter, 2000; Fritzell et al., 2004) or disposable household income adjusted for family size (Åberg Yngwe et al., 2001). The results tend to be relatively similar, no matter which income measure is used (individual or household): those classified as having a higher income have better health than those in the lower income strata, with a health gradient for the intermediate income groups (Hemström, 2005a p.638). However, Rahkonen et al.(2000) recommend the use of household equivalent income as the principal measure in studies of income and health. They found that individual and household income was related to poor health among British and Finnish men. For British women, and to a lesser extent for Finnish women, the association between income and health depended strongly on the income measure used, and for British women individual income had almost no effect on health (ibid.). However, results from Sweden indicate that wage income is a more important determinant of women’s ill health than of men’s (Hemström, 2005a).

Nevertheless, when measured as hourly wages or annual individual earnings grouped into quartiles, quintiles or other comparable strata, income level does indicate an individual’s relative position in the income hierarchy on the labour market. Measured like this, income and work environment are closely related. This is less so for household income, which is an indicator of family status and material resources averaged over all household members. Consid-
ering that income and work environment are related, surprisingly few studies of the work environment and health discuss the relationship between income and work environment (for exceptions, see Lynch et al., 1997a; Lynch et al., 1997b; Hemström, 2005a, 2005b), or even adjust for income in the analyses (for exceptions, see Alfredsson et al., 1985; Lynch et al., 1997a; Lynch et al., 1997b; Joksimovic et al., 2002; Ostry et al., 2003; Brunner et al., 2004; Hemström, 2005b).

Physical work environment

The physical work environment includes the ergonomic, biological, chemical and radiological aspects of the workplace. Most of the physical factors are objectively measured and monitored in the workplace, and exposure to these factors is regulated by existing standards. In addition to their direct effect on the human body, physical factors may have a psychological effect through the worker’s fear that such exposures might be detrimental to health. This fear can affect the worker’s task performance and physical and mental health (Cox et al., 2000). Physical factors interact with one another and with psychosocial factors in creating their effects (Schrijvers et al., 1998; Wigaæus Törnqvist et al., 2001).

In ergonomic epidemiological research, exposure variables are usually defined according to posture, motion/repetition, material handling, and external factors (Hagberg, 1992). Thus, physical workload or physically demanding job characteristics are usually measured as unsuitable work postures, bending and turning, repetitive movements, carrying and heavy lifting, and strenuous muscular work. High physical workload is a potential risk factor for musculoskeletal and cardiovascular diseases, and depression (Alfredsson et al., 1982; Hagberg, 1992; Hallqvist et al., 2000; Paterniti et al., 2002).

Many people in Sweden still have physically demanding jobs, but this is usually forgotten in the contemporary discussion about the psychosocial work environment and health. In fact, it is quite often maintained that the nature of work has changed from physical to mental and consequently that job characteristics have changed significantly (e.g., Kompier, 2006). Moreover, it is sometimes assumed that high physical workload is almost exclusively a characteristic of blue collar jobs, and that physical workload is therefore a valid measure of socioeconomic status. However, in Sweden it is relatively common for non-manual workers, especially women, to have jobs with considerable physical exposure, while by the same token not all manual workers report physical exposure (Statistics Sweden & Swedish Work Environment Authority, 2002).
Based on official statistics from the report *The Work Environment 2005* by Statistics Sweden and the Swedish Work Environment Authority (2006a), the change over time of a few central indicators of physical workload is presented. The presentation focuses on the 1990s which is the period under study in this thesis. In the official statistics, the distribution of the physical factors is reported by occupational class, gender, and age. The proportion of employed women and men reporting bending and turning in the same way several times during a regular working day was higher in 2003/05 than in 1991/93. This holds for different age groups (16-29, 30-49 and 50-64 years) and for all occupational classes except women in the higher non-manual class (Figure 7). Generally, the proportion of people reporting bending and turning is higher in women. For instance, women in lower non-manual jobs reported almost as high a proportion of bending and turning as skilled manual men in 2003/5 (31.7% versus 34.5%).

The proportion of women and men who reported that strenuous physical work that caused them to breathe heavily accounted for at least one quarter of their time at work increased in all age groups and occupational classes (except among higher non-manual women) between 1991/93 and 2005 (Figure 8). In the manual classes, the increase was higher among women than among men; in the non-manual classes the increase was higher among men. Generally, the proportion of people reporting strenuous physical work is higher in men. However, ergonomic load (assessed by an index comprising heavy lifting, unsuitable work postures, daily perspiration from work, physically
demanding work tasks, physical exhaustion, and repetitive movements) increased in women between 1981 and 2000 whereas there was no change among men (Hemström et al., 2007).

![Graph showing proportion of employed women and men engaged in physical work by occupational class.](image)

Figure 8. Proportion (%) of employed women and men (aged 16 – 64) in Sweden engaged for at least one quarter of their time in physical work, and having to exert themselves so that breathing quickens, by occupational class. Source: Statistics Sweden & Swedish Work Environment Authority (2006a)

From the above we can conclude that work characteristics have not changed dramatically from physical to psychosocial (the development of the psychosocial characteristics of work is described below). The overall picture of the physical work situation in Sweden is that the proportion of physical exposures among the workforce increased, or remained constant, between 1991 and 2005 (Statistics Sweden & Swedish Work Environment Authority, 2006a).

### Psychosocial work environment

Psychosocial aspects of the work environment are defined as:

> "those aspects of the design and management of work, and its social and organisational contexts, that have the potential for causing psychological or physical harm" (Cox et al., 2003, page 195).

Several conceptual models have been developed that link psychosocial working conditions with ill health (Cooper, 1999; Levi, 2000). Two frequently used models in the field of contemporary psychosocial work stress research are the demand-control model (DCM) by Karasek and Theorell (1990) and the effort-reward imbalance (ERI) model by Siegrist (1996).
These models are sometimes called the work stress models because the components measured by the models produce long-lasting stressful experience at work in exposed persons which may overactivate the body’s stress systems and therefore contribute to disease and illness (Marmot et al., 1999). For a recent review of the two work-stress models in relation to a variety of health outcomes, see further Siegrist and Theorell (2006).

**Demand-Control Model**

The demand-control model focuses on how situational workplace characteristics influence workers’ lifestyles and health (Karasek & Theorell, 1990). Psychological demands refer to factors related to time pressure, mental load, and coordination responsibilities. Job control (also called decision latitude) comprises two components: decision authority and skill discretion. Decision authority is a socially agreed upon form of control over job performance, allowing the employee to decide how and when the job task is done. Skill discretion refers to control over the use of one’s initiative and skills in the job. Theoretically, decision authority and skill discretion are closely related and are often combined into one measure (Karasek & Theorell, 2000, p.80).

Different combinations of demands and control result in four specific work situations: active (high demands and high job control), job strain (high demands and low job control), passive (low demands and low job control), and low strain (low demands and high job control) (Figure 9).

![Diagram of Demand-Control Model](image)

**Figure 9.** The demand-control model. Source: Karasek and Theorell (1990)

These four work situations may have different effects on health. Job strain is seen as the most stressful work situation because it limits an individual’s
autonomy and sense of control while the pressure is continuous, and it prevents optimal coping (Karasek et al., 1982; Siegrist & Theorell, 2006). However, social support at work moderates the adverse effect of job strain on health (Johnson & Hall, 1988). Not only support from colleagues but also the opportunity to participate in informal rituals, such as coffee breaks and chats, act as an additional tension-releasing mechanism during the work day (Karasek & Theorell, 2000).

In addition to social support at work, high job control is another buffering factor which moderates the adverse effects of high psychological demands on health (Karasek, 1979; Karasek & Theorell, 1990; Hallqvist et al., 1998; 1998; 2000). Active work is hypothesised to lead to learning and growth. It is assumed that people with active jobs will also be the most active group outside work, despite the high psychological demands. Similarly, it is assumed that passive work will give rise to learned helplessness, as the job rejects the employee’s initiatives and does not encourage using skills and talents at work. However, in empirical studies, both active and passive work have been found to be associated with an increased risk of ill health (Hemmingsson & Lundberg, 1998; Rostila, 2004). Theoretically, the ideal type of job with regard to strain would be the low strain job, a combination of low psychological demands and high job control (Karasek & Theorell, 1990; 2000). The demand-control model has been studied in relation to a large number of work-related health outcomes (The Job Stress Network, 2005), yet the majority of the studies have focused on CVD (Schnall et al., 1994; Schnall et al., 2000a; Belkic et al., 2004), mental health outcomes (van der Doef & Maes, 1999), and musculoskeletal disorders (van der Doef & Maes, 1998).

The demand-control model aims to focus on the situational aspects of the psychosocial work environment rather than on the individual variation in response to an adverse environment. Critics of the demand-control model’s limitations has focused on how it assesses psychological demands, which is methodologically problematic since questions about psychological demands are understood differently by different groups, e.g. men and women, and manual and non-manual workers (de Jonge et al., 2000b; Kristensen et al., 2004). Hemström (2005b) found an association between high psychological demands and self-rated health among high income earners but not among low income earners. These findings indicate that the significance of psychological demands may vary between occupational groups and also depending on which health outcome is under study. Physical demands are not explicitly addressed by the demand-control model, even though physical exertion is likely to be a source of mental arousal. Working hard includes high physical demands for many groups of workers (Karasek & Theorell, 1990; 2000). No matter the theoretical aspirations to measure situational aspects of the psy-
chosocial work environment, it has been argued that the demand-control model fails to study anything broader than the interaction between the individual worker and her/his immediate work environment (Muntaner & O'Campo, 1993).

**Job Control**

Decades of research in sociology and psychology have demonstrated that a sense of control in life in general is a robust predictor of physical and mental well-being (Skinner, 1996; Seeman, 1999). Although the findings of many studies are consistent, there is a wide heterogeneity among the constructs researchers use to describe control. Constructs such as *life control, personal control, sense of control,* and *locus of control* are commonly used. Other constructs do not use the term *control,* but seem closely related, such as *resources, capacity, mastery, autonomy, competence or self-determination* (Skinner, 1996).

Aronsson (1989a; 1989b) sees the term *control* as consisting of at least four dimensions: (1) having a determined influence over an outcome; (2) predictability; (3) participation (having a meaningful role); and (4) having control over a situation (to change the rules and/or to master the rules within a situation). According to Aronsson, there is an important distinction between objective and subjective control (ibid.). Skinner (1996) also points out that the most fundamental distinction in the literature on control is between actual control, i.e. objective control conditions present in the context, and perceived control, i.e. an individual’s subjective beliefs about how much control is available.

The demand-control model defines control as decision latitude, which is a combination of decision authority and skill discretion. The relationship between these dimensions derives from the notion that the acquisition of skills over time gives workers influence over the work process. The concept of decision latitude is interpreted as the worker’s ability to control his or her own activities and skill usage, not to control others, even if that is also a potentially important construct of control (Karasek & Theorell, 1990). Most studies of job control and health operationalize job control in terms of the control component of the demand-control model. According to a review, cardiovascular outcomes are more closely associated with job control than with psychological demands (Schnall *et al.*, 1994). Job control contributes to the socioeconomic gradient in health (Belkic *et al.*, 2000). For instance, in the Whitehall study, job control was the major factor contributing to the socioeconomic gradient in risk of CHD in civil servants (Marmot *et al.*, 1997b; Kawachi & Marmot, 1998). On the other hand, job strain has a weaker, or in some studies no association with socioeconomic status (Belkic *et al.*, 2000). However, job strain tends to interact with low socioeconomic
status. For instance, the association between job strain and blood pressure is stronger in workers with lower socioeconomic status (Landsbergis et al., 2003a).

**Effort-Reward Imbalance Model**

The effort-reward imbalance (ERI) model focuses on the connection between work tasks and labour market dynamics (Siegrist, 1996, 1998; Siegrist & Peter, 2000). The work role is the link between a person’s need for self-esteem and the structure of opportunities offered by society and the labour market to fulfil this fundamental need. Having a job is a prerequisite for a continuous income, and partly also for a person’s social status and identity. However, these potentially advantageous effects are possible only if the fundamental condition for social exchange is met - reciprocity and interaction. Effort at work is a part of this reciprocal action which is rewarded by society. Rewards are provided in the form of money, self-esteem and gratifications such as promotion prospects and job security. Receiving inadequate rewards for one’s effort elicits a state of emotional distress, particularly if the individual has a tendency to be overcommitted to work. Emotional distress leads to the arousal of the body’s stress defence systems, which in the long run may lead to deteriorating health. A threat against an individual’s work role, for example exclusion from a work group, is a tangible psychosocial stressor (ibid.). Having a demanding, but insecure job is another example of a high effort/low reward situation (Siegrist, 1996, 1998; Marmot et al., 1999; Siegrist & Peter, 2000).

The ERI model (Figure 10) consists of three components: two situation-specific and one person-specific. The effort component has both a situational and a person-specific source. The situational source is defined by the work-related demands and obligations. The person-specific source is the individual’s tendency to be overcommitted to work. Overcommitment is defined as a motivational pattern expressed as attitudes, behaviours, and emotions that reflect an excessiveendeavour for approval and acknowledgement in combination with excessive striving. A person’s effort at work is influenced by hers/his conscientiousness, and the experience of job stress is stronger if the person is overcommitted to work. The efforts made by an individual who is overcommitted usually exceed those normally considered to be reasonable. In addition to money, the reward component consists of esteem and gratifications and career opportunities, including job security. Although the ERI model makes a distinction between situation-specific and person-specific components it does not specify in advance how the different components help to explain stress-related conditions.
Previous research has shown that the various components contribute differently according to the occupational and socioeconomic context. Information from all the components of the ERI model gives a better estimation of the total amount of stress which can be related to work (Siegrist, 1996; Siegrist et al., 1997; Siegrist, 2000; Siegrist & Peter, 2000; Siegrist, 2002, 2003; Siegrist & Marmot, 2004; Siegrist, 2005; Siegrist & Theorell, 2006).

The ERI model postulates that a high effort/low reward situation persists if the following conditions exist: (1) lack of other options in the labour market may deter people from quitting even undesirable jobs, (2) for strategic reasons a person may accept unfair job arrangements for certain periods in order to promote future career opportunities (3) the motivational pattern characterized by overcommitment may prevent a person from correctly estimating high effort/low reward situations (Siegrist & Peter, 2000). High effort/low reward conditions have been shown to increase the risk for CVD (Siegrist et al., 1990; Siegrist, 1991, 1996; Siegrist et al., 1997; Bosma et al., 1998b; Peter et al., 1998a; Peter & Siegrist, 2000; Peter et al., 2002), mental health problems (Peter et al., 1998b; Stansfeld et al., 1999; Bakker et al., 2000; Tsutsumi et al., 2001; Pikhart et al., 2004), and for musculoskeletal pain (Joksimovic et al., 2002). In addition, effort-reward imbalance was found to be a risk factor for alcohol dependence among men (Head et al., 2004).

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7 See further www.uni-duesseldorf.de/MedicalSociology
Differences between the DCM and ERI model

The ERI model differs from the DCM chiefly in that the ERI model combines situation-specific and person-specific components. The ERI model extends the aspect of control to include income and other rewards derived from work (such as appreciation, career opportunities, job security) and the model focuses on the balance between received rewards and effort put into work. Consequently, the ERI model brings together psychosocial working conditions and labour market conditions. The DCM focuses on job task (high demands and low control), and consists entirely of situational characteristics. The two models also differ in terms of what kind of threats they pick up: the DCM captures threats to personal control, whereas the ERI model focuses on threats to social rewards (esteem, status). The policy implications of the two models also differ: the DCM advocates democracy and participation, while the ERI model argues for distributive justice and contractual fairness (Siegrist, 2003). The DCM has two hypotheses: health complaints arise from (1) adverse psychosocial working conditions (strain hypothesis), and (2) increased activity level due to advantageous psychosocial working conditions (active learning hypothesis). The ERI model has three hypotheses which combine situation-specific and person-specific components: (1) an imbalance between high effort and low reward (non-reciprocity) increases the risk of reduced health over and above the risk associated with each of the components individually, (2) overcommitted people are at increased risk of poor health (whether or not this pattern of coping is reinforced by work characteristics), (3) the relatively highest risk of poor health can be expected in people who are characterized by conditions (1) and (2).

Distribution of psychosocial work environment factors

Psychological demands at work increased during the 1980s, but job control did not, which worsened the psychosocial work environment in general and specifically in jobs where women are predominant (Szulkin & Tåhlin, 1994). The share of job strain increased among women and men and in all occupational classes between 1981 and 1991 in Sweden. The increase was largest for women in the skilled manuals class, from 8% to 31%. The corresponding increase for men was from 10% to 11% (ibid.). The negative trend of rising job strain continued in the 1990s when, unlike in the 1980s, there was actually a decline in job control along with increasing psychological demands (le Grand et al., 2001). Other Swedish studies confirm the increase in job strain from the mid-1980s to the mid-1990s, with a decline in job strain apparent at the end of the decade (Fritzell et al., 2000). The risk of job strain was found to be greatest among women and people born outside Sweden (ibid.). The worsening of the psychosocial work environment for all occupational groups
stands out as the most serious trend during the 1990s, and the gender differences increased because this worsening was more severe in jobs held by women (Bäckman & Edling, 2000). As a consequence, ill health increased in the 1990s, also among people with active jobs (Rostila, 2004).

Figure 11. Proportion (%) of employed women and men (aged 16 – 64) in Sweden who have to skip lunch, work late, or take work home every week, by occupational class. Source: Statistics Sweden & Swedish Work Environment Authority (2006)

Based on the report *The Work Environment 2005* by Statistics Sweden and the Swedish Work Environment Authority (2006a), the development of some central indicators for demands/efforts, decision authority and skill discretion between 1991 and 2005 is described below (Figures 11-13). The proportion of people reporting that they have to skip lunch, work late, or take work home every week (indicator of high demands/efforts) increased for women in all occupational classes, except among higher non-manuals between 1991/93 and 2003/05 (Figure 11). For men, there was an increase in demands in the manual classes while in the non-manual classes demands fell.
The proportion of people reporting that they are seldom able to decide for themselves when to carry out a particular work task (indicator of low decision authority) increased among women in the manual classes and in the intermediate non-manual class, and decreased in the lower and higher non-manual classes between 1991/93 and 2003/05 (Figure 12). For men there was a slight increase in the proportion reporting low decision authority in the unskilled manual class and in the lower and intermediate non-manual classes. In the skilled manual class and the higher non-manual class the proportions decreased somewhat. Generally, all the changes were larger for women than for men.

The proportion of monotonous work (indicator of low skill discretion), defined as having to repeat the same working operation several times per hour, increased among both women and men and in all occupational classes between 1991/93 and 2003/05 (Figure 13). The increase was highest for women in the skilled manual class and for men in the lower non-manual class.
Thus overall, demands at work increased between 1991/93 and 2003/05 for the work force in Sweden. However, there seem to have been a decrease in demands between 1999/01 and 2003/05. Low decision authority increased in most occupational classes, but decreased in a few, for both women and men. Skill discretion decreased (monotonous work increased) in all occupational classes, most markedly for women.8

Health protective personality factors

Measured at the individual level, low income and adverse work environment are powerful stressors which have an impact on people’s health and well-being. However, individual differences may affect how we perceive a challenging situation and thus how the body’s stress response is activated. Personality traits refer to individual differences in the tendency to think, behave and feel in certain consistent ways (Caspi, 1998). According to the Big Five personality traits taxonomy, the broad personality traits are (1) extraversion, (2) agreeableness, (3) conscientiousness, (4) neuroticism, and (5) openness to experience. Each trait is composed of more specific personality characteristics, or lower-order facets. These five dimensions represent personality at

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8 For a thorough presentation of the latest developments in the psychosocial work environment and organizational work factors in Sweden, see e.g. the Swedish Longitudinal Occupational Survey of Health (SLOSH 2006) (Kisten et al., 2006). The report can be found at www.psykosocialmedicin.se/SLOSH_2006v2.pdf
the broadest level of abstraction, and the taxonomy does not imply that personality differences can be reduced to only five traits (John & Srivastava, 1999).

Personality traits may act as resources in the stress process (Vollrath, 2001). Personality constructs such as hardiness (Kobasa, 1979), optimism (Scheier & Carver, 1992), self-efficacy (Bandura, 1977), locus of control (Rotter, 1966), and sense of coherence (Antonovsky, 1979; 1987a), to mention but a few, have been investigated in order to identify positive appraisal and successful coping in response to stressors. According to previous findings, hardiness, optimism, self-efficacy, locus of control, and sense of coherence load on personality factors of neuroticism, extraversion and conscientiousness, which are part of the five-factor model of personality (Vollrath, 2001). However, in the light of the transactional theory of stress and coping, personality traits appear too global and they do not take into account sufficient contextual factors to fully describe the complexity of the stress process (Lazarus & Folkman, 1984). Stress arises when the demands of a challenging situation exceed the resources at an individual’s disposal. In other words, stress is the result of a continuous relationship, referred to as transaction, between the individual and the environment (Folkman & Lazarus, 1988). Consequently, the way people manage stressors is important for their health and well-being. Even if certain personal attitudes, such as performance-based self-esteem, type A behaviour, or overcommitment to work, could make the individual more vulnerable to work stress, it could also work the other way around. As pointed out by Kohn and Schooler (1973), a person’s degree of self-direction at work clearly also influences personal attitudes and behavioural style in areas which are not related to work.

A number of studies indicate that effective coping modes are unequally distributed (Taylor, 1998b; Seeman, 1999), with men and the socioeconomically better-off being better at coping successfully (Pearlin & Schooler, 1978). Stronks et al (1998) demonstrate that neuroticism is associated with low socioeconomic status; it is thus suggested that high neuroticism contributes to socioeconomic inequalities in health. However, exposure to stressors such as negative life events and long term difficulties contribute to socioeconomic inequalities in perceived health, even after differences in neuroticism are controlled for (ibid.). Moreover, sense of coherence is found to be associated with age and social class, with middle-aged white collar workers having the strongest sense of coherence (Lundberg, 1996).
Sense of Coherence

Salutogenesis focuses on the origins of health, and on factors that promote good health. Sense of coherence (SOC) is the core construct of Antonovsky’s salutogenic model and it is defined as

“a global orientation that expresses the extent to which one has a pervasive, enduring, though dynamic feeling of confidence that (1) the stimuli deriving from one’s internal and external environments in the course of living are structured, predictable, and explicable; (2) the resources are available to one to meet the demands posed by these stimuli; and (3) these demands are challenges, worthy of investment and engagement” (Antonovsky, 1987a, p. 19)

SOC is based on three components, namely comprehensibility, manageability and meaningfulness. These components together form an individual’s global orientation towards life in general. According to Antonovsky (1987a; 1993), the three components are interrelated, and all of them are needed for successful coping. People with a strong SOC perceive life as comprehensible, manageable and meaningful, and are considered to be better equipped than people with a weak SOC to maintain good health in spite of experiencing stress (cf., Adler, 1997).

Figure 14. Illustration of how a strong sense of coherence protects health. Source: Lundberg (2007)

To the best of my knowledge, Antonovksy did not sketch or illustrate a model of the ways SOC is assumed to impact on health, despite his extensive publications on SOC and health. Based on the work of Lundberg (Lundberg & Nyström Peck, 1994, 1995; Lundberg, 1996, 1997a, 1997b, 2004; Lind-
fors et al., 2005, 2006; Lundberg, 2007, personal communication), Figure 14 illustrates how a strong SOC acts as a buffer against stressors, and thus protects health. People are confronted with innumerable, complex stimuli (demands) every day throughout life (Antonovsky, 1979, 1987a). Regardless of source or type of stimuli, whether from the inner or outer environment, acute or chronic, forced upon us or self-chosen, stimuli need to be acted on and adapted to. According to Antonovsky’s (ibid.) definitions, a stimulus (non-stressor) differs from a stressor in that it is considered to be of minor importance, and a stimulus does not put a strain on or exceed an organism’s resources. A stressor, on the other hand, is of a more severe character, such as an acute life event or a chronic adverse condition. When a stimulus is judged to be a non-stressor, adequate resources will be activated in order to act on the stimulus (Figure 14, # 1). People with a strong SOC are more likely to perceive stimuli as non-stressors than people with a weak SOC. When the stimulus is judged to be a stressor, tension will arise and manifest itself as emotions of uneasiness and psychophysiological activity (Figure 14, # 2). Again, people with a strong SOC are more likely to judge the stressor as manageable (thus, the stressor becomes a non-stressor) than people with a weak SOC. As a result, the tension will fade away, and health is preserved (Figure 14, # 3). When faced with stressors, people with a strong SOC tend to be able to keep their emotions focused and they are therefore better equipped to take appropriate action in demanding situations. On the other hand, people with a weak SOC find life more chaotic, unmanageable, and meaningless. Emotions tend to be diffuse and paralysing, and adaptation to stressors is devastating. In sum, SOC seem to be a marker of social stress adaptive capacity, and those with a strong SOC adapt more efficiently to the various demands (stimuli, stressors) of daily life and as a consequence health is preserved (Surtees et al., 2006c). For instance, faster adaptation to adverse events has been associated with a low rate of stroke incidence (Surtees et al., 2007). Yet, Antonovsky (1979; 1987a) claimed that SOC is not merely a coping strategy, rather an ability to choose the optimal way of coping in every distinct situation.

SOC is regarded as a fairly stable dispositional orientation of personality (Antonovsky et al., 1990; Sagy et al., 1990), which is assumed to be fully developed and stabilized around the age of 30. SOC is seen to arise from internal and external generalized resistance resources, such as wealth, ego strength, cultural stability, and social support. The more of these resources an individual possesses, the better are his or her chances of developing a strong SOC. Thus, having adequate generalised resistance resources and being able to use them properly facilitates successful coping with stressors (Antonovsky, 1979, 1987a). In a recent study, SOC was strongly associated with psycho-emotional resistance resources in a sample of Finnish women and men (Volanen et al., 2004). Some maintain that people in the highest
social positions, unlike those in the lowest social positions, enjoy the optimum conditions for developing a strong SOC (Geyer, 1997).

While some studies have confirmed SOC to be a relatively stable dispositional orientation to life (Feldt et al., 2000b; Kivimäki et al., 2000; Feldt et al., 2004), other studies have reported the opposite (Smith et al., 2003). A recent review concludes that SOC is comparatively stable over time although not that stable that Antonovsky assumed (Lindstrom & Eriksson, 2005). Despite the hypothesized stable nature of SOC in adulthood, major life events, for instance radical changes in working conditions, unemployment, or divorce, may affect an individual’s general resistance resources and thus substantially change the strength of SOC, even in older individuals (1987a; 1987b; 1991). In a recent five-year follow-up study, negative life events reduced the level of SOC in a large sample of Finnish women and men, irrespective of the timing of the event (Volanen et al., 2007). The more recent the life event, the lower was the SOC. Furthermore, an initially strong SOC did not prevent SOC levels from declining during the follow-up if the person was faced with a negative life event, indicating that a strong SOC was not more stable than an initially mediocre or weak SOC. Being a victim of violence was the life event with the strongest effect on SOC levels among both genders. Thus, the stability of SOC is related to negative changes in people's environment (ibid.). Other studies have shown that an initially strong SOC remained stable during follow-up (Takayama et al., 1999; Buddeberg-Fischer et al., 2001; Nilsson et al., 2003). However, these studies did not focus on the interaction between SOC and negative life events as did the study by Volanen et al. (2007).

SOC has been studied in life stress circumstances in a variety of settings and in relation to numerous health-related outcomes (Kivimäki et al., 2000; Suominen et al., 2001; Surtees et al., 2003; Lindfors et al., 2005; Ristkari et al., 2005; Savolainen et al., 2005; Suominen et al., 2005). The general findings from previous studies tend to indicate that SOC is associated with health in general (Lindstrom & Eriksson, 2005), and primarily with psychological measures of health (Flensborg-Madsen et al., 2005). SOC has also, to a lesser extent, been studied in work-related settings (e.g., Feldt, 2000; Feldt et al., 2000a). Most such studies have focused on psychosocial exposure at work in relation to SOC (Kalimo & Vuori, 1990; Ryland & Greenfeld, 1991; Söderfeldt et al., 2000; Albertsen et al., 2001; Kalimo et al., 2002; Agardh et al., 2003; Kalimo et al., 2003; Nasermoaddeli et al., 2003; Hoge & Bussing, 2004; Hoge & Mikkelsen, 2005). Only a few studies have also focused on physical exposure at work in relation to SOC (Feldt, 1997; Kalimo et al., 2002; Kalimo et al., 2003). Where the moderating role of SOC is concerned, there is some evidence that people with a strong SOC cope more efficiently with stressors at work than people with a weak SOC (Feldt, 1997; Albertsen
et al., 2001). However, SOC does not seem to act as a buffer against stress reactions when exposed to violence at work (Hogh & Mikkelsen, 2005). Because of the small number of studies of SOC in work-related settings, it is difficult to draw general conclusions about whether a strong SOC buffers against ill health. The buffering role of SOC may vary across health outcomes, and may also depend on the particular type of adverse exposure at the workplace.

**Physiological mechanisms linking work-related factors and health**

Long term or repeated exposure to work-related factors such as low income or adverse work environment may activate the body’s stress response which is a physiological mechanisms explaining how the adverse effects of work-related stressors “get under the skin” (Taylor et al., 1999; Lundberg, 2005). Taylor et al. (1999) call attention to the notion that the effects on health of environmental factors cannot be reduced to or explained by individual-level factors. They maintain that the individual characteristics are nested within social environments and that each level of analysis reveals information about the causes of health and illness (ibid.). The work-related social and physical environments have an enormous impact on people’s physiology and behavior and they influence the process of adaptation, or allostasis (McEwen, 2001).

**The stress response**

The stress response, also known as the fight-or-flight response, helps humans and other mammals to react to emergencies and to cope with change. This response is initiated in the brain, but involves several bodily systems simultaneously. The stress response provides the body with energy, muscle power, oxygen, pain resistance, and mental lucidity when we are faced with any kind of stressful event. The function of the stress response is to ensure our safety and survival under acute conditions. However, when this powerful system is activated chronically or is out of balance it can give rise to an array of illnesses, since the whole body and mind are involved (McCarty, 2002; McEwen & Norton Lasley, 2002).

The two main systems of the stress response are the sympato-adrenal-medullary (SAM) system and the hypothalamo-pituitary-adrenocortical (HPA) axis (McCarty, 2002). When we are faced with a stressor, the hypothalamus sends signals via the sympathetic nervous system to the medulla of the adrenal glands which starts to secrete adrenaline, thus kicking off the
stress response. The SAM system is the first phase of the body’s defence against stressors, and adrenaline is the main hormone of this system. The second and adjusting phase of the stress response consists of the HPA axis, in which the nervous, endocrine and immune systems work together. Cortisol is the main hormone of this defence system. The HPA axis is activated by the hypothalamus but uses hormones as carriers instead of the sympathetic nervous system. Consequently, the response of the HPA axis is slower compared to the SAM system. It takes thirty to forty minutes before the cortisol levels reach their peak after facing a stressor while adrenaline circulates in the system within a minute. Cortisol reloads the body’s energy reservoirs with glycogen and fat after the adrenaline rush, and helps the body to adjust to change and prolonged states of stress (McEwen & Norton Lasley, 2002).

The SAM system is the body’s active defence mechanism against stressors and it prepares the body to fight or to flee. The HPA axis represents a defeat reaction or a passive stress response. In prolonged exposures to stressors, the HPA axis tends to be the predominant stress response (Ljung & Friberg, 2004). When a stressful event is perceived as overwhelming, the fight-or-flight response becomes futile and is substituted by a defeat reaction. Compared to the fight-or-flight response, which is similar to an attack or a retreat reply, the defeat reaction is more like being subjected to a siege. HPA axis activation is also caused by smoking and alcohol intake (Björntorp, 1996).

The Allostatic Load Model

The allostatic load model explains how the long-term or repeated activation of the stress defence systems leads to ill health (Figure 15). Allostasis refers to the body’s ability to achieve stability (homeostasis) by adapting to change, and as such it is crucial to survival. Allostatic load is the long-term effect of the physiological response to stress, and it arises when the chronic overactivity or underactivity of allostatic systems (SAM system, HPA axis, the cardiovascular, metabolic and immune systems) causes some measure of wear and tear. This wear and tear also reflects the impact of genetic burden, life-course experiences and lifestyle differences that influence a person’s behavior and physiological reactivity. Allostatic load is the cumulative cost to the body of allostasis. Hence, the concept of allostatic load represents not only the physiological reaction to a stressor but a more complex picture of many factors which influence the physiological response to stress (McEwen & Stellar, 1993; McEwen, 1998a; McEwen, 1998b; McEwen & Seeman, 1999a; McEwen & Seeman, 1999b; McEwen, 2000; McEwen & Norton Lasley, 2002; McEwen, 2002; McEwen & Mirsky, 2002; McEwen & Lasley, 2003; McEwen, 2003c, 2003b).
The brain: perceiving stress (threat, helplessness, vigilance), and \( \text{Major life events} \) contribute to development of disease (Selye, 1956; Cooper & Dewe, 2004). According to McEwen (1998b; 1999b; 2002) and colleagues, the allostatic systems protect the body in the short run, but in the long term allostatic load and the hormones associated with stress cause disease (Figure 15).

"The perception of stress is influenced by one’s experiences, genetics, and behavior. When the brain perceives an experience as stressful, physiologic and behavioral responses are initiated, leading to allostasis and adaptation. Over time, allostatic load can accumulate, and the overexposure to mediators of neural, endocrine, and immune stress can have adverse effects on various organ systems, leading to disease". (McEwen, 1998b, p.172)

Both acute and chronic stress can have long term consequences, and the effects of chronic stress can be aggravated by a fatty and sugary diet and substance abuse (e.g. alcohol and tobacco). Moderate exercise reduces the adverse effects of chronic stress (McEwen & Seeman, 1999b). Negative health outcomes of allostatic load are impaired immunity, obesity, atherosclerosis, loss of bone minerals, and the atrophy of nerve cells in the hippocampus (McEwen, 1998b; McEwen & Seeman, 1999b). Allostatic load is also present in common mental disorders such as depressive illness and anxiety disorders (McEwen, 2003a). Early life experiences play an influential role in producing allostatic load over a life course in experimental animals. These animal models could help in understanding how developmental and environmental aspects influence individual differences in stress reactivity (McEwen & Seeman, 1999b).
Four types of situations are seen as leading to allostatic load. Firstly, frequent exposure to stressors leads to increased levels of stress hormones which in turn cause blood pressure surges and accelerate atherosclerosis. Secondly, failure to habituate (get used) to repeated challenges can lead to heightened cortisol levels. Thirdly, the inability to shut off allostatic responses causes allostatic load. For example, blood pressure may fail to recede after mental or physical stress and lead to hypertension, accelerated atherosclerosis and elevated SAM system and HPA axis activity. Fourthly, inadequate allostatic response triggers a compensatory rise in other allostatic systems. For example, if cortisol does not increase enough due to stress, cytokines start to increase (McEwen, 2000; 2001).

In a study by Seeman (1997) and co-workers, allostatic load is measured as a multisystem summary indicator of physiological activity across a range of regulatory systems, and those subjects in the highest quartile of the summary index are defined as having a high allostatic load. Elevated allostatic load predicts an increased risk of impaired cognitive and physical functioning, and cardiovascular disease in older people (ibid.). Moreover, there is an association between allostatic load and socioeconomic status, with people of lower socioeconomic status tending to have a more elevated allostatic load than people of higher socioeconomic status (for a review, see Szanton et al., 2005). In a Swedish study, Lindfors et al (2006) demonstrate that allostatic load is better than a clinical risk indicator in predicting future sense of coherence, and that allostatic load is associated with a weak sense of coherence at follow-up in Swedish middle-aged women.

Work-related health outcomes

The term work-related ill health comprises all non-occupational diseases to whose aetiology work contributes (WHO, 2002). Work-related ill health may manifest itself in a number of diseases and symptoms. Studies of psychosocial work environment and health have mainly focused on cardiovascular disease, mental health outcomes and musculoskeletal disorders (Siegrist & Theorell, 2006).

Cardiovascular disease

Cardiovascular disease (CVD) is a catchall term for diseases of the heart and the blood vessels, including coronary heart disease (CHD) and stroke. The main physiological cause of CVD is atherosclerosis, a hardening of the arteries, which leads to impaired blood circulation and lack of oxygen in the tissues (Mackay et al., 2004). The lack of oxygen can damage the heart and the brain permanently (Rosén, 2001). At least two hundred risk factors for CVD
have been discussed in the scientific literature (Hopkins & Williams, 1981). Age, gender, cigarette smoking, diabetes, hypertension and elevated serum cholesterol level are among the primary risk factors. In addition to these well-established risk factors, obesity, sedentary lifestyle, lack of social support, financial hardship, job stress and physical work demands have been found to increase the risk of CVD (Kaplan & Keil, 1993; Reuterwall et al., 1998; Fine, 2000; Rosén, 2001). Kölegård Stjärne (2005) showed in her doctoral thesis that social context influences the incidence of myocardial infarction. Individuals living in economically disadvantaged contexts had an increased risk of myocardial infarction, after adjustment had been made for individual social characteristics (ibid.). On the basis of a substantial body of findings concerning the impact of workplace physical and psychosocial factors on CVD, the relationship between workplace stressors and CVD risk has been shown to be causal (Schnall et al., 1994; Kristensen et al., 1998; Schnall et al., 2000a; Belkic et al., 2004).

CVD is among the biggest population health problems in the West, including Sweden. While mortality from cerebrovascular diseases (stroke) is low in Sweden, mortality from coronary heart disease is high; twice as high as in France, for example (Rosén, 2001). The risk of dying of CVD has diminished for both sexes and among all socioeconomic groups during the last three decades, yet the socioeconomic differences in CVD mortality have increased (ibid.).

**Stroke**

A stroke, or a cerebrovascular accident, occurs when the blood supply to the brain is disrupted (Mackay et al., 2004). This may result either from a rupture (hemorrhagic stroke) or a blockage (brain infarction, also called ischemic or occlusive stroke) of a blood vessel. The most important risk factor for stroke (hemorrhagic and ischemic) is high blood pressure, followed by smoking, diabetes, and high levels of serum cholesterol (Leppälä et al., 1999). The consequences of stroke in terms of production losses, sick leave, disability pension and premature death are considerable (Ghatnekar et al., 2004). Yet, stroke is a preventable disease because many of the risk factors associated with it are reversible (Stegmayr, 1996).

Stroke is a major cause of long-term disability and death worldwide (Stegmayr & Asplund, 2003). In Sweden, roughly 30,000 people suffer a stroke each year, and about a fifth of them are of working age (<65 years) (Medin, 2006). As a comparison, the number of deaths from stroke was greater (550) than the number of deaths in motor vehicle accidents (369) in the Swedish population <65 years in 2002 (Johansson et al., 2006). Some studies suggest that stroke incidence has risen in recent decades in Sweden.
(Pessah-Rasmussen et al., 2003; Medin et al., 2004), especially among women of working age (Medin et al., 2004). However, results from the Northern Sweden MONICA Project show that incidence rates have remained constant since 1985, while case fatality has decreased (Stegmayr & Asplund, 2003). Thus, stroke prevalence remains high and the burden of stroke will continue to increase in Sweden as the population ages and case-fatality decreases with better emergency care (Ellekjaer & Selmer, 2007). According to prognostic studies based on data from Statistics Sweden, the number of stroke cases in the Swedish population will increase by 55% by 2050 (Hallström, 2007).

The majority of studies of the DCM and ERI models have focused on CVD in general and CHD in particular (Schnall et al., 2000a). Stroke has hardly been in focus in studies of the work environment and health. Those previous studies of work environment factors that have focused on stroke have been relatively small or have studied women only (Uchiyama et al., 2005; Medin, 2006; Kuper et al., 2007). Consequently, the results are inconclusive (see further Study IV). The present thesis wishes to highlight the fact that stroke is a neglected CVD outcome in studies of the work environment and health.

Links between aspects of the work environment and elevated levels of blood pressure (a major risk factor for stroke) are well established (Landsbergis et al., 1994; Pickering, 1996; Pickering et al., 1996; Pickering, 1997; Landsbergis et al., 1999; Landsbergis et al., 2003a, 2003b; Pickering, 2004; Radi et al., 2005; Barbini et al., 2007). Ambulatory studies show that blood pressure is higher in participants reporting low rather than high job control, and these differences persist into the evening after work (Steptoe & Willemsen, 2004). The traditional risk factors for stroke have a complex set of determinants, many of which are of psychosocial origin (Schnall et al., 2000b). For instance, a strong SOC has been associated with a lower rate of stroke incidence after adjustment for age, sex, pre-existing myocardial infarction, diabetes, hypertension treatment, family history of stroke, cigarette smoking, systolic blood pressure, obesity, social class, education, hostility and depression (Surtees et al., 2007). Thus, stress-adaptive capacity as indicated by SOC is a potentially important candidate risk factor for stroke.

**Mental health outcomes**

Sick leave for reasons of mental ill health increased considerably during the 1990s in Sweden (The Swedish Social Insurance Agency, 2002, 2003). Consequently, conditions such as the *burnout syndrome*, vital exhaustion, and psychological distress have attracted much interest. Appels (2000) questions whether fatigue states are distinguishable from depression because almost everyone who is depressed also feels tired, yet not all of those who feel de-
pleted of energy suffer from mood disturbances or lack of self-esteem. However, the most authoritative classification of mental disorders, the Diagnostic and Statistical Manual of mental Disorders (DSMD) does not make a distinction between fatigue states and depression (ibid.).

Although there is an abundance of related mental health constructs, such as adaptation disorder, chronic fatigue syndrome, neurasthenia, vital exhaustion, and psychological distress, to mention but a few, the burnout syndrome is distinguished from these constructs. The burnout syndrome is an expression of professional crisis. It comprises three dimensions: (1) emotional exhaustion, (2) cynicism, and (3) inadequacy (for example low level of professional efficiency) (Maslach, 1982; Maslach & Leiter, 1999; Maslach, 2003). The emotional exhaustion component is independently related to depression (Appels, 2000). According to Schaufeli and Enzmann, burnout is described as

“a persistent, negative, work-related state of mind in ‘normal’ individuals that is primarily characterized by exhaustion, which is accompanied by distress, a sense of reduced competence, decreased motivation, and the development of dysfunctional attitudes at work” (Schaufeli & Enzmann, 1998)

The possible causes of burnout are high workload, emotional demands, role problems, poor social support, lack of control, lack of feedback, poor participation in decision-making, and work-home interference (Schaufeli, 2004). It seems that prolonged or repeated exposure to almost any adverse aspect of the psychosocial work environment may lead to burnout. Schaufeli claims that burnout can be viewed as a process of discrepancy between a worker’s input and expected output. To balance this equation, the burned out worker starts to give less to the job, as reciprocity is a fundamental psychological principle that is firmly rooted in human evolution. Lack of reciprocity leads to negative emotions and exhaustion (ibid.). Described like this, burnout resembles the theoretical foundations of the ERI model (cf., Siegrist, 1996).

Vital exhaustion is distinguished by (1) excessive fatigue and lack of energy, (2) increasing irritability, and (3) feelings of demoralization (Raikkonen, 1997). Vital exhaustion and depression overlap both conceptually and empirically (ibid.). Psychological distress relates to states of discomfort when work or social roles cannot be adequately fulfilled because of distress symptoms (Schaufeli, 2004). As such, psychological distress tends to be a lighter form of work-related exhaustion than the burnout syndrome. Swedish researchers recommend the concept ‘exhaustion syndrome’ when describing work-related exhaustion without depressive symptoms (The National Board of Health and Welfare, 2004). If depressive symptoms are present, the diag-
nosis should be ‘depression with exhaustion syndrome’. Lighter work-related mental health outcomes, which do not fulfil the criterion for exhaustion syndrome or depression, should be diagnosed as ‘maladaptive stress reaction’ (ibid.).

The proportion of people suffering from exhaustion and fatigue increased both in women (from 14.5% to 16.9%) and men (from 10.5% to 11.5%) between 1991 and 1997 in Sweden, as did the proportion of those reporting anxiety (women from 9.1% to 12.7% and men from 8.5% to 9.7%) (Bäckman & Edling, 2000). In a sample of employees in Sweden in 2000, almost 6% showed clear signs of burnout (Hallsten et al., 2002). Women, especially in higher socioeconomic status positions, had higher rates of burnout, as did single persons and immigrants. Teaching was the most highly afflicted occupation. Burnout was associated with several psychosocial work environment factors, such as demanding working conditions, interpersonal conflicts and bullying, and organisational changes. There was also a strong connection between burnout and long-term sickness absence (ibid.). Schaufeli (2004) claims that job stress is a social problem in Europe, and that work-related factors are more important than individual factors in the development of mental complaints. Of those incapacitated on mental grounds the majority (about 90%) are non-psychiatric cases. Further, most are young, under 35 years, and well educated. Women slightly outnumber men, and most of the incapacitated are employed in human services (i.e. health care, education and social work) (ibid.).

Musculoskeletal disorders

Work-related musculoskeletal disorders include a wide range of inflammatory and degenerative diseases and disorders that result in pain and functional impairment (Buckle et al., 1999). Musculoskeletal disorders have a multifactorial aetiology originating in the interaction of individual factors, behavior, lifestyle, physical environment, and psychosocial factors (Hagberg, 1996). The ergonomic factors of work frequently cited as risk factors for MSDs include rapid work pace and repetitive motion, forceful exertions, non-neutral body postures, and vibration (Punnett & Wegman, 2004). The etiological importance of occupational ergonomic factors for the occurrence of MSDs of the low back and upper extremities has been demonstrated in the scientific literature (ibid.). Psychosocial factors at work, such as lack of control over one’s work and repetitive tasks, are related to musculoskeletal disorders (Lundberg, 2003a). The results of a prospective cohort study based on a random sample of vocationally active women and men (aged 45 to 65) in Sweden, indicated that work-related mechanical exposure in both sexes, and psychosocial factors in women, had independent effects on the development of shoulder and neck pain (Östergren et al., 2005). The effect of psychoso-
cial factors was more prominent in women. In addition, high mechanical exposure and job strain acted synergistically in women (ibid.).

Even light physical work can generate musculoskeletal disorders, and it has been suggested that sustained low-level muscle activity may kick off a pathogenic mechanism which results in musculoskeletal pain (Lundberg, 2003a). According to the Cinderella hypothesis, single muscle fibres may be constantly and strongly activated in situations when the total muscle load is low (Sjögaard et al., 2000; Forde et al., 2002). The symptoms of musculoskeletal problems may appear early in life and after only a short exposure to adverse work environment factors (Lundberg, 2003a). Repetitive movements can elicit pain syndromes after only 6 to 12 months of exposure. However, lack of rest and recovery may be of more importance in the development of musculoskeletal pain than high physical workload or psychosocial stress at work (Lundberg, 2003b).

Theorell and Hasselhorn (2002) suggest three main mechanisms linking psychosocial factors to musculoskeletal pain. First, long-lasting adverse psychosocial exposure may increase the vulnerability of the musculoskeletal system to mechanical damage. Second, adverse psychosocial conditions can change pain sensitivity. Third, social conditions, such as a labour market crisis, may have the effect of selecting vulnerable individuals into strenuous jobs, which may then affect the prognosis of musculoskeletal disorders in these individuals. There is a strong association between occupational gender segregation and musculoskeletal-related sickness absence (Leijon et al., 2004). The highest incidence and duration of musculoskeletal-related sickness absence was found in women in male-dominated occupations. For both genders, the lowest cumulative incidence and duration occurred in gender-integrated occupations (ibid.).

Musculoskeletal disorders are among the most common diagnoses behind sickness absence and disability pensions (Leijon et al., 2004). Thus, musculoskeletal disorders represent a considerable public health problem. The proportion of working people in Sweden suffering from musculoskeletal pain increased in women (from 18.4% to 19.9%) and remained relatively stable in men between 1991 and 1997 (Bäckman & Edling, 2000).
DATA, VARIABLES AND METHODS

Data

Survey data
The Swedish Level of Living Survey (LNU) has been carried out by the Swedish Institute for Social Research at Stockholm University on five occasions, in 1968, 1974, 1981, 1991 and 2000 (Fritzell & Lundberg, 2000; Swedish Institute for Social Research, 2003). The Survey of Living Conditions (ULF) has been performed annually since 1975 by Statistics Sweden (Statistics Sweden, 2003). Both surveys include several questions on work life, working conditions, and health. The surveys comprise a random sample of the adult population residing in Sweden.

Register data
The Swedish Work and Mortality Data Base (HSIA in Swedish) maintained at the Centre for Health Equity Studies (CHESS), Stockholm University/Karolinska Institute, compiles several national registers provided by Statistics Sweden and the National Board of Health and Welfare. The studies of the present thesis used a subset of HSIA including information from the Total Population Register (TPR) (Statistics Sweden, 2002), National Population and Housing Census (Statistics Sweden, 1999), the Longitudinal Data Base on Education, Income and Employment (LOUISE) (Statistics Sweden, 2005), Hospital Discharge Register (The National Board of Health and Welfare, 2007a), and the Cause of Death Register (The National Board of Health and Welfare, 2007b). Linkages were possible using the 10-digit personal identity number, which was replaced by a serial number to ensure anonymity.
Variables

Health outcomes

**Cardiovascular disease**
In Study I, the CVD measure was self-reported in the survey sample, and based on the Cause of Death Register in the mortality follow-up. The self-reported CVD indicator included only doctor-certified diagnoses; no vague symptoms were included. Hypertension was excluded as it is a risk factor for CVD. The predictive validity of a similar CVD indicator using the same source of data was investigated in an earlier study by linking the survey group to the Cause of Death Register. The findings indicated a higher relative risk for CVD-related mortality during a six-year follow-up for individuals classified as having CVD in the survey than for those classified as not having CVD (Johnson & Hall, 1988). Based on these findings, the CVD prevalence measure from the survey is most likely valid.

**Stroke**
Information on stroke incidence (Study IV) and mortality (Study V) was linked from the Hospital Discharge Register and the Cause of Death Register. A validation study from Sweden, which compared routine registers with a population-based MONICA stroke register, concluded that official mortality statistics give a reasonably good estimate of fatal stroke events, whereas hospital discharge records reflect poorly the incidence of stroke in the population (Stegmayr & Asplund, 1992). Hospital discharge data may overestimate stroke incidence in the population if the diagnoses are not limited to specific ICD-9 codes for stroke (Ellekjaer et al., 1999). In order to avoid misclassification of outcome, the ICD codes for measuring incident stroke in Study IV were selected according to Ellekjaer’s et al. (1999) recommendation. However, this type of misclassification of outcome is most likely non-differential, meaning that it is unrelated to the exposure under study (job control in Study IV). Study IV used information on stroke diagnoses based on both ICD-9 and ICD-10 (the shift from ICD-9 to IDC-10 occurred in 1997 in Sweden). Medin et al. (2004) showed that the proportion of undetermined pathological types of stroke has decreased steadily since 1989 in Sweden with a notable dip between 1996-1997. Simultaneously, the proportion of brain infarctions increased, while the proportion of haemorrhages was stable. This may be an indication that the process of diagnosing stroke subtypes has become more efficient since 1997 in Sweden.
Psychological distress
In Studies II and III, the measure of psychological distress was based on an additive index answering the question: have you had any of the following illnesses or ailments during the past 12 months: tiredness, sleeping disturbances, nervousness (anxiety, worry), depression, dejection, overexertion or psychiatric illness? To each item, the respondent was asked to answer “No”, “Yes, mild” or “Yes, severe”. Those persons reporting at least one severe or three mild conditions for the first six items, or reporting mild or severe psychiatric illness were categorized as having psychological distress. The same measure of psychological distress has been used in several previous studies based on LNU data (e.g., Tåhlin, 1987; Lundberg, 1990; Lundberg & Fritzell, 1994; Fritzell et al., 2007).

Musculoskeletal pain
Similarly to psychological distress, the measure of musculoskeletal pain in Studies II and III was based on an additive index answering the question: have you had any of the following illnesses or ailments during the past 12 months: pain in shoulders, back pain or sciatica, pain in hands, elbows, feet or knees? Those persons reporting at least one severe or three mild conditions were categorized as having musculoskeletal pain. Also the measure of musculoskeletal pain has been frequently used in studies based on LNU data (e.g., Tåhlin, 1987; Lundberg, 1990; Lundberg & Fritzell, 1994; Fritzell et al., 2007).

Exposure variables

Income
As described in the background of the thesis (p.16), studies of health differentials by income have used various types of income measures ranging from individual to household income and from absolute to relative measures. When focusing on health inequalities and the mechanisms behind the development of such inequalities, relative measures are recommended (Anand et al., 2001; Lundberg, 2003). Household income is advocated for studies of income and health (e.g., Rahkonen et al., 2000). Yet, household income is mainly a measure of purchasing power, while individual income based on wages or annual earnings reflect an individual’s relative position in the income hierarchy on the labour market. Because the focus of the thesis is on work-related inequalities in health, a relative measure of individual income from work was preferred and regarded as most relevant. The income variable was categorized by quartile values based on the income distribution in the data.
In Study I, income was measured as annual earnings. For the survey sample (ULF 1996-1999), the income measure comprises the sum of payments of wages/salary including taxable bonuses and allowances for expenses during the year. In the census (1990) data, the income measure comprises the sum of payments of wages/salary including taxable bonuses, allowances for expenses, and social allowances during the year. These two income measures differ slightly as the former does not include social allowances such as sick leave compensation. However, the two income measures are highly correlated (Statistics Sweden, 2006b).

In Study II, income is measured as self reported pre-tax hourly wages based on regular working hours (Le Grand, 1991). Most respondents did not have a fixed hourly wage rate. Therefore, other compensation systems (e.g. daily, weekly and monthly earnings, bonus, commissions, and compensation for overtime and inconvenient working hours) were recalculated into hourly wages using information on regular working hours (ibid.).

In Study IV, income is measured as disposable income per person. Disposable income is the total of all incomes (including social allowances) liable to tax and exempt from tax minus taxes and negative transfers (Statistics Sweden, 2006b).

**Physical work environment**

Physical workload or physically demanding job characteristics are usually measured as unsuitable work postures, bending and turning, repetitive movements, carrying and heavy lifting, and strenuous muscular work (Hagberg, 1992). A host of occupational chemical and physical factors, such as cold weather, noise, passive smoking, and vibration have been studied to investigate their possible relationship to CVD (Fine, 2000). Three types of indices were used for assessing physical workload in the thesis. In Study I, a four-item index was used comprising noise, vibrations, heavy lifting, and daily sweating (dichotomized as no or yes). In Study II, physical work load was included as a control variable in the analyses, and it was assessed by a three-item index comprising whether the job includes daily sweating, unsuitable work postures, or heavy lifting (categorized as no, low or high). The item on whether the job is physically demanding was removed from the physical workload index in Study II as the ERI model also included a similar item. In Study III, a four-item index was used comprising whether the job is physically demanding, includes daily sweating, unsuitable work postures, or heavy lifting (dichotomized as low or high, for exact cut-points for the indices, see Studies I-III).
Psychosocial work environment

The demand-control model
The Job Content Questionnaire (JCQ) is the standardized instrument for measuring the DCM (Job Content Questionnaire Center, 2007). The instrument consists of 49 questions for the assessment of 5 scales: (1) decision latitude, (2) psychological demands, (3) social support, (4) physical demands and (5) job insecurity. The Swedish Demand-Control Questionnaire (DCQ) is often used in Swedish studies (Theorell, 1996). The main difference between the original JCQ and the Swedish DCQ is that the DCQ does not include questions on physical demands or job insecurity. The DCQ contains five questions on psychological demands (Do you have to work very fast? Do you have to work very intensively? Does your work demand too much effort? Do you have enough time to do everything? Does your work often involve conflicting demands?), and six questions on job control, of which two are on decision authority (Do you have a choice in deciding how you do your work? Do you have a choice in deciding what you do at work?) and four on skill discretion (Do you have the possibility of learning new things through your work? Does your work demand a high level of skill or expertise? Does your job require you to take the initiative; Do you have to do the same thing over and over again?).

Some of the previous studies of the demand-control model based on Swedish data use fewer items to operationalize the model than the DCQ (e.g., Karasek, 1979; Karasek et al., 1981; Alfredsson et al., 1982; Alfredsson et al., 1985; Tåhlin, 1987). In the Swedish Level of Living Survey the DCM is assessed by two questions on demands (Do you have to rush while working? Is your job psychologically demanding?) and two on job control (Can you decide your own pace of work? Is your job monotonous?) (e.g., Karasek, 1979; Tåhlin, 1987; Lundberg, 1990; le Grand et al., 2001; Rostila, 2004, 2007). Studies II and III of the present thesis are based on LNU data and have used the shorter measure for the DCM described above.

Job control
To meet the criticism of self-reporting bias, i.e. that self-reporting does not accurately describe job characteristics or the degree of control which individuals have over their work environment (Muntaner & O'Campo, 1993), the DCM has been assessed on an ecological level in Swedish studies (e.g., Alfredsson et al., 1985; Johnson et al., 1996; Hammar et al., 1998) using a psychosocial job exposure matrix (JEM) based on occupational categories (Johnson et al., 1990; Fredlund et al., 2000). However, in studies using the JEM (Fredlund et al., 2000), the results for job control are usually in the expected direction, while the findings for psychological demands and social
support point in the opposite direction than those for studies using individual level measurements. It has been suggested that this is because the aggregate measure of job control captures work characteristics, whereas psychological demands and social support vary across individuals in the same occupation and by work site (Johnson et al., 1996). Nevertheless, the associations between the aggregate measure of job control and CVD outcomes, and self-reported job control and CVD outcomes tend to be similar (Theorell et al., 1998).

In Studies I, IV-V job control was assessed using the JEM (Fredlund et al., 2000). In Study I, women and men were studied together. In Studies IV and V, separate analyses were performed for women and men. Study V also used a gender-specific distribution for the job control variable thus balancing the skewed distribution of job control among women. In the survey sample of Study I, job control was assessed by a five-item additive index constructed in accordance with the Swedish DCQ (dichotomized as low or high). The five items combined decision authority and skill discretion (influence over work pace, work monotony, repetitive movements, learning new things, and whether the job is meaningful).

The effort-reward imbalance model

The core aspects of the ERI model concern the experiences and perceptions of working people (Siegrist et al., 2004). Self-reported data is therefore considered important. In large scale social epidemiological research, however, a standardised questionnaire is often used. In its short version, the questionnaire includes 23 Likert-scaled items. These items define three scales: ‘effort’ (6 items), ‘reward’ (11 items), and ‘overcommitment’ (6 items). An example of effort is ‘I have constant time pressure due to a heavy work load’; of reward ‘My job promotion prospects are poor’; and of overcommitment ‘Work rarely lets me go, it is still on my mind when I go to bed’. The standardised questionnaire has been translated to many languages, including Swedish (ibid.).

In Study II, a proxy measure was constructed for the ERI model in line with the theoretical guidelines of the ERI model (Siegrist & Peter, 2002). As this proxy measure has not been validated against the standardized ERI questionnaire, the validity and reliability of the ERI proxy measure is a serious question. Yet, the results for the ERI proxy are generally in line with previous findings. In addition, several previous studies have used proxy measures for the work stress models (e.g. Bosma et al., 1998a; de Jonge et al., 2000a; Kivimäki et al., 2002). However, the findings for the ERI model in Study II should be interpreted with caution bearing in mind that the results are not completely comparable with previous studies.
Sense of Coherence
The Orientation to Life Questionnaire is an instrument for assessing SOC, and the questionnaire exists in a long (29 items) and a short (13 items) version (Antonovsky, 1987a), and in an array of alternative instruments (Eriksson & Lindstrom, 2005). A Swedish 3-item measure of SOC, developed to fit survey questionnaires addressed to population samples, includes one question for each of the three components of the SOC construct (comprehensibility ‘Do you usually feel that the things that happen to you in your daily life are hard to understand?’; manageability ‘Do you usually see a solution to problems and difficulties that other people find hopeless?’; meaningfulness ‘Do you usually feel that your daily life is a source of personal fulfilment?’) (Lundberg & Nyström Peck, 1994, 1995; Lundberg, 1996). This shortened way of measuring SOC has been validated in relation to the original SOC questionnaire (Lundberg & Nyström Peck, 1995), and several studies of SOC and health have used the Swedish 3-item SOC questionnaire (Surtees et al., 2003; Lindfors et al., 2005, 2006; Surtees et al., 2006a; Surtees et al., 2006b; Surtees et al., 2006c; Surtees et al., 2007; Wainwright et al., 2007), including the present thesis.

Control variables
In Study I, the analyses based on ULF data were adjusted for age (continuous), gender and smoking (yes-no) in order to make the results comparable with the results from the mortality follow-up based on register data, which were adjusted for age and gender.

In Study II, the analyses were adjusted for age (continuous), job sector (private or public), occupational class (unskilled manuals, skilled manuals, lower non manuals, intermediate non manuals, and higher non manuals), physical workload (no, low or high), marital status (married/cohabiting, divorced/widowed, or single), number of children (no children, 1 to 2 children, or ≥2 children), sense of coherence (weak or strong), body mass index (<20, 20 to <25, 25 to <30, ≥30 kg/m²), and smoking (never smoker, quitter, <10 cigarettes/day, ≥10 cigarettes/day).

Study III adjusted the analyses for age (ten-year groups). To study whether the exposure time to noxious working conditions increased between 1991 and 2000, a dichotomous variable (working >40 hours per week versus, ≤40 hours o per week) was included in the analyses.

Study IV adjusted for age (continuous), work hours (working fulltime, yes or no), education level (unknown, primary, secondary or tertiary), income
(categorized in four groups by quartile values of the income distribution), and marital status (married, never married, divorced or widowed).

Study V adjusted the analyses for age (five-year groups), education level (unknown, primary, short secondary, long secondary, short tertiary, long tertiary, PhD level), occupational class (unskilled manuals, skilled manuals, lower non manuals, intermediate non manuals, higher non manuals, self-employed, and farmers), and marital status (married, never married, divorced or widowed).

Methods

Logistic regression (Studies I-III), Poisson regression (Studies I and V), and Cox regression (Study IV) were applied to estimate the associations between the exposures and the health outcomes (Hosmer & Lemeshow, 1999, 2000). These estimates are interpreted as relative risks. The relative risk estimates the magnitude of an association between the exposure and the outcome and indicates the likelihood of developing the outcome under study in the exposed group in relation to those who are not exposed (Hennekens & Buring, 1987). However, the odds ratio diverges from the relative risk when the prevalence rate of the health outcome is high (Zocchetti et al., 1997; Thompson et al., 1998; Zhang & Yu, 1998; McNutt et al., 2000; Barros & Hirakata, 2003). As a consequence, the odds ratios of Studies II and III may be overestimated as psychological distress and musculoskeletal pain are highly prevalent in the working population. The relative risk estimates are presented with 95% confidence intervals which, in addition to significance, indicate the precision of the estimates (Sterne & Davey Smith, 2001).

In order to assess the contribution of work environment to the association between income and CVD in Study I, the explained fraction (XF) is calculated according to the formula \( (XF) = \frac{[\text{OR}_1-1]-(\text{OR}_i-1)}{\text{OR}_1-1} \). Where \( \text{OR}_1 \) is the odds ratio or the rate ratio in a specific income quartile in the base model, adjusted for control variables. \( \text{OR}_i \) refers to the corresponding odds ratio or rate ratio in subsequent regression models in which the potential mediating factors are included. The explained fraction estimates the proportion of excess risk attributable to the mediating factors (see further Hallqvist (1998)).

Effect modification (interaction) is present when the effect under study varies by levels of a third factor (Rothman, 2002). Statistical interaction (the product term of two covariates) is present if the interaction term is significant in a statistical model. Presence of statistical interaction is normally tested by a likelihood ratio test. Biological (or epidemiological) interaction,
however, arises when two factors cooperate in the same causal mechanism leading to the health outcome under study (cf. assessment of joint effects in occupational epidemiology as in Checkoway et al. (2004, pp. 112-117)). Biological interaction occurs if the effect of two variables under study departs from additivity (Rothman, 2002). Study III investigated whether a strong sense of coherence moderates the effect of work environment exposure on psychological distress or musculoskeletal pain. For biological interaction, as assessed in Study III, the testing of interaction is done by means of 2x2 tables and with the synergy index (see further Hallqvist, 1998; Hallqvist et al., 1998).
Study I: Income differences in cardiovascular disease: is the contribution from work similar in prevalence versus mortality outcomes?

Objective: to examine the contribution of job control and physical work demands to the association between income and cardiovascular disease, and to study possible differences across prevalence and mortality outcomes, and different methods of assigning work exposures.

In this study we adopted a comparative perspective, examining the research question by means of a cross-sectional versus a follow-up design based on two separate data sets. The first data set comprised a representative sample of the working population in Sweden based on self-reported survey data (ULF 1996-1999). The second data set was based on census (1990) data linked to the cause of death register after the census until 1995. We wanted to contribute to the current debate about methodological aspects of research into the work environment and health. Opinion has recently favoured follow-up studies. A consequence of this is that cross-sectional studies based on self-reported data have been considered inferior, and in some cases not even worth publishing. We argue that this kind of reasoning could lead to serious publication bias.

In our cross-sectional analyses, CVD prevalence was self-reported, as was job control and physical demands; the information on income was linked from the income register. In the register-based follow-up analyses, CVD mortality was the outcome and an aggregate measure of job control (job exposure matrix based on occupational titles) was applied. Multiple logistic and Poisson regressions were applied. The results were similar for the cross-sectional and the follow-up analyses. Associations between income and CVD were strong. Those in the lowest income quartile had a 3.6 (prevalence) and a 2.1 (mortality) times higher risk of CVD than those in the highest income quartile (with a gradient for the intermediate groups). In the survey, low job control and physical demands contributed 8-10% to the association between income and CVD prevalence. This contribution was 10% for
low job control in the mortality follow-up. A small proportion of the association between income and the prevalence or mortality from CVD was attributable to working conditions. It seems therefore that the association between income and CVD is more salient than the one between work environment factors and CVD. However, the main methodological contribution of the study is that it shows that the results from cross-sectional analyses are in line with those of prospective follow-up analyses, regardless of the different methods of assessing job control. In sum, self-reported CVD and job exposures are useful measures for assessing public health issues, and a cross-sectional design should not be regarded as a serious limitation.

Study II: Work stress and wages in relation to psychological distress and musculoskeletal pain: results from the Swedish Level of Living Survey

Objective: to examine the associations between work stress, wages and psychological distress or musculoskeletal pain, and to determine whether the association between work stress and ill health is independent of wages and potential confounding factors.

This study highlights the fact that studies of work stress seldom take work factors and income into account simultaneously. Given that income is correlated with positive job attributes, it may be that the association between psychosocial work factors and health is either underestimated or overestimated if it is not adjusted for income. Moreover, the way in which income is measured varies in studies of income and health. An income measure based on an hourly rate of pay is considered ideal, as hourly wages take into consideration the money received from work in relation to time spent at work. Thus, the results for women and men become more comparable as the gender difference in time spent at work is adjusted for.

The study is based on survey data (LNU 2000, controlling for health status 1991). The health outcomes were psychological distress and musculoskeletal pain, two common health impairments in the working population. Work stress was operationalised according to the demand-control model (DCM) and effort-reward imbalance model (ERI). Wages were measured as pre-tax hourly wages based on regular working hours. The final analyses were additionally adjusted for job sector, occupational class, physical work load, marital status, number of children, sense of coherence, body mass index, and smoking. Multiple logistic regressions were applied. When fully adjusted, the work stress models in both genders, and wages in men were associated with psychological distress. Effort-reward imbalance and wages in women (not significant), and both work stress models in men were related to muscu-
loskeletal pain. Thus, both work stress and wages are important factors for psychological distress and musculoskeletal pain in the working population. However, different factors are of importance for women’s and men’s health.

Study III: Work stress and health: is the association moderated by sense of coherence?

Objective: to examine

- whether there were any changes in work stress exposures, in sense of coherence, or in the prevalence of psychological distress and musculoskeletal pain between 1991 and 2000, and whether there were gender differences in these factors.
- whether work stress exposures or a weak sense of coherence or both predict psychological distress or musculoskeletal pain incidence in a sample of initially healthy employees.
- whether a strong sense of coherence moderates the work stress effect on psychological distress or musculoskeletal pain.

Previous research has shown that people with a strong SOC are better equipped to deal with difficult circumstances in daily life. Therefore, they are able to maintain good health despite severe demands. Whether a strong SOC is a buffering factor in working life settings is less clear. The main objective of the study was to investigate whether a strong SOC acts as a buffer against adverse work environment exposures. Taking advantage of the longitudinal panel data in LNU, changes in work stress exposures and SOC during the study period were also investigated, keeping the gender differences in focus.

The share of both women and men reporting poor working conditions increased between the years 1991 and 2000. The share of low strain and passive jobs decreased. Active jobs and job strain increased, with a remarkable increase in job strain (5.6 percentage units for men and 5.4 percentage units for women). The share of job strain was approximately 11 percentage units higher among women than men at both measuring periods. The exposure time to adverse work environment increased during the study period. The proportion of men and women working more than 40 hours per week increased notably. SOC remained reasonably stable among the subjects of this cohort. The prevalence of psychological distress and musculoskeletal pain increased in both men and women between 1991 and 2000. The gender difference in psychological distress and in musculoskeletal pain rose. However, the respondents aged nine years during the course of the study period, and this is reflected in the figures.
In men, high physical demands, job strain, and an active job predicted new cases of psychological distress. In women, although the demand-control indicator did not reach statistical significance, job strain increased the odds for psychological distress. Having a weak SOC doubled the odds for psychological distress incidence in women. In men, high physical demands, active job, job strain, passive job, and SOC predicted new cases of musculoskeletal pain. However, the estimate of an active job and that of job strain were of similar magnitude. The case for women was similar: high physical demands, job strain, and a passive job predicted musculoskeletal pain incidence. SOC predicted musculoskeletal pain in women in a similar manner as in men but the odds ratio was not statistically significant. Thus, there were interesting gender differences in the ability of work stress exposures and SOC to predict the health outcomes. In men, work stress exposures had a substantial impact on psychological distress, whereas in women, SOC was the most important factor for future psychological distress. For musculoskeletal pain the results were more or less similar in men and in women. Nevertheless, it should be noted that an active job for men and a passive job for women seem to be as harmful as job strain for the risk of musculoskeletal pain.

The moderating role of SOC seemed to depend on gender, work stress exposure, and health outcome. The most substantial moderating effects can be summarized as follows: (1) a strong SOC moderated the adverse effects of physical demands on musculoskeletal pain incidence in men and in women, (2) a strong SOC moderated the adverse effects of job strain on psychological distress incidence in women and when men and women were studied together, but not in men alone. In line with the theoretical argumentation of SOC (Antonovsky, 1979, 1987a), viewing life as comprehensible, manageable and meaningful apparently provided these women and men with the strength to meet challenges in the workplace more successfully.

**Study IV: Job control and risk of incident stroke in the working population in Sweden**

*Objective: to examine the long-term effect of low job control on the risk of incident stroke (nonfatal or fatal), and to explore whether the impact of job control differs for stroke subtypes, or in women versus men.*

There is extensive evidence that an adverse psychosocial work environment, as measured by low job control, increases the risk of cardiovascular disease (CVD). However, only a few studies of the psychosocial work environment have focused on stroke as a specific CVD outcome, and the results are inconsistent. This was a register-based cohort study of the working population in Sweden based on nearly 3 million working people (aged 30-64 in 1990) with a 13-year follow-up (1991-2003) for incident stroke. Incident stroke
was defined either as a first-ever hospital admission for stroke or as death from stroke, and the following subtypes were studied: intracerebral hemorrhage (ICH), brain (cerebral) infarction (BI), and undetermined pathological type (UND). Job control was aggregated to the data by a secondary data source (job exposure matrix) in 1990. The cohort was followed-up for nonfatal stroke by record linkage to the Swedish Hospital Discharge Register 1991-2003, and for fatal stroke by linkage to the Cause of Death Register 1991-2002. Gender-specific Cox regressions were applied.

The risk of stroke was higher in women and men in occupations with low job control than in those with high job control. When adjusted for education, marital status and income, low job control had more impact on the risk of intracerebral hemorrhage (ICH) than on that of brain infarction (BI). Moreover, the impact of low job control on stroke subtypes differed as a function of gender. The relative risk of ICH was highest in women in low job control occupations, while low job control did not significantly increase the risk of BI in women. In men, low job control increased the risk of ICH, and BI risk rose in the two lowest job control quartiles. This study provided new prospective findings indicating that low job control may increase the risk of stroke. As there are only a few studies on working environment factors and risk of stroke, further work is required to examine the associations in different settings, preferably using individual-level data, comparing various methods of exposure assessment, and classifying stroke by subtypes.

Study V: Is the impact of job control on stroke independent of socioeconomic status? A large-scale study of the Swedish working population.

Objective: to examine whether the impact of job control on stroke mortality is independent of socioeconomic factors.

With this study we wanted to contribute to the current debate about whether the impact of job control on stroke is independent of or confounded by occupational class or other socioeconomic circumstances. Although other investigators (Brunner et al., 2004) have convincingly shown that the association between work stress (job strain and effort-reward imbalance) and mortality from CVD is not explained by confounding from socioeconomic circumstances (childhood factors, education, occupational group, salary), it has not yet been established whether this is also valid for stroke. Therefore, the aim of Study V was to investigate the association between job control and stroke mortality in the working population in Sweden, taking age, occupational class, educational level, and marital status into account. This was a register-based cohort study based on nearly 3.5 million working people (aged 25-64
in 1990) with a 5-year follow-up (November 1990-1995) for stroke mortality. Stroke mortality was divided into two main subtypes: hemorrhagic and ischemic or unspecified.

Job control was significantly related to stroke mortality in women, but not in men. In women, the effect of low job control was stronger for hemorrhagic than for ischemic stroke. Estimates clearly decreased after adjustment for education and occupational class. In the fully-adjusted model, job control was significantly related to hemorrhagic and all-stroke mortality. In women, the effect of job control was consistent in all occupational classes except for upper non-manuals, in which the overall level of job control is high and the variability is small. We observed similar effects of low job control in manual workers and lower non-manuals. One possible explanation is that in these occupations low job control is often combined with high psychological (job strain) or physical demands. Women’s experience of domestic stressors may also interact with harmful job exposures. However, when it comes to the effects of confounders, occupational class was of least importance for stroke mortality in terms of explained statistical variance in the models, and marital status was always of greatest impact for women as well as for men. We therefore conclude that the impact of job control on stroke mortality is independent of socioeconomic status, at least for women.
In this thesis my aim was to elucidate how work-related inequalities in health are generated. I focused on income, aspects of the physical and psychosocial work environment, and sense of coherence, and in the ways these factors – individually or jointly – contribute to inequalities in various health outcomes in the working population in Sweden. The model by Diderichsen and Hallqvist (1998) that was introduced at the beginning of the thesis as a framework for studying the pathways between work-related factors and health is again helpful for putting the various studies of the thesis into a relevant context (Figure 16).

Figure 16. A framework for illustrating the pathways from income, work environment, and sense of coherence (SOC) to work-related ill health. Source: Diderichsen and Hallqvist (1998), modified by author
The main focus of studies I & II was the associations between income and work environment exposures in relation to work-related ill-health manifested as CVD, psychological distress and musculoskeletal pain. Differential exposure (see Figure 16, Mechanism II) in the form of various health-related behaviors such as smoking was taken into account (mainly in Study II). The results varied according to the health outcome under study. For CVD prevalence and mortality (Study I), the impact of income was stronger than that of work environment factors, yet for CVD mortality the impact of job control was significant when income had been adjusted for. Working conditions contributed 8-10% of the association between income and CVD prevalence and 10% of the association between income and CVD mortality. These results are in line with previous findings. Working conditions contributed 8% of the CVD mortality gradient by occupational class (Virtanen & Notkola, 2002). According to a Danish study, the aetiologic fraction of working conditions to premature CVD mortality is between 16 and 22% (Olsen & Kristensen, 1991). The association between people’s relative income and CVD was found to be stronger than the corresponding one between working conditions and CVD, regardless of the method used to measure working conditions (self-reported versus occupation-based JEM). Also these results are in line with the study by Virtanen and Notkola (2002) which indicated that income has a strong effect on CVD mortality. CVD is regarded as an important outcome in studies of the association between working conditions and health since many factors, social as well as biological, contribute to its development (Theorell, 2000). However, when one studies the association between income and CVD, working conditions do not seem to be among the most important contributing factors.

In Study II, the associations between work stress and wages in relation to psychological distress and musculoskeletal pain were in focus. The work stress models in both genders, and wages in men were associated with psychological distress. Effort-reward imbalance and wages in women (not significant), and both work stress models in men were related to musculoskeletal pain. Previous studies of work environment and health that adjust for income have focused mainly on cardiovascular outcomes (Alfredsson et al., 1985; Lynch et al., 1997a; Lynch et al., 1997b; Brunner et al., 2004) or self-rated health (Ostry et al., 2003; Hemström, 2005b). Joksimovic (2002) and co-workers reported greater odds of hip pain in respondents exposed to effort-reward imbalance when the analyses were adjusted for education and income. When the analyses of Study II were adjusted for wages, the odds ratios increased for men exposed to job strain or active jobs, suggesting that omitting income from the regression model may result in underestimated associations between work stress and the health outcomes.
A previous study of socioeconomic circumstances and common mental disorders indicated that past and present economic difficulties (childhood economic difficulties, household income, current economic difficulties) were strongly associated with common mental disorders, whereas conventional past and present socioeconomic status measures (parental education, own education, occupational class, home ownership) showed weak or slightly reverse associations (Lahelma et al., 2006). In Study II wages were associated with psychological distress in men and with musculoskeletal pain in women (almost significantly). In Studies II and III, sense of coherence showed a strong association with psychological distress in women in comparison to work environment exposures and socioeconomic circumstances. In Study II, a reason for the found association between wages and musculoskeletal pain in women, but not in men, may be that occupational class differences in the proportions of physical exposures seem to be larger for women than for men (see Figures 7 and 8, pp.19-20).

Where the joint effect of work environment factors and income are concerned, the results from previous studies tend to differ. On the one hand, Lynch et al. (1997a) concluded that jobs characterised by high job demands and low income were associated with a greater accelerated progression of carotid atherosclerosis in Finnish men than jobs with low demands and high income. However, the job demands measure used in the study by Lynch et al. (ibid.) was broad and included both physical and psychosocial demands, as well as the risk of unemployment and accidents. The impact of an adverse psychosocial work environment on all-cause mortality and myocardial infarction risk in Finnish men depended on income level, and the effects of the work-related factors were largely mediated by known risk factors (Lynch et al., 1997b). On the other hand, in a representative sample of the Swedish working population, poor work environment was related to poor self-rated health even when income was high, suggesting that high income does not buffer against a detrimental work environment (Hemström, 2005b). However, the combined effects of work stress and wages were not in focus in Study II. Thus, the results from studies I & II indicate that income and work environment have an independent impact on CVD, psychological distress and musculoskeletal pain. Consequently, both income and work environment are important in generating poor health in the working population.

Study III focused on whether differential vulnerability (see Figure 16, Mechanism III) assessed by means of SOC moderated the impact of physical and psychosocial work environment exposures on psychological distress and musculoskeletal pain. A strong SOC did indeed buffer against adverse exposure at work, but not in a consistent way. The moderating role of SOC depended on gender, type of adverse exposure and health outcome. Most substantially a strong SOC acted as a buffer against the impact of physical de-
mands on musculoskeletal pain incidence in both women and men. There was also some evidence that a strong SOC moderated the impact of job strain on psychological distress, mainly in women.

The moderating role of SOC on the impact of adverse working conditions has not been studied extensively, and previous findings tend to be inconclusive. In addition, most previous studies have focused on psychosocial exposure at work only. Some results suggest that people with a strong SOC cope more efficiently with adverse psychosocial working conditions than people with a low SOC (Feldt, 1997; Albertsen et al., 2001). According to two cross-sectional studies from Sweden, a weak SOC in combination with low decision latitude increased the risk of type 2 diabetes in Swedish women (Agardh et al., 2003), and a weak SOC combined with emotional job strain increased the risk of exhaustion and depersonalization in a small sample of Swedish civil servants (Söderfeldt et al., 2000).

The physical work environment in combination with SOC has hardly been studied before. Feldt (1997) showed that SOC moderated the effect of poor lighting, soundproofing, noise, dirt and dust and crowded working space on emotional exhaustion. However, these results were based on a relatively small sample (n=989) consisting mainly of male technical designers in Finland, and the study design was cross-sectional (ibid). Thus, the main contribution of Study II was to demonstrate that SOC moderated the impact of high physical demands on musculoskeletal pain incidence in a representative sample of the working population in Sweden. Thus, in line with Antonovsky’s SOC theory (Antonovsky, 1979; 1987a; 1987b), viewing the world, and most likely also working conditions, as comprehensible, manageable and meaningful helped these women and men to cope better with daily stressors in the work place and to protect themselves against musculoskeletal pain. However, people with a strong SOC and high physical demands also demonstrated an increased risk of musculoskeletal pain. This indicates that the main focus of occupational stress research should be on work environment, and not on individual differences in the ability to cope with adverse environments. To conclude, SOC moderates, yet not consistently, the impact of adverse working conditions on psychological distress and musculoskeletal pain. Hence, the results do not fully support the hypothesis that SOC is a global health protective factor. However, differential vulnerability in terms of the strength of SOC contributed to work-related inequalities in health.

Study IV focused on the effect of job control on the risk of incident stroke, and adjusted the analyses for age, education, income, and marital status. Previous findings on the psychosocial work environment and risk of stroke are inconclusive (Uchiyama et al., 2005; Medin, 2006; Kuper et al., 2007). In a small case-control study, an active job (high psychological demands in
combination with high job control) seemed to reduce the risk of first-ever stroke (Medin, 2006). A cohort study of treated hypertensive workers showed that high psychological demands in both women and men, and low job control in women were associated with increased risk of cardiovascular events, including stroke (Uchiyama et al., 2005). Recent findings from a cohort study of middle-aged women in Sweden showed a weakly increased risk of ischemic stroke by job strain and low job control, respectively (Kuper et al., 2007). However, no such association was found for low job control and hemorrhagic stroke (ibid.). Conversely, in Study IV, the relative risk of hemorrhagic stroke was highest in women with lowest job control, but low job control did not significantly increase the risk of ischemic stroke in women. In men, low job control increased the risk of both hemorrhagic and ischemic stroke.

In Study IV, the sizes of the effect estimates between job control and risk of stroke were small after adjustment for relevant covariates that could be adjusted for using register data. However, the true risks are most likely underestimated due to the crude exposure measure in terms of the JEM. Nevertheless, the small sizes of the present effect estimates are in line with other studies which have used the JEM in relation to CVD outcomes. In a cohort study of young men in Sweden, the age-adjusted hazard ratio was 1.55 between low job control and incident CHD (Hemmingsson & Lundberg, 2006). In a large cohort of men in Finland, the rate ratio was 1.19 between low job control and cerebrovascular mortality, adjusted for education, marital status and income (Virtanen & Notkola, 2002). Although the sizes of the effect estimates are small, the increased risk for stroke in low job control occupations may have considerable consequences for health in the working population because many people, especially women, are exposed to low job control. In Sweden, about a fifth of the new stroke events occur among people of working age. Compared to a myocardial infarction, the consequences of a stroke are often dramatic, and many people never come back to working life after suffering a stroke, while people suffering a myocardial infarction can be back at work in less than two weeks. It is evident that more research is needed on working conditions and risk of stroke in different settings and based on different sources of data.

As stroke has hardly been studied in relation to work environment exposures, the findings from Study IV have been questioned. It has been suggested that the association between job control and risk of stroke may be due to residual confounding from occupational class (Macleod et al., 2001), given also that the effect estimates between job control and stroke incidence are small in Study IV. Childhood circumstances are suggested to be a significant determinant of stroke in adulthood (Davey Smith et al., 1998), particularly of hemorrhagic stroke (Hart & Davey Smith, 2003). However, other
investigators have convincingly shown that the association between work stress (job strain and effort-reward imbalance) and mortality from CVD is not explained by confounding from socioeconomic circumstances (childhood factors, education, occupational group, salary) over the life course (Kivimäki et al., 2002; Brunner et al., 2004). Therefore, the aim of Study V was to investigate whether the association between job control and stroke is independent of occupational class and other social and socioeconomic circumstances. Job control was significantly related to stroke mortality in women, but not in men. In women, the effect of low job control was stronger for hemorrhagic than for ischemic stroke. The effect of job control on stroke mortality was consistent in all occupational classes except for upper non-manuals, in which the overall level of job control is high and the variability is small. Of all confounding factors, occupational class was of least importance in terms of explained statistical variance in the models, and marital status was always of greatest impact for women as well as for men. Yet, in line with Lahelma et al. (2004), I am apt to conclude that the development of health inequalities is a complex process in which the interrelations between various socioeconomic indicators need to be taken into account. Neither would it be sufficient for our efforts to deepen our understanding of the production of health inequalities to rely only on the statistically strongest socioeconomic indicator (ibid.). Thus, the results from both Study IV and Study V indicate that the impact of low job control on risk of stroke (especially intracerebral hemorrhage) tends to be highest for women in occupations with low job control. Consequently, job control is a source of work related inequalities in health.

Sociologists are concerned with social regularities, such as work-related inequalities in health in a population (author’s comment), that can be established on a probabilistic basis in populations and sub-populations ranging from national populations to households (Goldthorpe, 1998; 2000). The explanatory task is to show how these regularities are generated and sustained through the action and interaction of individuals. The action to be captured needs to feature the central tendencies of the individuals’ actions which are relevant to the explanation. Thus, it is not necessary for all the actors to act rationally all the time, only that the tendency to act rationally is the most important common factor (ibid.).

Rational action theory (RAT) focuses on how actors choose particular courses of action in pursuit of their goals, according to their resources and the opportunities and constraints that characterize their situation (Goldthorpe, 1998; 2000). As RAT is not one theory but a family of theories, Goldthorpe (ibid.) suggests that sociologists should look for the kind of RAT that provides the greatest explanatory power in regard to action in generating social regularities via the micro-macro link. James Coleman’s famous “boat”
illustrates the linkages between the macro-micro-macro relations, and forms the basis of the theoretical approach called methodological individualism (Coleman, 1986, p.1322). Methodological individualism maintains that:

“The elementary unit of social life is the individual human action. To explain social institutions and social change is to show how they arise as the result of the action and interaction of individuals” (Elster, 1989, p.13)

Looking at my research findings from a RAT perspective, individuals are not regarded as ‘victims’ of their social positions. Although risk factors tend to cluster in more disadvantageous socioeconomic positions, people in more advantageous positions also have their share of risk factors. For instance, as showed in Figure 5, roughly 15% of people in the highest income quartile report smoking, compared to 30% of those in the lowest quartile. Thus, regardless of their social position, individuals always have a choice to make, according to their resources and the opportunities and constraints that characterize their situation. These choices may have far-reaching consequences for health, both for the individuals, groups and the society at large.

Methodological considerations

The breadth of the studies in the present thesis was intentional and an attempt to contribute to the current debate on research on work environment and health (see e.g., Kompier, 2002; Theorell, 2006). The interdisciplinary research field of work environment and health is dominated by the disciplines of sociology, psychology, and epidemiology. Thus, due to different methodological traditions, opinions about gold-standard methods vary within the field. Cross-sectional studies are sometimes criticized for being inferior to longitudinal studies. Self-reported data are accused of common method variance (see e.g. Kline et al., 2000). Yet the theoretical foundations of the frequently used work-stress models (DCM and ERI) are the experiences and perceptions of working people and therefore information from self-reported data is considered important. The excellence of register data is sometimes advocated as it facilitates the assessment of the health measures on objective grounds (diagnosed diseases or death). Lahelma (2001), however, states that health measures are by their very nature self-reported, and working with people’s own reports is an inherent characteristic of several medical sociological studies. The main strength of register data is that it comprises the total population, yet on the other hand, registers do not usually include vast amounts of detailed data on the individuals that may be of importance for the research question. As a result, by applying different types of data and methods, and even comparing them (Study I), this thesis wanted to demonstrate
that all types of data and study designs have their advantages and disadvantages.

**Sources of potential bias**

**Selection**

Selection may be a source of bias in the surveys. For instance, if some groups of individuals are systematically selected to the non-responders in survey studies, this could affect the precision of the analyses. Both in ULF and LNU, the total drop-out rates were 21.3% - 23.4% for the survey years used in the present studies (ULF 1996-1999; LNU 1991 and 2000). Although drop-out rates of these magnitudes are not uncommon in survey studies, it is impossible to establish a general limit for a drop-out rate. However, the scientific precision of certain types of analysis, mainly on marginalized groups, may suffer (Fritzell *et al.*, 2001). For instance, in the ULF samples 1996-1999, the total drop-out rate for unmarried men (25.2% - 26.3%) was higher than the average total drop-out (21.8% - 23.3%). As unmarried men are usually overrepresented among men with low job control, the results for men may be underestimated due to the higher drop-out rate among unmarried men (Study I). Regarding the attrition rate in the LNU panel, of those individuals in the LNU panel 1991, 18% dropped out on the next survey occasion in 2000 (Study III).

Another source of selection bias may be the healthy worker effect (Rothman, 2002; Checkoway *et al.*, 2004). Mortality related to occupational exposures, for example, is lower in workers than in the general population. This is due to the fact that the general population comprises two groups: a majority that is healthy enough to work and a minority that is too ill to work. Those who are too ill to work have normally a much higher mortality rate than the healthy ones. Thus, comparing the results from a working population with the general population will result in an underestimation of the effect of work environment exposures on health (ibid.).

**Misclassification**

Common method variance may be a source of information bias in studies based on self-reported surveys. In other words, the association between two self-reported variables may be spurious and caused by a common third variable (Kline *et al.*, 2000; Podsakoff *et al.*, 2003). It has been suggested that common method variance inflates the associations between exposures and outcomes. In order to meet the criticism of common method variance, we performed a validation test in Study I by comparing the results from analyses based on a cross-sectional survey sample and a register-based follow-up study. The results of this validation test suggest that the effect of job control
on CVD prevalence in the cross-sectional sample is if anything underestimated rather than overestimated. This finding is of methodological importance for research into the work environment and CVD, as longitudinal data and objective outcomes are widely believed to be superior to cross-sections and self-reported health measures. However, it may be that the two data sets of Study I are not optimally comparable as they do not cover the same time period and moreover the income measures differed somewhat. For future studies, comparing the results of different data sources would seem to be a relevant approach (e.g., Lorant et al., 2007).

Register-based health research has a long tradition in the Nordic countries, and the quality of Swedish register data is considered to be good. Regardless of data, misclassification of exposure and outcome may be a source of information bias in any cohort study (Hennekens & Buring, 1987). The effect of the misclassification will depend on whether the misclassification is nondifferential (random) or differential. Nondifferential misclassification arises when individuals are categorised wrongly according to their exposure or outcome status, but the misclassification of the exposure and the outcome are unrelated to each other. The result of such nondifferential misclassification is that the relative risk estimate will be biased towards the null value of 1.0. Hence, nondifferential misclassification may blur the true association between an exposure and an outcome, but it cannot cause the observation if it does not truly exist. Differential misclassification arises when the errors in the classification of an individual by exposure or outcome are related to each other. For instance, classification of low job control depends on the stroke status of the individuals. Differential misclassification may result in a biased estimate that is either underestimated or overestimated, or due to chance, the same as the true association (ibid.).

Studies I, IV & V classified job control using a JEM (job exposure matrix) based on occupational categories. This may have resulted in a certain degree of misclassification with respect to exposure to job control. However, this potential misclassification is likely to be nondifferential and unrelated to the health outcomes under study. A previous study suggests that occupational classification systems differentiate women’s jobs less well than men’s (Ljung & Hallqvist, 2007). Thus, a consequence for the present studies would be that health differentials by job control (assessed by JEM) may be more underestimated for women than for men. Ljung & Hallqvist (ibid.) conclude, however, that misclassification of socioeconomic position among women due to a crude occupational classification for women’s jobs is not a crucial issue when comparing measures of socioeconomic inequalities in health between women and men. In fact, despite there being more occupational categories for men’s jobs, the socioeconomic heterogeneity within occupational categories was actually larger for men, implying larger mis-
classification among men (ibid.). Conversely, in Study V we found more variation in job control within occupational classes for women.

Studies I-III defined the exposure variables (job control, DCM, ERI, wages, SOC) based on self reported survey data. All these above-mentioned variables, and also the health outcomes, may include misclassifications (see further Data, variables and methods, p.43). However, the misclassifications are judged to be nondifferential, i.e. the misclassifications of exposures and health outcomes are not likely to be associated with each other, and the most likely consequence is for the found associations to be underestimated.

Confounding
Confounding implies a mixing of the effect of an exposure (e.g. job control) on a health outcome (e.g. CVD) with that of a third factor (e.g. socioeconomic status). The third factor must be associated with the exposure (but not an effect of the exposure), and must be an independent risk factor for the outcome (Hennekens & Buring, 1987; Rothman, 2002). In such a case, the association between the exposure and the outcome can be attributable (partly or totally) to the effect of the confounder. Confounding may result in an underestimation or overestimation of an association, or it may even change the direction of the observed effect (ibid.). Residual confounding refers to a situation in which the categories of the confounding variable are too broad or insufficient to control for confounding, or when potential confounders are not adjusted for in a study. Over-adjustment for confounding is likely to occur if a confounder tracks over the lifecourse and becomes a mediator (intermediate variable). Yet, the difference between a confounding variable and an intermediate variable is theoretical, and one cannot distinguish statistically whether a factor is a confounder or a mediator. Thus, such a theoretical decision should be made at the study design phase. As a consequence, theoretically, a variable could either be a confounder or a mediator. A factor may be considered to be a confounder (e.g. smoking) if information about the factor is collected earlier than information on the exposure. However, a factor such as smoking tends to track over the life course and consequently it may also operate as a mediator (ibid). Thus, including stroke risk factors (e.g. hypertension) as confounders in Study IV, if they are in fact considered to be mediators, would result in an over-adjustment of confounding and consequently to an underestimation of the effect of job control on the risk of stroke. Elevation of blood pressure may be an effect of low job control. For instance ambulatory studies show that blood pressure is higher in participants reporting low rather than high job control, and these differences persist into the evening after work (Steptoe & Willemsen, 2004).
Additional sources of bias

In the studies of the thesis the exposure variables (income, work environment, sense of coherence) were measured only at one point in time which does not allow studying the cumulative effect of these factors. A previous study of the dynamic nature of people's experiences of income and health indicated that long-term income is more important for health than current income; that income levels are more significant than income change; that persistent poverty is more harmful for health than occasional episodes; and, that income reductions appear to have a greater effect on health than income increases (Benzeval & Judge, 2001). A previous study on cumulative exposure to low job control (assessed by JEM) and risk of CVD mortality indicated that the risk increased with 5-year cumulative exposure periods up to 15 years, and then slightly decreased from 20 years onward (Johnson et al., 1996). In addition, in Study IV, the follow-up period of 13 years may have complicated the picture. People may have changed jobs during the follow-up, and a portion of the study population may have retired. These weaknesses mentioned above, in addition to the crude exposure measure for job control in terms of a JEM, have most likely resulted in increased random errors with resulting spuriously small albeit significant relative risk estimates between job control and risk of incident stroke in Study IV.

Gender differences

Women and men were studied separately (an exception is Study I, see below) because the labour market in Sweden, as elsewhere, is strongly structured by gender, in such a way that women and men tend to work in different sectors of the economy (Nermo, 1999). An obvious consequence is that women and men experience largely different working conditions, both as regards physical workload and psychosocial job exposures. Women's work tends to be characterised by higher levels of job insecurity, lower wages, lower job control and higher psychological demands. It is of relevance that Swedish women, in international comparisons of 22 OECD countries, have a leading position in terms of full-time labour force participation and high labour force participation rates also in the age group 55-64 years (Björk & Hemström, 2007). Thus, working conditions may be of greater importance for Swedish women than for women in most other countries.

Because of low power in the cross-sectional survey sample of Study I, it was not possible to study men and women separately. This limited the study of gender differences in the association between income and CVD, and the contribution of working conditions. However, results from the mortality follow-up in Study I indicate that the impact of income on CVD mortality
was stronger among men than women, and the impact of job control on CVD mortality was somewhat stronger among women than men. Both in the survey and in the mortality follow-up, the income distributions were reversed between women (about 10% in the highest income quartile and 40% in the lowest income quartile) and men (about 40% in the highest income quartile and 10% in the lowest income quartile), showing that low income was accumulated among women. The distribution of job control was also reversed between women (about 11% among high job control and 30% among lowest job control) and men (about 50% among high job control and 10% among lowest job control).

In Sweden, the wage gap between women and men (adjusted for age, education, work hours, occupational group, and sector) was fairly stable at around 8% in all sectors (municipality, county council, state, and private) during the period 1995-2004 (Statistics Sweden, 2006c). The stable gender wage gap indicates in part that women’s work is less valued than men’s work. Such an evaluation is most likely based on attitudes towards women’s and men’s work in society. Attitudes are difficult to influence which the prevailing gender wage gap may be an example of. Since narrowing the gender wage gap does not seem to be among the main issues on the political agenda in Sweden, more research is needed to scrutinize and highlight the consequences of women’s disadvantaged socioeconomic status for health. Evidently, a gender-theoretical perspective is needed to explain why the more disadvantaged socioeconomic status of women persists in an advanced industrialized nation such as Sweden in the 21st century.

The longitudinal analyses of Study II also revealed gender differences with regard to the predictive role of adverse working conditions and sense of coherence on psychological distress. Both physical and psychosocial exposure at work significantly increased the risk of psychological distress in men, and to a lesser extent also in women (job strain only). However, a weak sense of coherence increased the risk of future psychological distress more than two-fold in women, while it had no effect in men. This could indicate that viewing the world as comprehensible, manageable and meaningful is more important for women’s psychological well-being than men’s. In other words, women’s worlds may be more complex than men’s, since women more often than men have to divide themselves between home duties and work-life challenges. According to a Swedish study, employed women’s health was determined by the interaction between conditions at work and household duties, whereas men responded more selectively to long working hours (Krantz et al., 2005). Thus, it might be the case that strengthening women’s sense of coherence in both private and working life spheres, and facilitating the balance of these spheres, could promote psychological well-being in women. It should be borne in mind, however, that the women in the Study II sample on
both measuring occasions had a slightly greater share of strong sense of coherence than men. Consequently, because of this gender difference in the predictive role of sense of coherence for psychological distress, the findings about the moderating role of sense of coherence for the impact of job strain on psychological distress also need to be interpreted carefully.

Studies II-V showed that income, work environment, and sense of coherence were associated with health in both women and men. However, the kind of ill health that was manifested differed by gender. It seems evident that the factors that play a role for future ill health differ for men and for women. According to a Canadian study, there are real differences in the factors that predict women's and men's health (Denton & Walters, 1999). Social structural factors – i.e. being in the highest income category, working full-time, caring for a family and having social support – appear to play a more important role in determining women’s health. Smoking and alcohol consumption seem to be more important determinants of men’s health, while body weight and being physically inactive seem to be more important for women than men (ibid.). Even if similar numbers of women and men are in gainful employment in Sweden, they tend to have different kinds of jobs. There are also big gender differences in part-time working and in the reasons for working part-time (see e.g. Evertsson, 2004). These factors most likely contribute to the gender differences in ill health found in the present Studies II-V.

In Study IV, the impact of low job control on the risk of any type of stroke appeared to be similar for women and men, but the impact on stroke subtypes differed as a function of gender. More women than men are exposed to low job control and low income. One way to demonstrate the consequences of these gender differences would be to compute proportions of stroke events that would have been prevented following elimination of low job control. Thus, based on the data of Study IV, the population-attributable fraction, adjusted for confounders, was 2.4% in women and 1.6% in men for any type of stroke, 7% in women and 2.4% in men for ICH, and 1.1% in women and 1.6% in men for BI. These population-attributable fractions suggest that a larger proportion of the stroke events would have been prevented among women if low job control could have been eliminated. However, these estimates should be interpreted with caution, as population-attributable fractions are based on a strong assumption that the exposure is causal (Rockhill et al., 1998; Nurminen & Karjalainen, 2001).

Although the main aim of the thesis was not explicitly on gender differences in work-related health inequalities, one of the main implications from the studies is that gender is of major importance when studying the effects of work on health.
CONCLUSIONS

The studies in the present thesis suggest that:

- The associations between income and CVD prevalence and mortality are strong and that working conditions contribute slightly to these associations.

- Work environment and wages are independently associated with psychological distress and musculoskeletal pain, although there are gender differences in these associations. Consequently, both factors are important in generating poor health in the working population.

- Sense of coherence moderates, yet not consistently, the impact of adverse work environment on psychological distress and musculoskeletal pain. The moderating role seems to vary by work exposure, gender and health outcome. Hence, the results do not support the hypothesis that sense of coherence is a global health-protective factor.

- The impact of job control on risk of stroke (especially intracerebral hemorrhage) tends to be highest for women in occupations with low job control.

- Job control is related to stroke mortality in women, but not in men. The effect of job control on stroke mortality is consistent in all occupational classes except for upper non-manuals.

- Low job control may increase the risk of stroke. As there are only a few studies of working environment factors and risk of stroke, further work is required to examine the associations in different settings, preferably using individual-level data, comparing various methods of exposure assessment, and classifying stroke by subtypes.
This thesis is a result of my long-term interest in how aspects of work influence people’s health and wellbeing. For twenty years, my interest came from an employee’s and union member’s perspective and for the last five years mainly from a researcher’s perspective. Needless to say, writing this thesis has been one of the biggest challenges in my working life. However, research at its best is a dynamic and very stimulating team work. Consequently, several people have contributed to my work, and I want to thank every one of you wholeheartedly. My doctoral work was jointly financed by the Centre for Health Equity Studies (CHESS) and the Department of Sociology at Stockholm University which I gratefully acknowledge.

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CHESS is a multidisciplinary research centre with multifriendly people, to quote my doctoral student colleague Mikael Rostila, and I agree with Mikael. Many thanks and a big hug to all my wonderful fellow workers at CHESS for creating a supporting work environment ideal for research. When I was finalizing my doctoral thesis and the workdays became very long, I got loads of support in the form of dark chocolate, warm tea, beams of energy, pep talks, encouraging smiles, and helping hands. It felt great. Thanks to all my doctoral student colleagues, including research assistants, for sharing the
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Thank you to my friends and to my huge extended family for being in my life. *Per aspera ad astra.*

Susanna Toivanen, October 2007
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