Rhythm of the job stress blues
Psychosocial working conditions and depression in working life and across retirement

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Abstract
A work environment characterized by poor psychosocial working conditions may lead to stress and mental health problems such as depression, a common and burdensome public health problem with significant consequences for individuals and for society at large. A number of psychosocial working characteristics have been found to be associated with increased depressive symptoms or clinical depression. This thesis aims to further examine how certain psychosocial working conditions predict depressive symptoms over time, in working life and across retirement. This was done by using several repeated measures from the Swedish Longitudinal Occupational Survey of Health (SLOSH) in 2006–2018.

In study I, we investigated how long-term patterns of exposure to job demands and job control were associated with major depressive symptoms. Those with high strain (high demands, low control) and active (high demands, high control) jobs were more likely to have subsequent major depressive symptoms compared to those with low strain jobs (low demands, high control). However, after adjusting for baseline depressive symptoms and various demographic factors, the associations did not remain statistically significant.

In study II, we assessed how job demands, job control and workplace social support were related to long-term development of depressive symptoms. A perception of high job demands and low social support predicted higher or increasing depressive symptom trajectories. In addition, negative changes in job demands, job control and social support were associated with increased symptoms, indicating that the onset of poor working conditions could negatively impact depressive symptoms.

In study III, we investigated simultaneous and lagged bidirectional associations between job demands, job control, balance between demands and control, social support, procedural justice, effort, reward, balance between efforts and rewards, and depressive symptoms, while controlling for individual time-stable characteristics. There were associations between all work stressors and depressive symptoms when measured simultaneously, except for job control. However, only efforts, were prospectively associated with depressive symptoms measured later.

In study IV, we examined how the same psychosocial working characteristics as in study III were associated with the development of depressive symptoms across retirement. Generally, depressive symptoms appeared to decrease across retirement. Job demands, job strain, social support, rewards, effort-reward imbalance and procedural justice, but to a lesser extent job control and efforts, were associated with a more negative and positive course of depressive symptoms across retirement. Especially, depressive symptoms decreased in relation to retirement for a small group with previously high exposure to work stress.

In conclusion, this thesis indicates that particularly perceptions of high job demands, low workplace social support and high work effort predict subsequent higher levels of depressive symptoms, and/or influence the course of symptoms both in working life and past retirement. In addition, changes in these types of conditions seemed to influence the course of depressive symptoms. Especially, the relief from previous exposure to work stress at retirement seemed to have a clear positive impact on depressive symptoms. These results contribute to strengthen the evidence of causality between these types of work stressors and depressive symptoms.

Keywords: job stress, psychosocial working conditions, job demand-control-support model, effort-reward imbalance model, organizational justice, depressive symptoms, longitudinal studies, trajectory analysis, latent class analysis, fixed-effects regression.

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Rest is not idleness, and to lie sometimes on the grass under the trees on a summer’s day, listening to the murmur of water, or watching the clouds float across the sky, is by no means a waste of time.

Quote by John Lubbock
LIST OF SCIENTIFIC PAPERS

Study I


Study II


Study III


Study IV

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**Key words:** job stress, psychosocial working conditions, job demand-control-support model, effort-reward imbalance model, organizational justice, depressive symptoms, longitudinal studies, trajectory analysis, latent class analysis, fixed-effects regression
SAMMANFATTNING


I studie I undersöktes hur utvecklingen av arbetskrav och arbetskонтroll över tid var kopplade till symtom på depression. De som upplevde ett så kallat "spänt arbete" (kombinationen av höga krav och låg kontroll) och "aktivt arbete" (kombinationen av höga krav och hög kontroll) hade högre risk för senare depressiva symtom, än de som upplevde "avspänt arbete" (låga krav och hög kontroll). Däremot så förblev inte sambanden statistiskt signifikantha då vi kontrollerade för demografiska faktorer och för initiala depressiva symtom.

I studie II undersöktes hur arbetskrav, arbetskонтroll och socialt stöd i arbetet var kopplade till utvecklingen av depressiva symtom över tid. En upplevelse av höga krav, respektive lågt socialt stöd hade samband med högre, eller ökande depressiva symtom över tid. Dessutom ökade symtomen i samband med uppkomst av denna typ av exponering, vilket tyder på att en negativ förändring i arbetskrav, arbetskонтroll och socialt stöd kan öka depressiva symtom.

I studie III undersöktes sambanden mellan arbetskrav, arbetskontroll, balans mellan krav och kontroll, socialt stöd, processrättvisa, ansträngning, belönning, balans mellan ansträngning och belönning, och depressiva symtom. I samtliga analyser kontrollerades för individuella stabila faktorer. Alla psykosociala arbetsmiljöfaktorer förutom kontroll, var relaterade till depressiva symtom, när de mättes samtidigt. Däremot var det endast ansträngning som
hade ett samband med depressiva symtom mätt senare. Inga så kallade om-
vända samband förekom när depressiva symtom mättes före de psykosociala
arbetsmiljöfaktorerna.

I studie IV undersöktes samma psykosociala arbetsmiljöfaktorer som i stu-
die III, i relation till utvecklingen av depressiva symtom i samband med pensi-
onering. Generellt satt minskade symtommätnivån i samband med övergången
från arbete till pensionering. Arbetskraav, spänt arbete, socialt stöd, belöning,
obalans i ansträngning-belöning och processrättvisa, men inte kontroll och an-
strängning i samma utsträckning, var kopplade till både ett mer negativt och
positivt förlopp av depressiva symtom i samband med pensioneringen. De-
pressiva symtom minskade särskilt i en liten grupp som varit exponerade för
psykosocial stress i arbetet.

Sammanfattningsvis så indikerar denna avhandling att särskilt upplevelsen
av höga arbetskraav, lågt socialt stöd och hög ansträngning predicerar deprer-
siva symtom, och/eller påverkar förlippet av symtom under arbetslivet och i
samband med pensioneringen. Dessutom verkar förändringar i dessa arbets-
miljöfaktorer påverka förlippet av depressiva symtom. Speciellt en befrielse
från arbetsstress i samband med pensionering, verkar ha en positiv inverkan
på depressiva symtom. Resultaten i denna avhandling bidrar till att stärka be-
läggen för kausalitet mellan dessa typer av arbetsmiljöfaktorer och depressiva
symtom.
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LIST OF ABBREVIATIONS

CI     Confidence Interval
CMD    Common Mental Disorder
DAG    Directed Acyclic Graph
DCSQ   Demand-Control-Support Questionnaire
DSM    Diagnostic and Statistical Manual of Mental Disorders
ERI    Effort-Reward Imbalance
GBTM   Group-Based Trajectory Modeling
HPA axis Hypothalamic-Pituitary-Adrenal axis
ICD    International Classification of Diseases
JDC(S) Job Demand-Control-(Support)
LFS    Labor Force Survey
MD     Major Depression
OR     Odds Ratio
RR     Risk Ratio
SCB    Statistiska Centralbyrån (Statistics Sweden)
SCL-CD Symptom Check List-Core Depression
SEM    Structural Equation Modeling
SEP    Socioeconomic position
SLOSH  Swedish Longitudinal Occupational Survey of Health
SWES   Swedish Work Environment Surveys
INTRODUCTION

A few words about work and health

In general, work is beneficial for our physical and mental health and well-being, as it constitutes an important mean of obtaining economic resources, meeting psychosocial needs, and significantly contributes to shape our identity, social roles and status (Waddell & Burton, 2006). However, different aspects of work can also have a negative impact on health, not the least mental health. Psychiatric disorders, including stress-related disorders and mood disorders are presently the most common reasons for sick-leave spells in Sweden (Swedish Social Insurance Agency, 2017). The burden of mental and behavioral disorders is a major contributor to the health burden globally, and these disorders must be prevented and treated if population health is to improve (Whiteford et al., 2013). Mental illness does clearly impose a great societal burden in terms of human suffering, stigmatization and economic costs. Mental health problems in the workplace can also affect employees’ work capacity and performance, illness rates, absenteeism, accidents and staff turnover, and thus not only have consequences for the individual but for the entire workplace and organization (Harnois & Gabriel, 2000).

Depression is a common mental disorder in the working population (Sanderson & Andrews, 2006). It has been suggested that depression may increasingly be caused by work-related stressors because employees often face great demands and low job security, factors that are likely to be stressful in the working life (Tennant, 2001). However, solid evidence of work-related risk factors is a prerequisite for development of effective workplace interventions to prevent work-related mental illness. This thesis addresses some of the existing knowledge gaps, contributing to better evidence regarding associations between psychosocial work characteristics such as job demands, job control and workplace social support, and depressive symptoms.
Stress has become a very popular term in research as well as in everyday life. Stress is an umbrella concept lacking a generally accepted definition, which results in many, frequently conflicting meanings. For example, stress can on the one hand be considered a stimulus, i.e. a stressor that you are exposed to. On the other hand, stress can refer to the stress response, or even a health condition that may be stress-related. Lazarus and Folkman provided a definition of stress which emphasizes the relationship between the individual and the environment: “Psychological stress is a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being” (Lazarus & Folkman, 1984, p.19).

A potentially relevant theory for the understanding of stress is the “allostatic load” theory. For organisms to function optimally and to survive, a stable internal environment must be maintained through homeostasis. In turn, homeostasis, is ensured by the allostatic (adaptation) process which maintains stability through change (McEwen, 1998). Any stimulus that is perceived as a threat to homeostasis can be considered a stressor, may it be internal such as pain, or external such as some kind of social challenge (Murison, 2016). This stimulus elicits a stress response that re-allocates energy resources and activates biological and behavioral processes (Murison, 2016). Short-term stress responses are adaptive since they help individuals to adapt to a challenge. More specifically, catabolic, antireproductive, antigrowth, and immunomodulating effects are observed during the stress response, which are beneficial in the short-term as they allow focusing the body’s energy on the immediate response to the stressor. These changes can, however, threaten homeostasis and be deleterious in the long-term, and therefore it is important that the stress response is terminated and not sustained for too long (Murison, 2016). It is hypothesized that repeated and chronic stressors can lead to allostatic load. Allostatic load has been defined as the state of an individual that results from repeated ups and downs of the physiological response, the elevated activity of the physiological systems under challenge, and a dysregulation of these systems, resulting in the wear and tear of organs and tissues in the body (McEwen & Stellar, 1993). This state is associated with alterations in metabolic, cardiovascular and immune systems (Seeman, Singer, Rowe, Horwitz, & McEwen, 1997), and may predispose organisms to disease (McEwen & Stellar, 1993).

However, individuals vary in their behavioral and biological responses to stressful situations, depending on factors like genes, gender, developmental stage and previous physiological and psychological experiences (McEwen &
Stellar, 1993). What might be perceived as stressful by one individual, might not be by another individual. Also, the effects of stress depend on the nature, intensity and duration of the stressor (Murison, 2016). Therefore, understanding the adaptive and maladaptive consequences of stressors is highly important.

Stress is certainly an inevitable part of our lives. Stress gets much attention in the media today and often with a rather alarmistic tone that stress is always harmful and that just about everyone is affected by stress. What is more, stress is generally considered a negative term, even though stress can both be considered something positive and negative depending on the context including several different factors. I believe it is important that messages about stress are evidence-based and balanced. Nevertheless, we certainly need to be aware of, and aim at preventing the negative consequences that stress can actually have. In this thesis, I focus mainly on stress in the sense of stressors within the work environment (work stress) and their role as risk factors for depression or depressive symptoms.

Work environment, psychosocial work characteristics and work stress

The work environment encompasses all conditions at a workplace – including the physical, psychological, social and organizational factors, which may affect the employees. In this thesis the focus is put on the psychosocial aspects of the work environment. There is no official definition of psychosocial work environment, perhaps because researchers working in this field come from different scientific backgrounds. The psychosocial work environment is multifaceted and includes a wide range of factors which can act as risk or protective factors in terms of health. Work stress is a closely related term that can have two meanings: the working conditions which tend to generate a stress response (workplace stressors) and the stress response per se (Chandola, 2010). Job stress has been defined as “a situation wherein job-related factors interact with the worker to change his or her psychological and/or physiological condition such that the person is forced to deviate from normal functioning.” (Newman & Beehr, 1979, p.1). A more recent description of work stress is “the aspects of work design, organization, and management, and their social and organizational contexts, that have the potential to cause harm to employee health” (Härmä, Vahtera, & Kompier, 2006, p.413). Hence, work stressors could comprise a wide range of factors, ranging from e.g. work load, working hours, work-family conflict to interpersonal factors such as conflicts, threats,
violence and harassment. In this thesis, working conditions that may generate stress often referred to as psychosocial working conditions will be the focus. I will use the terms work stressor(s) interchangeably with psychosocial working conditions or psychosocial working characteristics.

Work stress models

By using work stress models, researchers have tried to elucidate the complex relationships between the work and health. In this thesis, primarily the Job Demand-Control (JDC) model (Karasek, 1979; Karasek & Theorell, 1990), but also the Effort-Reward Imbalance (ERI) model (Siegrist, 1996) and the Organizational Justice model (Greenberg, 1987) are used. Even though several methods of assessing psychosocial factors at work exist, self-reported measures in which employees are asked to make various kinds of quantitative ratings of particular psychosocial factors are by far the most common way of measuring psychosocial working conditions (Rick, Briner, Daniels, Perryman, & Guppy, 2001; Rugulies, 2012). In the following section, the work stress models including their components will be introduced.

Job demands, job control and job strain

The demands of the job and the possibilities that employees have to control or master these demands have been identified as essential job characteristics that are likely to influence well-being (Karasek, 1979). The Job Demand-Control model, also known as the Job strain model (Karasek, 1979; Karasek & Theorell, 1990), has been a highly influential model in occupational health research (de Lange, Taris, Kompier, Houtman, & Bongers, 2003; Van der Doef & Maes, 1999). According to this model, the combination of high job demands and low job control is hypothesized to result in mental strain (Karasek, 1979; Karasek & Theorell, 1990). Job demands are commonly operationalized as quantitative aspects of the work such as workload and time pressure, while job control, or decision latitude as it is also termed, refers to control over work tasks and activities (Karasek & Theorell, 1990). Job control comprises two sub-dimensions: skill discretion and decision authority, with the former referring to the opportunity to use one’s specific job skills and the latter to autonomy in task-related decisions (Karasek & Theorell, 1990).

According to the JDC model, jobs can be classified as “high-strain,” “low-strain,” “active,” and “passive” (Karasek, 1979) see Figure 1. High-strain jobs (also called job strain) are characterized by high demands and low control,
whereas low strain reflects low demands and high control. Active jobs involve high demands and high control, whereas passive jobs involve low demands and low control. According to the model, high strain jobs entail the highest risk of reduced well-being and illness, and in contrast, low-strain jobs appear to be associated with lower health risks (Karasek & Theorell, 1990).

A wide range of health outcomes have been investigated in relation to the job strain model, including e.g. cardiovascular disease (Fransson et al., 2015; Kivimäki & Kawachi, 2015; Kivimäki et al., 2012; Schnall, Landsbergis, & Baker, 1994; Theorell et al., 2016), depression (Bonde, 2008; Madsen et al., 2017; Netterstrøm et al., 2008; Theorell et al., 2015) and stress-related disorders (Nieuwenhuijsen, Bruinvels, & Frings-Dresen, 2010).

Regarding the relationship between job demands and job control and well-being, there are two hypotheses stemming from the model sometimes discussed in the literature: the strain hypothesis and the buffer hypothesis. According to the strain hypothesis, high-strain jobs are associated with highest risk of mental and physical illness, which can be the result from both additive and multiplicative effects of high job demands and lack of job control (Van Vegchel, De Jonge, & Landsbergis, 2005). On the other hand, the buffer hypothesis refers exclusively to an interactive/multiplicative effect of demands and control, predicting that control buffers/attenuates the negative effects from high job demands, so that high demands in itself does not constitute any particular health risk as long as the job control is high (Van der Doef & Maes, 1999). Thus, these two hypotheses are not mutually exclusive, but the buffer hypothesis can be seen as a form of the strain hypothesis (Van der Doef & Maes, 1999). Evidence for the strain hypothesis seems to be stronger compared to the evidence for the buffer hypothesis (Häusser, Mojzisch, Niesel, & Schulz-Hardt, 2010).

![Figure 1. The Job Strain Model (adapted from Karasek, 1979)]
Workplace social support

Social support can be defined as the aid, comfort, and confirmation from family, friends, co-workers and others, which makes the individual perceive that she/he is cared for, beloved, esteemed, and part of a network (Cobb, 1976). Social support is often divided into instrumental support, referring to the provision of financial aid, material resources and services, while emotional support has to do with communicating to someone that she/he is valued for her/his own worth (Cobb, 1976). Social support can be viewed as a protective factor in terms of many aspects of health and a coping resource in dealing with stress. The beneficial effects of social support have been attributable both to main effects (direct effects) as well as buffering effects (i.e. protective against the adverse effects of stress) (Cohen & Wills, 1985). Workplace social support can be described as the beneficial social interaction that is available at work from co-workers and supervisors (Karasek & Theorell, 1990).

The Job Demand-Control-Support (JDCS) model extends the JDC model by integrating social support at the workplace as a fundamental characteristic in the work environment. According to the JDCS model, especially the combination of high job demands, low job control and low social support predicts poor well-being (Johnson & Hall, 1988; Johnson, Hall, & Theorell, 1989), see Figure 2. The same distinction between additive and interactive effects of work characteristics in the JDC model can be applied to the JDCS model. The so-called iso-strain hypothesis (stating that jobs with high demands, low control and low social support are the most disadvantageous ones, with “iso” denoting “isolated”) (Johnson et al., 1989) has been supported to some extent (de Lange et al., 2003; Häusser et al., 2010), even though relatively few studies have actually investigated iso-strain. According to the buffer hypothesis, workplace social support moderates the negative effects of high demands and low control (i.e. job strain) (Johnson & Hall, 1988). However, support for this buffering effect has been inconsistent (Häusser et al., 2010). The support for both additive and interactive (buffering) effects of the JDCS model have been found weaker compared to the support for the JDC model, and one explanation is that including social support in the JDCS model, adds an additional criterion for the model to be approved, and thus finding support for this model becomes less likely (Häusser et al., 2010). Nevertheless, poor workplace social support as an independent risk factor has been associated with various mental and physical health outcomes including depressive symptoms (Netterstrøm et al., 2008; Nieuwenhuijsen et al., 2010), emotional exhaustion (Arónsson et al., 2017), musculoskeletal problems such as low back pain (Lang, Ochsmann, Kraus, & Lang, 2012; Swedish Council on Health Technology Assessment, 2014a) and cardiovascular disease (Theorell et al., 2016).
Figure 2. The Job Demand-Control-Support Model (adapted from Karasek & Theorell, 1990)

Effort-Reward Imbalance

Another theoretically based model that is often used in epidemiological studies is the Effort-Reward Imbalance model (Siegrist, 1996, 2008). It concerns the reciprocity of exchange at work in which high-cost/low-gain conditions are considered to elicit negative emotions and to be particularly stressful, potentially leading to adverse health effects (Siegrist, 1996). An effort-reward imbalance situation (failed reciprocity) is considered to occur if the efforts one perceives (like demands or obligations at the workplace) exceed the received rewards, which can be material (e.g. salary), social (e.g. promotion and job security prospects) or psychological (e.g. positive feedback). An effort-reward imbalance has been suggested to predict for instance mental health problems including depression (Nieuwenhuijsen et al., 2010; Rugulies, Aust, & Madsen, 2017; Swedish Council on Health Technology Assessment, 2014b) and coronary heart disease (Theorell et al., 2016). A third dimension of the ERI model is overcommitment. Effort-reward imbalance can be maintained when individuals have a special form of personal pattern of coping with demands, by being excessively overcommitted at the same time as having a
high need for control (Siegrist, 1998). There are similarities between the demand dimension of the JDC model and efforts. While the JDC model attempts to capture objective demands in the work environment, often through individual perceptions, the ERI model describes effort as the subjective effort that the employee exerts.

Organizational Justice

The Organizational Justice model builds on equity theory (Adams, 1965) and refers to the role of fairness in the workplace (Greenberg, 1987, 1990). Organizational justice concerns the ways in which employees decide whether they have been fairly treated at their jobs and how their perception affects other work-related factors (Moorman, 1991). It has been hypothesized that lack of organizational justice could have negative consequences for organizational citizenship behavior (i.e., altruism, courtesy, sportsmanship, conscientiousness, and civic virtue) (Moorman, 1991) and health (Elovainio, Kivimäki, & Vahtera, 2002). Four different types, or dimensions, of organizational justice have been suggested: distributive, procedural, interpersonal and informational justice (Colquitt, 2001). Distributive justice was initially the interest of organizational justice research and is related to the justice of decision outcomes (outcome distributions) (Cohen-Charash & Spector, 2001; Greenberg, 1990). However, concerns were raised about how decisions were made and not only what those decisions were, which led to a focus on policies and procedures, namely procedural justice (Greenberg, 1990). Procedural justice refers to the extent to which decision-making procedures are consistently applied, free from bias, accurate, correctable, ethical and representative of all concerns (Cropanzano & Ambrose, 2001).

What was originally, and sometimes still is, referred to as interactional justice has been suggested to be split into two dimensions: interpersonal justice and informational justice (Colquitt, 2001). Interpersonal justice concerns the sincere and respectful treatment including appropriate language (Lewicki, Sheppard, & Bazerman, 1986), while informational justice concerns the interaction related to information, including provision of correct, sufficient, and timely information regarding positions, decisions, and actions taken (Greenberg, 1993).

Although all the dimensions of organizational justice may predict various health-related outcomes, the potential influence of procedural justice on health and well-being seems most well-documented empirically. Lack of pro-
cedural justice has been related to e.g. poor mental health (Elovainio, Hepo-
niemi, Sinervo, & Magnavita, 2010; Ndjaboué, Brisson, & Vézina, 2012; ... Swedish Council on Health Technology Assessment, 2014b), the metabolic syndrome (Bergmann, Gyntelberg, & Faber, 2014) and coronary heart disease (Theorell et al., 2016).

Work stress and health

Scandinavian countries have a longstanding tradition of studying the relationship between work stress and health (Gardell, 1982). Work-related stress is a major public health problem affecting individuals, companies and societies (Härmä et al., 2006). As illustrated in the former sections describing the work stress models, work stress has been related to many different health outcomes. For example, aspects of the work environment have been shown to be associated with cardiovascular disease (Fishta & Backe, 2015; Kivimäki & Kawachi, 2015) including coronary heart disease (Kivimäki et al., 2012), the metabolic syndrome (Bergmann et al., 2014; Chandola, Brunner, & Marmot, 2006; Watanabe et al., 2018), type 2 diabetes (Kelly & Ismail, 2015), musculoskeletal problems e.g. back pain (Bongers, Dewinter, Kompier, & Hildebrandt, 1993; Swedish Council on Health Technology Assessment, 2014a), impaired sleep (Swedish Council on Health Technology Assessment, 2013; Åkerstedt, 2006), but not e.g. the most common types of cancer (Heikkilä et al., 2013).

Psychosocial work stressors have also been studied extensively in relation to mental health (Rugulies, 2012), and have been shown to be associated with mental health problems such as anxiety and depression (Harvey et al., 2017; Stansfeld & Candy, 2006; Vingård, 2015) and stress-related disorders (Nieuwenhuijsen et al., 2010). For example, low job control, low workplace social support, high psychological demands, high effort-reward imbalance and high job insecurity have been found to predict common mental health problems (Harvey et al., 2017; Stansfeld & Candy, 2006). Likewise, a Swedish report similarly concluded that job strain, high demands, low job control, effort-reward imbalance and role conflicts could be linked to mental illness and sick leave (Vingård, 2015).

On the other hand, a number of factors have been found to be protective against mental illness and beneficial for mental health: good leadership, control, work-life balance, effort-reward balance, clear goals and job security (Vingård, 2015). Further, when factors indicative of a healthy work environment were reviewed, the nine most important ones were: collaboration/team-
work, growth and development of the individual, recognition, employee involvement, positive, accessible and fair leader, autonomy and empowerment, appropriate staffing, skilled communication and safe physical work (Lindberg & Vingård, 2012).

While observational studies collect data without consciously affecting or intervening any conditions in the studied population, intervention studies manipulate the conditions for (part of) the studied population to investigate whether an intervention, treatment or health-promoting effort has an effect on a certain outcome.

A meta-review which systematically summarized the results of existing reviews regarding workplace interventions for depression and anxiety concluded that there is support for certain workplace interventions that can be used to prevent common mental disorders (Joyce et al., 2016). Among 20 reviews deemed to be of moderate quality, two primary prevention strategies showed moderate effects: improving employee control and promoting physical activity. Most interventions in the workplace that aim at preventing mental illness target the individual while fewer interventions have focused on the organization (Martin, Sanderson, & Cocker, 2009; Nigatu et al., 2019), resulting in a demand for high quality intervention studies focusing on organization-level factors (Nigatu et al., 2019).

When it comes to targeting the consequences of work stress at the individual level, cognitive behavioral therapy (CBT) interventions have shown good results (Hofmann, Asnaani, Vonk, Sawyer, & Fang, 2012), and workplace CBT interventions have also been found successful in reducing depressive symptoms in the workforce (Tan et al., 2014).

Interventions targeting psychosocial risk factors departing from e.g. the JDC(S) and ERI models, and including both individual and organizational components have been shown to have beneficial mental health effects (Corbière, Shen, Rouleau, & Dewa, 2009; Egan et al., 2007). Still, the evidence for preventing depression in the workplace by organizational interventions is weak, and there seems to be a need to pay attention to factors at the organizational level like control over workload, decreased demand, supportive work environment, rewards aligned with efforts among other factors in further studies (Couser, 2008). In summary, intervention studies are overall relatively scarce and data from observational studies is still the main source of evidence.
Mental health

Mental health is a broad and somewhat vague concept, but has been defined as “a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community” (World Health Organization, 2001a). Mental illness, or mental ill health, on the other hand, can be described as “health conditions that are characterized by alterations in thinking, mood, or behavior (or some combination thereof) associated with distress and/or impaired functioning” (U.S. Department of Health and Human Services, 1999), even though no clear definition exists. About a quarter of all years lost due to disability is caused by mental and substance-use disorders (World Health Organization, 2014). Mental and behavioral disorders may present differently, but are in general characterized by some combination of abnormal thoughts, emotions, behavior and relationships with others (World Health Organization, 2001b). Mental disorders may include depression, schizophrenia and other psychoses, dementia, intellectual disabilities and developmental disorders including autism (World Health Organization, 2017). A term often used in the international literature is “Common Mental Disorders” (CMD), which includes depression, generalized anxiety disorder, panic disorder, phobias, social anxiety disorder, obsessive-compulsive disorder and post-traumatic stress disorder (Kendrick & Pilling, 2012). Nearly 30% of the population experience a common mental disorder during their lifetime globally, indicating high prevalence of mental disorders (Steel et al., 2014).

Depression

What is it?

Depression is a common and burdensome mental disorder (World Health Organization, 2017). The global point prevalence of major depressive disorder has been estimated at nearly 5%, but with large variations between countries (Ferrari, Somerville, et al., 2013). The one-year prevalence of major depression (MD) was estimated at 6.9% in the European population (Wittchen et al., 2011), while around 16% of the population experience depression during their lifetime (Kessler et al., 2003). Depression is one of the leading causes of the global disease burden. In Sweden, it was the third leading cause of years lost to disability in 2016 (Vos et al., 2017). Depression has negative consequences
at the individual and societal level. Major depressive disorder causes role impairment, meaning that it interferes with functioning in e.g. work, household, relationships and social roles, in more than half of all patients (Kessler et al., 2003). Decrements in role functioning can include low marital quality, low work performance and low earnings (Kessler, 2012). Major depressive disorder is also associated with higher risk of occurrence, persistence and severity of a wide range of (chronic) physical disorders (Kessler, 2012; Kessler & Bromet, 2013) In terms of societal burden, depression is associated with higher healthcare utilization and spending, and may cause absenteeism and reduced work productivity (Donohue & Pincus, 2007). Without a doubt, depression is a major public health concern.

Depression is usually characterized by low mood, loss of interest in activities and reduced energy (World Health Organization, 2001b). Other symptoms include reduced concentration and attention, reduced self-esteem and self-confidence, ideas of guilt and unworthiness, pessimistic view of the future, ideas or acts of self-harm or suicide and disturbed sleep and appetite (World Health Organization, 2013). Since variations in symptoms and severity can be wide, depression is considered a heterogeneous disorder (Fava & Kendler, 2000). Depression also overlaps with burnout, especially with the emotional exhaustion component of burnout, and whether burnout can be conceptually distinguished from depression seems uncertain (Bianchi, Schonfeld, & Laurent, 2015).

The term depression can be used both to indicate a diagnosed disorder, but also the presence of depressive symptoms. In this thesis the focus is mainly on depressive symptoms even though the term depression might occasionally be used to denote the outcome in our studies, or when referring to other studies. In study I, we assess depressive symptoms indicating major depression by using a cut-off score, while in the remaining studies we assess depressive symptoms.

Age of onset of depression is typically during early adulthood (early to mid 20s), with the median age of onset for a major depressive episode in high-income countries estimated at 25.7 years, but the age of onset can range from adolescence to late adulthood (Kessler & Bromet, 2013). It has been suggested that levels of depressive symptoms are often higher in young adulthood, decrease in midlife and increase again in older adulthood (Sutin et al., 2013). On the other hand, major depressive disorder has been shown to be most prevalent among middle-aged (Ferrari, Charlson, et al., 2013). Depression is in many cases a recurrent (episodic) disease with previous episodes and subclinical residual symptoms being important predictors of recurrence (Hardeveld, Spijker, De Graaf, Nolen, & Beekman, 2010). Most people can benefit from
depression treatment and common treatments include antidepressant medication and psychotherapeutic treatments, such as cognitive behavioral therapy.

Assessments of depression and depressive symptoms

Measures of depression can be divided into two main categories, clinical ratings and self-report inventories (Gotlib & Hammen, 2009). The two main international standard classification systems for depression are the ICD-11 International Classification of Diseases for Mortality and Morbidity Statistics (World Health Organization, 2018) (previously The ICD-10 Classification of Mental and Behavioural Disorders) and the Diagnostic and Statistical Manual of Mental disorders (DSM-V) (American Psychiatric Association, 2013). The systems differ somewhat in their classification of depression. Depression may for instance consist of different subtypes (e.g. unipolar, bipolar, dysthymia) and can be defined as mild, moderate, severe, with or without psychotic symptoms. According to DSM-V, depressive disorders include major depressive disorder (including major depressive episode), persistent depressive disorder (dysthymia), and some other types of depressive disorders, but not bipolar disorder, in which both manic and depressive episodes occur (American Psychiatric Association, 2013). A diagnosis of major depression requires that a certain number of symptoms must have been present during a certain time.

Measuring clinically diagnosed depression in population studies is very costly and time-consuming and therefore often not feasible. Therefore epidemiological studies using ICD and DSM criteria for depression sometimes use standardized interviews like the clinical Schedules for Clinical Assessment in Neuropsychiatry (SCAN) (Wing et al., 1990; Wing, Sartorius, & Üstun, 1998), or the non-clinical Composite International Diagnostic Interview (CIDI) (World Health Organization, 1997). Depressive symptoms are also commonly measured by questionnaires like the Center for Epidemiological Studies – Depression scale (CES-D) (Radloff, 1977) and the Symptom Check List (SCL) (Lipman, 1986). The questionnaires are not as detailed as the standardized interviews, but they often show high diagnostic accuracy and external validity (Christensen et al., 2005). Most often, these scales are designed to capture unipolar and not bipolar depression. In this thesis, we used the Symptom Checklist-Core Depression scale (SCL-CD6) – a brief 6-item subscale of the (Hopkins) Symptom Checklist depression scale (Lipman, 1986; Magnusson Hanson et al., 2014) to assess depressive symptoms and symptoms indicating major depression. A further description of this scale is provided in the section “Assessment of the outcome variable”.
Causes of depression

Depression is believed to result from a complex interaction between nature and nurture, i.e. with both genetics and environment being important (Colman et al., 2014; Pasquini, Berardelli, & Biondi, 2014). Even though the etiology of depression is complex and not yet completely understood, biological, psychological, social, and genetic factors all seem to be involved (Sullivan, Neale, & Kendler, 2000; Tennant, 2002). Risk factors can thus be both modifiable and nonmodifiable. Several putative risk factors for depression have been identified within psychiatric epidemiology, and risk factors which have been found to stand out as consistently associated with major depressive disorder are e.g. stressful life events, adverse childhood experiences, certain personality traits and the female gender (Fava & Kendler, 2000). It is not completely understood why women are at higher risk of depression than men, but potential explanations for this gender gap include gender-related subtypes of depression, genetic factors, hormonal influence, psychological factors, and environmental factors at micro and macro level (Kuehner, 2017).

Another factor associated with depression is socioeconomic status, or socioeconomic position (SEP) (often indicated by education, income, or occupation). However, as compared to other psychiatric disorders, which are often associated with low SEP, the picture is not as clear for depression. Low socioeconomic status has been found more strongly related to increased risk for persistence of depression, compared to increased risk of depression onset (Lorant et al., 2003). Stress could be involved in this relationship, for instance may those with higher socioeconomic status be better equipped to handle stressors. Stress-related neurobiological pathways have been discussed as a link between low socioeconomic status and disease (McEwen & Gianaros, 2010).

It is clear that there is a strong relationship between stress and depression (Tennant, 2002). Most episodes of major depression are preceded by stressful life events, even though not everyone experiencing significant stressors develops depression later on (Hammen, 2005). Both current and earlier stressors, as well as both acute and chronic stressors can act as risk factors (Maddock & Pariante, 2001; Tennant, 2002), although it has been suggested that chronic stress is more strongly associated with depressive symptoms (McGonagle & Kessler, 1990). The link between work stress and depression will be further discussed in the coming sections.
Work stress and depression

What is known and what are the gaps?

Occupational stress research has found that both acute work-related stressful experiences and enduring structural occupational factors can contribute to depression (Tennant, 2001). As previously described, several psychosocial factors at work have been shown to be prospectively associated with mental illness including depression and depressive symptoms. For example, a Swedish systematic review and meta-analysis found moderately strong evidence that job strain, low decision latitude (control) and bullying were associated with the development of depressive symptoms (Theorell et al., 2015). The same study found limited evidence for high job demands, effort-reward imbalance, low social support, unfavorable social climate, lack of work justice, conflicts, limited skill discretion, job insecurity and long working hours. Previous reviews of associations between psychosocial working conditions and depression found strongest support for job strain (in men) (Bonde, 2008) or high job demands and low social support (Netterstrøm et al., 2008).

Despite an extensive literature on work stressors and their prospective associations with depression, there is still limited evidence for associations between certain psychosocial working conditions and depressive symptoms (Theorell et al., 2015). Moreover, the development of work stressors and depressive symptoms over time has rarely been considered. Several reviews have pointed out the lack of studies taking the duration and intensity of exposure to psychosocial work characteristics into account (Bonde, 2008; Netterstrøm et al., 2008; Nieuwenhuijsen et al., 2010). This contributes to making these associations less well understood. Few longitudinal studies have investigated how accumulated or changed (increased/decreased) exposure to psychosocial work stressors is associated with subsequent depression. Although it has been suggested that for instance accumulated or increased job strain is associated with depression, the results are still not consistent and few studies included more than two measurement points (Burns, Butterworth, & Anstey, 2016; Stansfeld, Shipley, Head, & Fuhrer, 2012). To properly examine how accumulated or changed exposure affects subsequent depression, more than two measurements are needed. We also know little about the long-term effects of psychosocial work characteristics on depression because studies rarely assess the development of depression in relation to previous work stress exposure. It is also not completely clear whether the associations differ depending on life stage/age or how a transition like retirement plays a role.
Are the associations causal?

Even though the evidence on the relationship between work stress and the onset of depression has gradually been accumulating, it is not yet clear to what extent these associations are really causal, i.e. whether stressful working conditions have a causal effect on depression (Virtanen, 2010). This is due to a number of methodological problems which preclude establishing causation between work and mental health (Harvey et al., 2017). These methodological problems are common not only within this specific research area but in observational studies in general.

A common methodological limitation in this area are confounding factors (Bonde, 2008; Netterstrøm et al., 2008; Stansfeld & Candy, 2006). Confounding factors are variables that are associated with the exposure and risk factors of the outcome, and thus may cause bias unless they are taken into consideration. Studies in this field commonly adjust for potential confounders such as gender, age, income and education, but more rarely for life events, personality traits and previous mental disorders (Bonde, 2008). Another problem may be that multiple interconnected risk factors (e.g. related to social class) operate in the causal chain and tend to cluster among high-risk individuals, which makes it hard to extract the independent effect of work stressors from other related exposures that bring about disease (Virtanen, 2010).

There is also a type of bias called “common method bias”, which can occur when the same method is used to measure both the exposure and outcome (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), e.g. using questionnaires. Factors associated with the method of assessment may then inflate or create a spurious association between exposure and outcome. For example, some individuals have a tendency to report that the work environment is poor and their mental health is poor, both potentially being the result of negative affectivity in the individual, rather than a true reflection of the situation (Burke, Brief, & George, 1993). Furthermore, it is difficult to know to what extent work stress is causing depression and depression is causing more work stress, since people who are depressed, or experience depressive symptoms, might perceive their working conditions as more stressful and negative than they would have, had they not been depressed. This is often referred to as reverse causation, when it is rather the outcome that causes the exposure and not the other way around, as hypothesized. In contrast to cross-sectional studies, individuals are followed over time in longitudinal studies. Longitudinal analyses enable to exclude or consider individuals with pre-existing depression/depressive symptoms and thus decrease the risk that the associations are affected by existing poor mental health. By only analyzing healthy (in terms of the outcome) persons at baseline reverse causality may be circumvented.
Other methodological problems include selection effects (that people who are more unhealthy tend to get worse jobs characterized by worse work characteristics compared to healthy people who tend to get better jobs) and publication bias meaning that studies showing significant results in the expected direction are more likely to get published (Kivimäki et al., 2012).

Mechanisms
The literature offers some potential mechanisms or pathways to explain how work stress could influence depressive symptoms and depression which can also support causality. Because of the complexity of this area and since this is not the focus of this thesis, mechanisms will only be briefly discussed here. It has been assumed that biological, psychological, psychosomatic, and behavioral mechanisms contribute to the influence of work stress on the risk for mood disorders like depression (Woo & Postolache, 2008). A review of workplace stressors (mainly including studies using the job strain or effort-reward imbalance model) found work stressors to be related to an elevated stress response, as measured by increased production of biomarkers of the two main systems activated during stress, i.e. the sympatho-adrenal axis and the hypothalamic-pituitary-adrenal (HPA) axis (Chandola, Heraclides, & Kumari, 2010). Chronic activation of the HPA axis is a well-known neurobiological feature of depression and can thus contribute to the development of depression (Pariante & Lightman, 2008). In addition, chronic activation of the HPA axis can lead to a dysregulation of the immune system, as the immune system is one of the main targets of the HPA axis. Activation of the immune system results in behavioral changes (so-called “sickness behavior”), which can develop into depression when activation of the immune system becomes chronic (Horowitz, Zunszain, Anacker, Musaelyan, & Pariante, 2013; Maddock & Pariante, 2001). Furthermore, allostatic load may lead to atrophy of nerve cells in brain structures central for depression (McEwen, 2003).

Work stress may also increase the risk of other risk factors for depression, thus predisposing individuals to chronic disease development (Härmä et al., 2006). Indirect pathways from work stress to depression could be via health risk behaviors, which can be triggered by psychosocial work stress and which could increase the risk of mental illness. For instance, there is evidence of an association between work stress and alcohol consumption as well as overweight (Siegrist & Rodel, 2006). Other health behaviors that increase the risk of depression include physical inactivity, disturbed sleep and unhealthy diet (Lopresti, Hood, & Drummond, 2013), and these factors may well result from work stress. However, establishing the exact mechanism(s) whereby work
stress influences depression is challenging (Härmä et al., 2006), and there is still limited direct evidence regarding this issue.

What is needed?
Because it is difficult to design randomized controlled studies in this field, we most often have to rely on observational studies or natural experiments. It has been concluded that more high quality research is needed regarding the associations between psychosocial working conditions and depressive symptoms, ideally studies over long time periods with frequent repeat measures that also assess and consider potential confounding factors properly (Swedish Council on Health Technology Assessment, 2014b). This can also contribute to better evidence regarding change, duration, and long-term consequences of exposure in terms of psychosocial working conditions, and outcome in terms of depressive symptoms, thus addressing some of the existing research gaps in this area.
AIM(S)

Overall aim
The general aim of this thesis is to examine how psychosocial working conditions such as job demands, job control, and workplace social support are related to depressive symptoms, in working life and across retirement, by using several repeated measures of both psychosocial working conditions and depressive symptoms and taking the long-term course of exposure and/or outcome into account.

Study-specific aims

Study I
To increase the knowledge regarding the role of job demand/control dynamics by investigating how trajectories of job demands and job control jointly influence the risk of subsequent symptoms of major depression (Åhlin, Westerlund, Griep, & Magnusson Hanson, 2017).

Study II
To investigate the relationship between high job demands, low job control and low social support at work and subsequent trajectories of depressive symptoms (Åhlin, Rajaleid, Jansson-Fröjmark, Westerlund, & Magnusson Hanson, 2018).

Study III
To examine bidirectional relationships between psychosocial work characteristics and depressive symptoms including both contemporaneous (i.e. measured simultaneously) and lagged (with a two-year time lag) relationships,
while controlling for time-stable individual characteristics (Åhlin, LaMontagne, & Magnusson Hanson, 2019).

Study IV
To increase the knowledge about psychosocial working conditions at the end of working life and effects on mental health, by investigating trajectories of depressive symptoms across retirement, assuming that different groups may have different trajectories across retirement. In addition, to examine how a number of psychosocial working conditions influence the trajectories.
MATERIALS AND METHODS

This section will describe the data source and study population, ethical considerations, what measures were used as well as which statistical methods were applied. For an overview of the four studies, see Table 1.

Data material and study population

The SLOSH study

This PhD project is based on data from the Swedish Longitudinal Occupational Survey of Health (SLOSH). SLOSH is a longitudinal psychosocial survey of labor market attachment, work environment, social situation, health and well-being. SLOSH was initiated in 2006 by the former Institute for Psychosocial Medicine (IPM) (now the Stress Research Institute, Stockholm University). It was initiated in response to the lack of prospective cohort studies with regularly repeated measures of work environment and health in Sweden. The original overall aim of SLOSH was “to further work environment research by a longitudinal approach in a nationally representative survey of the Swedish working population”, but it has later been expanded to “investigate longitudinal associations between work organization, work environment, labour force participation, health and well-being, taking social conditions, individual differences, health behaviours, coping strategies, work private life interaction, sleep and ageing into account” (Magnusson Hanson et al., 2018, p.692). So far, seven waves of data collection have been completed: wave 1 (2006), wave 2 (2008), wave 3 (2010), wave 4 (2012), wave 5 (2014), wave 6 (2016) and wave 7 (2018) and new data collections are planned to continue in the foreseeable future. A more thorough description of the design, data collection, responders/non-responders and measures of the SLOSH study can be found in the cohort profile (Magnusson Hanson et al., 2018) and for information on e.g. publications of SLOSH, please visit the website [www.slosh.se].
Participants
The SLOSH cohort consists of participants from the cross-sectional Swedish Work Environment Surveys (SWES) 2003, 2005, 2007, 2009 and 2011, n=40 877. SWES have been conducted every other year since 1989. The participants in SWES are in turn sampled from the Labor Force Survey (LFS), by inviting a sample of gainfully employed to respond to questionnaires, first randomly drawn from the entire Swedish working age population after stratification for county, sex, citizenship and inferred employment status. This makes SLOSH approximately representative of the Swedish active workforce. A subsample of SWES participants has been followed up biennially since the first SLOSH wave in 2006 (n=9214), while some SWES participants have been followed up since 2008 (n=9703), 2010 (n=2572) and 2014 (n=19388). The response rates in SLOSH have varied from 65% in 2006 to 48% in 2018. All in all, 29 676 (73%) of the 40 877 individuals included in SWES 2003–2011 had responded to at least one SLOSH follow-up questionnaire by 2018. The study specific sample sizes and inclusion criteria for study I–IV can be found in Table 1. Some characteristics of the respective study sample in study I–IV compared to the respondents to SLOSH 2006 (wave 1) is presented in Table 2. As can been seen in Table 2, the study samples compared to the respondents in the first SLOSH follow-up did not differ so much from each other. Some differences between the study samples of studies I–IV are to be expected because of different inclusion/exclusion criteria in the studies.

Questionnaires
The participants in SLOSH are sent two versions of a self-completion questionnaire every other year. One version is intended for those currently in gainful employment at least 30% of full time on average over the past three months (referred to as the “worker questionnaire”). The other version is intended for those who are in gainful employment less than 30% of full time during the past three months, or who has left the labor market temporarily or permanently (referred to as the “non-worker questionnaire”). Participants thus choose to answer one of these versions in each data collection depending on their work status in the past three months. The questionnaires have been postal self-completion pen and paper questionnaires, except for in 2012 when a web-based questionnaire provided the possibility for some respondent to respond electronically, but because this did not improve the response rate, pen and paper versions have been used since.
Measures in SLOSH

SLOSH includes a wide range of questions about work organization, work environment, health and general life circumstances. The first part of the questionnaire focuses on either factors related to working life in the version for “workers”, or factors related to having left active working life temporarily or permanently, in the version for “non-workers”. The second and third parts focus on health, health-related behaviors and social situation in both versions of the questionnaire. Some core questions are asked in every wave, while some other questions and scales have changed over time. SLOSH data is regularly complemented and linked to public national registers including a range of information about e.g. demographics, employment, sickness absence, hospital records, mortality and prescribed drugs.

Ethical considerations

All previous SLOSH data collections have been approved by The Regional Ethical Review Board in Stockholm, meaning that SLOSH is conducted in accordance with Swedish law and international conventions pertaining to ethical research. When new data is collected, ethical permissions are continually renewed. Participants give their informed consent in each data collection. They are informed about the purpose of SLOSH, which questionnaire they should chose and that linkage to register data will be carried out. In addition, they are informed that their participation is voluntary and that they have the right to decline participation in the current or any future data collection. They are also informed about how the data will be handled, where the results will be presented and that the information they provide is confidential.

Statistics Sweden (Statistiska Centralbyråen, SCB) is responsible for the sampling, distribution of questionnaires, data collection and registration of responses. The questionnaires include an identification number to be able to link subjects’ responses from different waves. Only SCB have access to the key which is used to match the questionnaire number with the personal identification number. All data are delivered from SCB to the Stress Research Institute in de-identified form. In that way, researchers are not able to connect data to individuals and accordingly, anonymity of the participants is assured. Registry data are linked to SLOSH both retrospectively and prospectively by identification numbers provided by SCB. When SLOSH data is being presented, all results are presented on an aggregated (group) level including many different individuals, to ensure effective protection of the personal integrity of the participants. The risk of identifying individuals is thus very small. The
SLOSH data is also rigorously protected to avoid any misuse. As SLOSH involves sensitive information about participants which could potentially mean backward identification of single individuals, data are not published and openly accessible to the public, even if that risk is small. Because some of the questions may be perceived as sensitive, or personal (e.g. questions about mental health), there is a risk that responding to the questionnaire might evoke negative feelings and thoughts. On the other hand, answering questions regarding e.g. health and health behaviors could increase the health awareness and perhaps motivate improvements in health behavior or reduce stress levels.

There is no direct benefit of participation for the respondents, such as compensation. However, hopefully, the respondents feel that they contribute to important research, which in the long run has the potential to contribute to a better labor market and work environment, and improved health, through increased knowledge, new interventions and policies. This could benefit not only the participants but many others. I believe that the benefits of new knowledge and potentially improved work environment and health that could stem from this research are likely to outweigh the potential costs.

Methods overview of the four studies

An overview of the four studies including which SLOSH participants were included in each study, which exposure, outcome and confounder variables were used, as well as which statistical methods were applied is presented in Table 1. In Table 2, characteristics of the study samples and of the respondents to SLOSH wave 1 is presented. Thereafter follows a description of the measures and statistical methods being used. It should also be mentioned that some additional analyses were carried out, which were not presented in the scientific papers or were conducted after the papers were published to address some questions and concerns that arouse. The results from these analyses will be briefly presented in the “Overview of studies and results” section where appropriate, but they will not be specifically addressed in the “Materials and Methods” section.
<table>
<thead>
<tr>
<th>Study</th>
<th>Title</th>
<th>Study population</th>
<th>Inclusion</th>
<th>Exposure(s)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study I</td>
<td>Trajectories of job demands and control: risk for subsequent symptoms of major depression in the nationally representative Swedish Longitudinal Occupational Survey of Health (SLOSH)</td>
<td>7949 SLOSH participants in waves 1–5</td>
<td>Individuals responding to at least one “worker questionnaire” in waves 1–4, responding to either questionnaire in wave 5, and not reaching depressive symptoms of ≥17 in wave 1–4 were included</td>
<td>Job demands and job control modeled as joint group-based trajectories (in waves 1–4)</td>
<td>Symptoms of major depression (in wave 5) (indicated by a SCL-CD6 score ≥17)</td>
</tr>
<tr>
<td>Study II</td>
<td>Job demands, control and social support as predictors of trajectories of depressive symptoms</td>
<td>6679 SLOSH participants in waves 1–6</td>
<td>Individuals responding to the “worker” questionnaire in wave 1 or 2, responding to depression questions at least once during waves 3–6, and who were ≤54 years old in wave 1 were included</td>
<td>Job demands, job control, workplace social support and additionally the four combinations of demand and control (in wave 2 or 1)</td>
<td>Trajectories of depressive symptoms (in waves 3–6)</td>
</tr>
<tr>
<td>Study III</td>
<td>Are there bidirectional relationships between psychosocial work characteristics and depressive symptoms? A fixed effects analysis of Swedish national panel survey data</td>
<td>3947 SLOSH participants in waves 3–6</td>
<td>Individuals responding to the “worker” questionnaire in wave 3, and at least once more during waves 4–6, and responding to the depression questions in waves 3–6 were included</td>
<td>Job demands, job control, demand-control ratio, workplace social support, work efforts, rewards, effort-reward imbalance, procedural justice (in wave 3–6)</td>
<td>Depressive symptoms (in waves 3–6)</td>
</tr>
<tr>
<td>Study IV</td>
<td>Psychosocial working characteristics before retirement and their influence on depressive symptoms across the retirement transition: a longitudinal latent class analysis</td>
<td>1735 SLOSH participants in waves 1–7, who retired in waves 2–6</td>
<td>Individuals retiring between waves 2–6, who did not report transitions from retirement back to paid work, and responding to depression questions in at least four waves were included</td>
<td>Job demands, job control, job strain, workplace social support, work efforts, rewards, ERI, procedural justice (in waves 1, 2, 3, 4 or 5)</td>
<td>Trajectories of depressive symptoms across retirement (in waves 1–7)</td>
</tr>
</tbody>
</table>

**Table 1. Overview of the methods and material in the four studies**
<table>
<thead>
<tr>
<th>Potential confounders</th>
<th>Baseline depressive symptoms, sex, age, children at home, civil status</th>
<th>Baseline depressive symptoms, sex, age, occupational position, civil status</th>
<th>(Only in the traditional cross-lagged Structural equation modeling (SEM) analyses): sex, age, occupational position, civil status</th>
<th>Sex, age, occupational position, civil status prior to retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical methods</td>
<td>Group-based trajectory modeling, logistic regression</td>
<td>Group-based trajectory modeling, multinomial logistic regression</td>
<td>Dynamic panel models with fixed effects using SEM, traditional cross-lagged SEM analyses</td>
<td>Group-based trajectory modeling, multinomial logistic regression</td>
</tr>
</tbody>
</table>
Table 2. Characteristics of the samples in the four studies and of the respondents to SLOSH wave 1 (2006), out of those with complete data on the variables presented.

<table>
<thead>
<tr>
<th></th>
<th>Study I</th>
<th>Study II</th>
<th>Study III</th>
<th>Study IV</th>
<th>SLOSH Wave 1</th>
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<tr>
<td></td>
<td>N=7494</td>
<td>N=6679</td>
<td>N=3947</td>
<td>N=1735</td>
<td>N=5985&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>55</td>
</tr>
<tr>
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\(a\) The total number of respondents in wave 1 was 5985, of which 844 responded to the “non-worker questionnaire” and 5141 responded to the “worker questionnaire”. Psychosocial work characteristics are based on those 5141 responding to the “worker questionnaire”.

\(b\) Refers to the mean age at retirement, as this study only included respondents who retired during waves 2–6.

\(c\) Married/registered partner (vs. not married/registered partner) comes from register data and does not consider cohabitation.
Assessment of exposure variables

We included exposure variables from SLOSH waves one, two, three, four, five and six in the different studies. The wave(s) in which exposures were assessed in the respective studies can be found in Table 1. All exposure variables were self-reported in the SLOSH “worker” questionnaire version. An overview of the content of all exposure items can be found in Table 3.
Table 3. Item content of the exposure and outcome variables

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<tr>
<td>working fast</td>
<td>Subdimension decision authority</td>
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<tr>
<td>(working hard)</td>
<td>deciding how you do your work</td>
</tr>
<tr>
<td>too much effort</td>
<td>deciding what you do at work</td>
</tr>
<tr>
<td>enough time</td>
<td>Subdimension skill discretion</td>
</tr>
<tr>
<td>work involve conflicting</td>
<td>learn new things</td>
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<tr>
<td>demands</td>
<td>high level of skill or expertise</td>
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<td>requiring ingenuity</td>
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<td>(repetitive work)</td>
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Workplace Social support items

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<td>calm pleasant atmosphere</td>
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<td>good spirit of unity</td>
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<tr>
<td>colleagues are there for me</td>
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<tr>
<td>can have a bad day</td>
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<tr>
<td>get on with supervisors</td>
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Work efforts items

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<th>Reward items</th>
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<td>lack acknowledgement supervisor</td>
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<td>to work load</td>
<td>poor promotion prospects</td>
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<td>job become more</td>
<td>experience(d) undesirable change</td>
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<td>demanding</td>
<td>job security poor</td>
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<td>workload increased</td>
<td>not receive respect/prestige</td>
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<td>salary/income adequate</td>
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Procedural justice items

decisions taken correctly
bad decisions revoked/changed
all sides affected represented
decisions taken consistently
everyone give their opinion
feedback provided and people informed
possible obtain details underlying decision


Depressive symptoms items

feeling blue
feeling no interest in things
feeling lethargic or low in energy
worrying too much about things
blaming oneself for things
feeling everything is an effort


\(^a\) Only included in study I instead of working fast
\(^b\) Only included in study I
Job demands, job control, job strain and workplace social support

Job demands, job control and workplace social support were measured using the Swedish Demand-Control-Support Questionnaire (DCSQ) which has shown satisfactory psychometric properties (Chungkham, Ingre, Karasek, Westerlund, & Theorell, 2013; Fransson et al., 2012; Sanne, Torp, Mykletun, & Dahl, 2005). In study I and III, job demands, job control and social support (study III) were used as continuous variables since we were modeling trajectories of job demands and job control (study I) and we used dynamic panel models with fixed effects (study III) in which the application of continuous variables is preferred. In study II and IV on the other hand, demands, control and social support were included as dichotomous variables. Median split was used to classify high and low levels, in line with the most common operationalization of the JDC model (Courvoisier & Perneger, 2010; de Lange et al., 2003; Landsbergis, Schnall, Warren, Pickering, & Schwartz, 1994). For example, high demands was classified as values above the median while low demands was classified as values below or at the median. Low control was classified as below the median, while high control was classified as a value above or at the median and so on. This could result in groups that are not exactly 50% because some individuals had the median value.

Four items (working fast, too much effort, enough time and conflicting demands) were used to create a job demand score. We used four items instead of five since two of the items (working fast and working hard) have been found to be highly correlated (Chungkham et al., 2013). However, in study I, instead of the item working fast, the item working hard was used, which was in the remaining studies changed to working fast because partial intercept invariance had been found for working hard (Chungkham et al., 2013).

Five items (deciding how you do your work, deciding what you do at work, learn new things, high level of skill or expertise, requiring ingenuity) were generally used to create a job control score. However, in study I we used all six items including the item repetitive work. In the remaining studies this item was not included since the best fit of the sub-dimension skill discretion of job control was found when removing repetitive work (Chungkham et al., 2013). The demand and control items were scored on a Likert scale with four response options: “Never/almost never” (1), “Seldom” (2), “Sometimes” (3) and “Often” (4).

In study I in which we studied joint trajectories of demand and control, i.e. the combination of demand and control trajectories, we classified the trajectories in line with the JDC model (job strain model) (Karasek, 1979), in which different combinations of high/low demands and control are classified as “high-strain” (high demands and low control), “low-strain,” (low demands
and high control) “active,” (high demands and high control) and “passive” (low demands and low control) as shown in Figure 1. The exposure in study I was thus mainly the combination of demands and control according to the job strain model, even though separate demand and control trajectories were also modeled. In study II and IV, as an additional exposure, we also used a variable with the four categories according to the JDC model, to investigate whether there was a difference in the results when comparing job demands and job control separately and when combined as job strain. In study I, II and IV job strain categories were based on high/low levels of demands and control using median-split. In study III, on the other hand, we created a continuous variable of the demand-control ratio. We divided demands by control (and control was multiplied by a correction factor of 0.8 for unequal number of demand and control items). This continuous demand-control ratio was used because the statistical method in study III was not well-suited for categorical variables, and yet we wanted to investigate job demands and control in combination and not only separately.

Five items (calm pleasant atmosphere, good spirit of unity, colleagues are there for me, can have a bad day, get on with supervisors) were used to create a score reflecting workplace social support. The social support scale that is based on the DCSQ is usually based on six items, including the item “get on well with colleagues” but this item was not measured in SLOSH wave 5 and thus we excluded it to be consistent across waves. Items were scored on a Likert scale with four response options: “Strongly disagree” (1), “Mildly disagree” (2), “Mildly agree” (3) and “Strongly agree” (4) (Fransson et al., 2012).

Efforts, rewards and effort-reward imbalance

In study III and IV we included work efforts and rewards using a short version of the effort-reward imbalance questionnaire which has shown satisfactory psychometric properties (Leineweber et al., 2010; Siegrist, 1996; Siegrist, Li, & Montano, 2014; Siegrist, Wege, Pühlhofer, & Wahrendorf, 2009). Three items were used to create an effort scale (time pressure due to work load, job become more demanding and workload increased) and seven items were used to create the reward scale (lack acknowledgement supervisor, poor promotion prospects, experience(d) undesirable change, job security poor, not receive respect/prestige, work prospects adequate, salary/income adequate) (Siegrist et al., 2014). Items were scored on a Likert scale with four response options: “Strongly disagree” (1), “Somewhat disagree” (2), “Somewhat agree” (3) and “Strongly agree” (4).
Similarly, to the demand-control ratio variable in study III, we created a continuous variable of the effort-reward ratio (i.e. effort-reward imbalance), by dividing the effort score with the reward score (and reward was multiplied by a correction factor of 0.43 for unequal number of effort and reward items). In study IV we included effort-reward imbalance as a dichotomous variable with a ratio of >1 indicating a high level of effort that is not met by the rewards received or expected while a ratio <1 indicating a favorable condition of relatively low efforts in relation to rewards (Siegrist et al., 2004).

Procedural justice

Procedural justice was measured using a seven-item scale (Moorman, 1991) (decisions taken correctly, bad decisions revoked/changed, all sides affected represented, decisions taken consistently, everyone give their opinion, feedback provided and people informed, possible obtain details underlying decision). Items were scored on a Likert scale with five response options: “Strongly agree” (1), “Somewhat agree” (2), “Neither agree or not” (3), “Somewhat disagree” (4), and “Strongly disagree” (5).

Assessment of the outcome variable

We included the outcome variable depressive symptoms from SLOSH waves one, two, three, four, five, six and seven in the different studies. The wave(s) in which the outcome was assessed in the respective studies can be found in Table 1. Depressive symptoms were self-reported in both versions of the SLOSH questionnaires. An overview of the outcome items can be found in Table 3.

Depressive symptoms

Depressive symptoms were measured with a subscale from the (Hopkins) Symptom Checklist (SCL-90) (Lipman, 1986), namely the Symptom Checklist-core depression (SCL-CD) scale including six items (Magnusson Hanson et al., 2014). The participants were asked how much during the last week they experienced: feeling blue, feeling no interest in things, feeling lethargic or low in energy, worrying too much about things, blaming oneself for things, and feeling everything is an effort. The items were scored on a Likert scale with five response options ranging from "Not at all" (0), “A little” (1), “Moderately” (2), “Quite a bit” (3) or "Very much" (4). These six items represent core
symptoms, whose selection was based on principles of clinical validity (Bech, 2008). This scale has been validated and found to have good psychometric properties (Magnusson Hanson et al., 2014). We used a sum scale serving as an indicator of depression severity, ranging from 0 to 24 (Magnusson Hanson et al., 2014). A score <7 has been suggested to indicate no depression, 7–9 doubtful depression, 10–11 mild depression, 12–15 moderate depression and 16–24 severe depression, in line with the International Classification of Diseases (ICD-10) diagnostic system (Bech, 2011) and these cut-offs were considered in study II and IV in which the outcome was trajectories of depressive symptoms, to define the trajectories.

In study I we created a dichotomous variable for depressive symptoms using a cut-off score of ≥17 to separate individuals with or without symptoms indicating major depression. This cut-off point has been identified as the most suitable threshold value for major depression in epidemiological research, it has been proved predictive of both antidepressant treatment and hospitalization in depressive episodes (Magnusson Hanson et al., 2014).

Covariates

We included the following variables as covariates: sex (man/women), age, civil status (single, or married/cohabiting), children living at home, referring to children living with you at least half of the time (yes/no), depressive symptoms at baseline and occupational position. In study I, models were adjusted for sex, age, civil status (also referred to as marital status in Study I), children at home and baseline depressive symptoms. In study II, the same covariates were included except children at home and additionally, occupational position was included. In study III, sex, age, civil status and occupational position were adjusted for, but only in the standard SEM models (see section “Structural equation modeling: dynamic panel models with fixed effects”). In study IV, models were adjusted for sex, age, civil status and occupational status. More detailed information regarding the covariates in the respective study can be found in the separate studies.

The covariates described have been found to be related to depressive symptoms as well as to work stressors and have been identified as potential confounders (Bonde, 2008). A further description of the rationale for choosing these covariates can be found in the “Confounding” section in the discussion. Controlling for baseline depressive symptoms (outcome variable) made it possible to assess whether psychosocial working conditions predicted the level of
depressive symptoms measured at a later time point over and above the influence of baseline depressive symptoms, thus the effect on change from baseline was assessed. Occupational position was based on the Swedish socioeconomic classification, “Socio-ekonomiskt index” (SEI) (Statistics Sweden, 1984), and we used this as a proxy measure of socioeconomic position. Occupational position was measured using six categories: unskilled workers, skilled workers, assistant non-manual employees, intermediate non-manual employees, professionals/upper-level executives or self-employed. The reason for using occupational position as a SEP measure was partly because education was not measured in all waves in SLOSH and register-data on education were not updated. On the other hand, the measure of occupational position partly captures education since the definition of each occupational group include the normal amount of education required. Education has also been observed to be associated with depression in an unexpected direction in SLOSH, with higher education predicting more severe symptoms (Nyberg, Peristera, Magnusson Hanson, & Westerlund, 2019). The use of several measures of SEP was also assumed to reduce power of the analyses. Occupational status was therefore judged to best capture socioeconomic position and considered sufficient as a measure of SEP.

Statistical methods

In this project, we have modelled data repeatedly measured in SLOSH during waves 1–7, and investigated associations between psychosocial work characteristics and depression using different statistical methods. The statistical analyses were carried out using STATA/SE version 14 for Mac (StataCorp, College Station, Texas) and R Studio version 1.0.136 for Mac (Boston, Massachusetts). In all studies p-values <0.05 were considered as statistically significant.

Descriptive analyses

In all studies we initially conducted some descriptive analyses to investigate the means, standard deviations, proportions, change scores and distributions of the variables of interest. We also investigated some statistical associations between variables by using Chi²-test, T-tests, Analysis of variance (ANOVA).
Group-based trajectory modeling

Group-based trajectory modeling (GBTM) was used in Study I, II and IV. The term “trajectory” can be described as a path, or course. GBTM was developed to study a behavior/phenomenon which is repeatedly measured over time, and it identifies subgroups of individuals who follow similar developmental courses over time or age (Nagin, 2005) and have become widely used in epidemiology. More specifically, the method we used can be referred to as Latent Class Growth Analysis (LCGA) (Jung & Wickrama, 2008). The GBTM approach assumes that the population consists of distinct groups of individuals defined by their developmental trajectories, and thereby enables to study heterogeneity (Nagin, 1999, 2005). For example, there might be groups that increase, decrease, or remain stable to different extents in terms of some behavior or characteristic measured over time. Trajectory parameters are estimated for each group separately. An important purpose of GBTM is to analyze potential causes and consequences of the trajectories within the population (Nagin, 1999).

We have conducted GBTM using the STATA TRAJ plugin (Jones & Nagin, 2012), to model trajectories of job demands and job control in combination (Study I) and trajectories of depressive symptoms (Study II and IV). A few studies have investigated demand and control trajectories (Igic et al., 2017; Wickrama, Lorenz, Fang, Abraham, & Elder, 2005). In contrast, numerous studies have used group-based trajectory methods to examine heterogeneity in trajectories of depressive symptoms (Musliner, Munk-Olsen, Eaton, & Zandi, 2016).

To determine the optimal number of trajectory groups, and the level of complexity (i.e. the shape of the polynomial curves) that best described the trajectories, we followed a similar procedure as previously described in the literature (Andruff, Carraro, Thompson, Gaudreau, & Louvet, 2009; Nagin, 2005). By using GBTM, the dynamics of either the psychosocial work characteristics job demands and job control (study I) or depressive symptoms (study II and IV) could be modelled. For a more detailed description of how we applied GBTM, see the methods sections in study I, II and IV.

Logistic regression analysis and Multinomial logistic regression analysis

Logistic regression analyses were used in study I to estimate the odds ratios (OR) of incident symptoms of depression indicating major depression (score ≥17) in wave 5, as predicted by the joint trajectories of job demands and con-
trol during wave 1–4. Several logistic regression models were estimated including different covariates, see the statistical methods section of study I for a detailed description.

Multinomial logistic regression analyses were conducted in study II and IV to estimate relative risk ratios (RR) (StataCorp, 2015) of belonging to a certain trajectory group (of depressive symptoms) depending on the baseline level of job demands, job control and social support (study II) and depending on the level of job demands, job control, social support, effort, reward and procedural justice prior retirement (study IV). In the multinomial logistic regression models the outcome was categorical (trajectories) in contrast to the logistic regression analyses in which the outcome was dichotomous. For further description, see the statistical analyses sections of study I and IV.

Structural equation modeling: dynamic panel models with fixed effects

In study III, we used structural equation modeling (SEM). SEM can be seen as an extension of path analysis and allows paths to be drawn between latent variables, meaning variables that are not directly observed but seen through their effect on observed variables (Streiner, 2006). SEM can also be described as a technique to specify and estimate models of linear relationships among variables, with a SEM model being an assumed pattern of directional and non-directional linear relationships among measured and/or latent variables (MacCallum & Austin, 2000). By using SEM, we aimed to fully consider the temporal dynamics of both psychosocial working conditions and depressive symptoms across waves 3–6. By means of dynamic panel models with fixed effects (Allison, Williams, & Moral-Benito, 2017) we assessed the relationship between psychosocial working characteristics and depressive symptoms in successive waves but also the lagged relationship between depressive symptoms and psychosocial working conditions. The dynamic panel models included both work characteristics and depressive symptoms as observed variables. These types of models enable assessment of the influence of lagged predictors, while simultaneously adjusting for time-stable characteristics of the individual through the inclusion of a latent variable representing all stable characteristics of the individuals. The models hence use variation within individuals to estimate the relationships between variables of interest, with each individual serving as his/her own control. The time-stable characteristics include both measured and unmeasured time-invariant factors such as sex, genetics, childhood conditions, personality and reporting style, which may give rise to common method bias. Adjusting for time-stable individual factors
should also account for prior morbidity which may coexist with depression. Hence, the associations assessed by this method are likely to be less subject to bias, and more likely to represent causal associations than previous analyses of observational data. We used R Studio to conduct these analyses, building on a previous procedure using maximum likelihood estimation (Allison et al., 2017). See Figure 3 for an example path diagram.

**Figure 3.** Example of path diagram of the dynamic panel models with fixed effects, using four data waves.

Alpha=latent variable representing all the time-stable characteristics of the individuals, x=representing the independent variables, y=representing the dependent variables, e=error term, c=contemporaneous coefficient, l=lagged coefficient. For c and l, only one coefficient is estimated across the four waves since estimates are assumed to be equal across time.
OVERVIEW OF THE STUDIES AND RESULTS

Study I – Trajectories of job demands and control: risk for subsequent symptoms of major depression in the nationally representative Swedish Longitudinal Occupational Survey of Health (SLOSH)

In the first study we investigated joint trajectories of job demands and job control across waves 1–4 and how they influenced the risk of subsequent symptoms of major depression in wave 5, in a sample of 7949 SLOSH participants. We did also investigate univariate trajectories of job demands and job control separately. By applying group-based trajectory modeling, we first found that the best fitting univariate job demand trajectory model consisted of six trajectories which were mainly stable over time, except two groups which decreased over time (see supplement “Online resource figure 3”). The best fitting univariate job control trajectory model also included six trajectories which were more or less stable over time (see supplement “Online resource figure 4”). More importantly, the joint trajectory model combining job demands and job control included seven groups, all with fairly stable levels of demands and control across six years, indicating that the levels of job demands, job control and their combination were relatively stable/unchanged over time. The seven joint trajectory groups were labelled according to the Job Demand-Control model: “Passive” (3.7%), “Passive” (13.3%), “High strain” (10.1%), “Low strain” (11.0 %), “Active” (14.7%), “Low strain” (18.1%), but also included a “Hybrid” (29.0%) group (see “Figure 1” in study I). The trajectory groups differed in terms of the distribution of sex, age groups, civil status and occupational position (see “Table 2” in study I). The two “Low strain” groups were merged to form a larger reference group for the logistic regression analyses. Results showed that individuals in the “High strain” (high demands and low control) and “Active” (high demands and high control) trajectories were significantly more likely to have symptoms of subsequent major depression (i.e. a score of $\geq 17$ on the SCL-CD6) in wave 5,
compared to those in the “Low strain” trajectory (reference), controlling for demographic covariates (OR 2.15; 95% CI 1.24–3.74 and OR 2.04; 95% CI 1.23–3.40) (see “Table 3” in study I). When also controlling for baseline depressive symptoms (in addition to the demographic covariates) the associations were no longer statistically significant even though the ORs for the “High strain” and “Active” trajectories indicated a slightly increased risk of later depression. Additional analyses did not find any statistically significant interaction effects of sex and age. In addition, analyses carried out later, in which occupational position was adjusted for did not alter the results.

Study II – Job demands, control and social support as predictors of trajectories of depressive symptoms

In the second study we investigated the relationship between high job demands, low job control and low social support at work and subsequent trajectories of depressive symptoms across waves 3–6 in a sample of 6679 SLOSH participants (analytical sample: 6080). By applying GBTM, we identified six trajectories of depressive symptoms with varying severity and stability across waves 3–6 which were labelled: “Persistent very low” (18.6%), “Persistent low” (54.6%), “Increasing doubtful-to-mild” (12.6%), “Decreasing moderate-to-low” (3.7%), “Persistent moderate” (9.4%) and “Persistent severe” (1.1%) (see “Figure 1” in study II). The individuals in the different trajectories differed in terms of the distribution of baseline sex, age, civil status, occupational position, job demands, job control and social support (see “Table 1” in study II). For example, women were overrepresented in the “Decreasing moderate-to-low” and “Persistent severe” trajectory group. Moreover, the proportion of unskilled workers was higher in the “Persistent severe” trajectory compared to the other trajectories.

Those perceiving high, compared to low job demands had significantly higher probability of belonging to all depression trajectory groups respectively compared to the reference group “Persistent very low” (with lowest symptom level), generally with increasing relative risk ratios as the symptom levels of the trajectories increased (see “Table 2” in study II). For example, if individuals were exposed to high job demands, the risk of belonging to the “Persistent severe trajectory” was higher than the risk of belonging to the “Persistent low” trajectory (compared to belonging to the reference trajectory). Though somewhat attenuated, the associations remained statistically significant when adjusting for sex, age, civil status, occupational position and baseline depressive symptoms with the exception of one trajectory group for
which the risk ratio became non-significant. Low (compared to high) social support was also associated with significantly higher probability of belonging to all other trajectories compared to the reference trajectory, with increasing relative risk ratios as the symptom severity of the trajectories increased. As for low job control, the associations with the depression trajectories were not as evident. Experiencing low (compared to high) job control was associated with a significantly higher probability of belonging to some of the depression trajectories, but when adjusting for baseline depressive symptoms no associations remained statistically significant. An additional model of job strain (defined as four categories: passive, active, high strain and low strain (reference) was conducted (see “Supplemental Table 1”). Results showed that individuals perceiving their job situation as “Active”, compared to individuals perceiving their job situation as “Low strain” had higher probability of belonging to the “Persistent low”, “Increasing doubtful-to-mild”, and “Persistent moderate trajectories”, compared to the reference trajectory. Those perceiving their job as “High strain”, had higher probability of belonging to the “Increasing doubtful-to-mild”, and “Persistent moderate” trajectories. A “Passive” situation, was not associated with any of the depressive symptom trajectories.

Results from additional analyses in which job demands, control and social support in wave three through six were separately added as time-varying covariates in the trajectory models, indicated that onset of high demands, low control and low social support was associated with increases in depressive symptoms over time (see “Figure 2–3” in study II, and Supplemental “Table 3”, and Supplemental “Figure 1–2”).

The main analyses were stratified by sex, and indicated somewhat stronger associations for men but overall the results were similar for men and women (see Supplemental “Table 2”). However, the relationships between the psychosocial working conditions and depression trajectories did not differ significantly by age or sex as shown by interaction analyses. Additional analyses carried out later on showed no interaction effect of occupational position, thus indicating that the effects of demand, control, or social support on depressive symptom trajectories did not differ depending on which occupational position individuals held.
Study III – Are there bidirectional relationships between psychosocial work characteristics and depressive symptoms? A fixed effects analysis of Swedish national panel survey data

In the third study, we used dynamic panel models with fixed effects (a type of SEM analysis), which makes it possible to control for all time-stable individual characteristics. We investigated both contemporaneous associations (meaning measured simultaneously) as well as lagged associations (with a two-year time lag) between psychosocial work characteristics and depressive symptoms in waves 3–6 among 3947 SLOSH participants. The psychosocial work characteristics included job demands, job control, demand-control ration, workplace social support, effort, reward, effort-reward imbalance and procedural justice. As for the lagged associations we investigated associations in both directions, including reverse associations, i.e. to what extent depressive symptoms were associated with subsequent psychosocial work characteristics.

We found that higher levels of job demands, a larger ratio between job demands and control, higher work efforts and effort-reward imbalance were contemporaneously associated with more depressive symptoms, while higher levels of workplace social support, rewards at work and procedural justice were associated with less depressive symptoms (see “Table 2” in study III). In contrast, only (higher) work efforts predicted higher levels of depressive symptoms two years later, i.e. there was a lagged association (see “Table 3” in study III). No other lagged associations were found in any direction, and thus there was no evidence of reverse causation between depressive symptoms and any of the psychosocial work characteristics two years later.

Results from additional analyses of traditional cross-lagged Structural equation modeling showed that all psychosocial work characteristics were contemporaneously associated with depressive symptoms and all work characteristics but job control predicted subsequent depressive symptoms (i.e. significant lagged effects) (see Supplemental “Table 1 a,b”). In addition, the effect estimates for the associations between depressive symptoms and subsequent work characteristics also indicated bidirectional lagged associations (except for job control). However, because the fit indices were poor, the results from these models should be interpreted with caution.

There were some overlap between the exposure variables, e.g. there was a correlation between job demand and effort of about 0.7, and between reward and social support of about 0.5. Otherwise, correlations were quite low.
Study IV – Psychosocial working characteristics before retirement and depressive symptoms across the retirement transition: a longitudinal latent class analysis

In study IV we investigated trajectories of depressive symptoms before and after retirement, among 1735 SLOSH participants who retired between waves 2 to 6, and how some psychosocial working characteristics before retirement influenced these trajectories. The psychosocial working characteristics included job demands, job control, job strain, social support, effort, reward, effort-reward imbalance and procedural justice.

First, we found that depressive symptoms on average decreased until retirement, which was when the lowest symptom level was reached and then the symptom level continued to be lower than before retirement (see “Figure 2” in study IV). GBTM identified six trajectories of depressive symptoms with varying severity and stability across retirement (spanning from nine years before, to eleven years after retirement). The trajectories were labelled: “No depression (very low symptoms)” (27.2%), “No depression (low symptoms)” (48.3%), “Moderate to no depression” (2.2%), “Mild to doubtful depression” (18.8%) and “Moderate depression” (3.6%) (see “Figure 3” in study IV). Overall, trajectory groups decreased slightly in terms of the symptom level in relation to retirement, while the “Moderate to no depression” showed a clear decrease. The trajectory groups differed regarding the distribution of sex, pre-retirement age, civil status, occupational position and work stressors (see “Table 1” in study IV). The “Moderate to no depression” trajectory, the “Mild to doubtful depression” trajectory and the “Moderate depression” trajectory, included larger proportions of retirees who were female, singles, unskilled employees, who perceived high demands, low control, job strain, low social support, high efforts, low rewards, effort-reward imbalance, and low procedural justice compared to the proportions in the “No depression (very low symptoms)” trajectory.

Perceiving high job demands, job strain, low social support, low rewards, effort-reward imbalance and low procedural justice prior retirement was associated with trajectories of depressive symptoms with higher symptom level compared to the reference trajectory of “No depression (very low symptoms)” (see “Table 2” in study IV). On the other hand, perceiving low control was only significantly associated with a higher risk of belonging to the “Moderate depression” and perceiving high effort was only associated with “Moderate to no depression” and “Mild to doubtful depression”. The risk ratios of belonging to the trajectories “Moderate to no depression” and the “Moderate depres-
sion” if being exposed to a “risky” level of the psychosocial working condi-
tions were particularly large, indicating that exposure to job stress prior to
retirement was particularly associated with a clear decrease of initially high
symptoms, or with a continuously moderate symptom level over time.
DISCUSSION

The overall aim of this thesis was to examine how a number of psychosocial working conditions are related to depressive symptoms over time, in working life and across retirement. In this following discussion section, the findings from the four studies will first be summarized and discussed. Then, some methodological considerations as well as the strengths and limitations of this work will be discussed. Finally, the conclusions will be presented, and what public health implications these findings could have. Some future research recommendations will also be provided.

Main findings and interpretation

Study I
When investigating the joint development of job demands and job control across 2006, 2008, 2010 and 2012 (waves 1–4), we found that the trajectories had different levels of job demands and job control, but in terms of changes in the levels over time, the trajectories were overall stable. This indicated that for the majority in our sample of Swedish workers, the levels of job demands and job control were relatively unchanged over a time period of six years, even though there is likely more variation at the individual level than as shown by the trajectories. Individuals following the “High strain” (high demands combined with low control) and “Active” (high demands combined with high control) trajectories were more likely to experience subsequent symptoms indicating major depression (i.e. scoring ≥17 on the SCL-CD6 scale) in 2014 (wave 5), compared to individuals following the “Low strain” (low demands combined with high control) trajectory. However, these associations were no longer statistically significant when baseline depressive symptoms were controlled for.

It appeared somewhat surprising that the trajectories of job demands and job control (both when investigated separately and jointly), were so stable over time. On the other hand, it was difficult to have any clear expectations in
advance, based on the literature. There are few previous studies modeling trajectories of demands and control, and none (to our knowledge) that specifically has investigated joint trajectories of demand and control. In line with our rather stable trajectories, another study investigating control trajectories did not find any significant increase/decrease across four years (Wickrama et al., 2005). Another study, (not published by the time we conducted study I), examined how cumulative exposure to different constellations of the Job Demand-Control model were related to health and well-being, by applying growth mixture modeling. They identified homogeneous latent classes of individuals across five waves spanning over ten years and found that the conditions were rather stable for the majority of participants (Igic et al., 2017).

The fact that the “High strain” trajectory predicted higher probability of depressive symptoms indicating major depression, even though not statistically significant in all models, was in line with previous research linking job strain to depression (Bonde, 2008; Netterstrøm et al., 2008; Nieuwenhuijsen et al., 2010; Stansfeld & Candy, 2006; Theorell et al., 2015). However, because of the stable trajectories, what we actually were able to explore was the impact of exposure to repeated/cumulated job strain. Previous studies regarding cumulative effects have been relatively few with rather inconsistent results (Burns et al., 2016; Stansfeld et al., 2012). In one of them, job strain was measured at three time points and there was a twofold risk of subsequent depression for those exposed to repeated job strain at two or three time points compared to one (Stansfeld et al., 2012). In one of them, job strain was measured at three time points and there was a twofold risk of subsequent depression for those exposed to repeated job strain at two or three time points compared to one (Stansfeld et al., 2012).

The fact that the “Active” trajectory was associated with higher probability of depression was more surprising and not in line with the Job Demand-Control model. One explanation for this could be that the level of demands was quite high, while the level of control was above, but not much above the median, so even though this trajectory was classified as high control, the control might not have been high enough to mitigate the (negative) effect of high demands. Judging from these results, it seems as if high job demands might be more strongly predictive of depressive symptoms than low job control and this will be discussed further in relation to the findings of study II.

Finally, the fact that when we adjusted for baseline depressive symptoms, the associations between the demand-control trajectories and depression did not remain statistically significant, may suggest that reverse associations could be an issue, i.e. that depressive symptoms predict ratings of poorer job demands and job control, or similarly common method bias, that there is a tendency for those who report more depressive symptoms to also report poorer working conditions. However, it should be noted that we excluded individuals with depressive symptoms reaching the level indicating major depression in
2006–2012, to decrease the risk of reverse associations. Nevertheless, this implies that we should be careful in drawing too strong conclusions about the associations between repeated/cumulative job strain and depressive symptoms from these findings.

Study II
When investigating the development of depressive symptoms across 2010–2016 (waves 3–6), we identified six trajectories with different severity and stability of depressive symptoms, even though most trajectories remained stable over time. The majority of participants followed trajectories with no or very low symptoms. However, around 10% of our sample followed trajectories of persistent moderate or severe depressive symptoms, which could be considered rather worrisome from a public health perspective. These individuals were more often women, singles, had a lower occupational position and did to a higher extent perceive high demands, low control and low social support at work than individuals in the “Persistent very low” symptom trajectory.

Perceiving high job demands and low workplace social support, respectively, and thus being exposed to potentially stressful working conditions prior to wave three, was more strongly related to subsequent trajectories with higher levels of depressive symptoms compared to the trajectory with very low symptoms (the reference group), even after adjustments for demographic covariates and baseline level of depressive symptoms. Additional analyses indicated that a deterioration in psychosocial work characteristics (e.g. changing from low to high demands) over the course of the trajectories was associated with an increase in depressive symptoms, suggesting that the initiation of poor work characteristics may also play a role for depressive symptom trajectories. In conclusion, especially high job demands and low workplace social support seemed to have long-term consequences for depressive symptoms.

Trajectories of depressive symptoms have been found to vary in terms of number of groups, severity and stability and our results were overall in line with previous findings (Musliner et al., 2016). However, it can be difficult to compare our trajectories because they were modelled over calendar time and not over age which seems most common. It should also be kept in mind that the nature and course of depression is difficult to assess (Richards, 2011). Also, the time lag of two years might have been too long to capture changes in depression symptoms which may occur much faster. What we captured is average and long-term patterns which at an individual level may be much more varying.
The fact that the estimate of association for job demands but not job control was significantly associated with the trajectories of depressive symptoms is in line with the results in study I, indicating that demands seem more strongly related to depressive symptoms than control using these data and methods. To understand this better, I carried out additional analyses and investigated the two sub-dimension of job control, skill discretion and decision authority separately. Skill discretion refers to the opportunity to use one’s specific job skills, while decision authority refers to the autonomy in task-related decisions. This led to two interesting findings. First, low skill discretion was significantly associated with lower probability of belonging to the “Persistent severe” depressive symptoms trajectory, thus low skill discretion appeared to be protective in terms of the risk of following the most severe course of depressive symptoms. Second, low decision authority on the other hand, was significantly predicting higher probability of belonging to two of the trajectories, “Increasing doubtful-to-mild” and “Persistent moderate”, in contrast to low job control as a whole. One potential explanation could be that our SLOSH sample is in general rather highly educated and that the sub-dimension skill discretion of job control could rather be perceived as a demand (i.e. something stressful) than as control (i.e. something protective). Skill discretion has been seen to increase over the years and thereby the exposure contrast in the job control score could have decreased. This would make it more difficult to observe an association when investigating job control combining the two subdimensions. Decision authority, on the other hand is more likely to reflect the feeling of control over one’s work situation and thus low decision authority may be more harmful in relation to depressive symptoms in this context. In addition, histograms showed that job control was more skewed compared to job demands and skewness may have influenced the results of job control.

The literature provides somewhat conflicting evidence whether high demands or low control (or the combination job strain) is the strongest predictor of mental health. It may depend on what specific outcome is investigated, in what population and also at what point in time, because the labor market and work environment change. de Lange et al. found that 63% of their reviewed studies reported main effects of job demands, 47% of control and 47% of social support on different health outcomes (de Lange et al., 2003). Häusser et al. reported that 80% of the reviewed studies found support for main effects of job demands, while 60% found main effects for job control and social support (Häusser et al., 2010). Netterstrøm et al. (2008) found moderate evidence of demands (but not of control), but on the other hand, in the systematic review by Theorell et al. (2015) there were moderately strong evidence for low
decision latitude (control), while there was limited evidence for psychological demands, in predicting depressive symptoms.

Study III

In the third study, we investigated contemporaneous (simultaneously measured) as well as lagged associations between a number of psychosocial work characteristics and depressive symptoms, while controlling for time-stable individual characteristics through fixed effects. We found that increasing efforts at work was associated with a higher level of depressive symptoms two years later. We found no other prospective associations between either job demands, job control, social support, rewards, or procedural justice and depressive symptoms two years later. Further, we found no reverse (lagged) associations between depressive symptoms and subsequent work stressors. On the other hand, there were contemporaneous associations between all psychosocial work stressors and depressive symptoms, except job control. In contrast to some previous evidence, these results indicate that these psychosocial work characteristics predominantly affect depressive symptoms immediately or with a short time lag, i.e. the causal associations may be rather short-term. What is more, we cannot exclude the possibility of reverse associations, i.e. that depressive symptoms may affect psychosocial working conditions with only a short time lag.

The lack of findings of lagged associations for most psychosocial work characteristics differs from much previous research which has found prospective associations with depression/depressive symptoms (Bonde, 2008; Madsen et al., 2017; Ndjaboué et al., 2012; Netterstrøm et al., 2008; Rugulies et al., 2017; Theorell et al., 2015). On the other hand, using traditional cross-lagged structural equation modeling analyses that did not control for time-stable characteristics (in contrast to the dynamic panel models with fixed effects), we found significant lagged associations in both directions for all work stressors except job control. However, those models had relatively poor fit and may thus not be completely trustworthy. One explanation for the lack of significant lagged associations in this study compared to other studies could be that individual characteristics such as genetics, childhood experiences or stable personality traits were controlled for. Not controlling for these factors in previous traditional analyses may thus at least partly explain some of the associations, while we were able to control for such factors by using a fixed-effects method. Another possible explanation is that the time lag of two years could have been too long to detect any effects of job stressors on depressive symptoms. An additional explanation may be that only changes in exposure
were considered using this method, so that only changes in the work characteristics or depressive symptoms (depending on model) are considered. This means that e.g. possible cumulative effects cannot be not captured like in more traditional models, and like in study I.

It should be noted that work efforts and job demands were highly correlated, which indicates that they mirror similar phenomena. And even though only work effort was a statistically significant predictor of depressive symptoms, job demands was close to significant.

**Study IV**

When investigating the development of depressive symptoms across retirement, we found that the mean level of depressive symptoms decreased until the retirement transition and then remained at a lower level after retirement than before, while still in work. Even though the changes were relatively small, these findings indicated beneficial effects of retirement on depressive symptoms. This is in line with previous findings of beneficial effects of retirement on mental health (van der Heide, van Rijn, Robroek, Burdorf, & Proper, 2013; Westerlund et al., 2010). The development of depressive symptoms, however differed between the five trajectory groups that were identified. In four of the trajectories, individuals seemed to experience some slight improvements regarding depressive symptoms across retirement. In addition, one small trajectory group “Moderate to no depression”, which had an initially high level of symptoms, distinctively decreased (improved) and thus seemed to benefit much from retirement. Potentially, this improvement had to do with the relief from job stressors, because this group was also seen to perceive the highest levels of work stress prior to retirement. In this group, 37% perceived job strain and 58% perceived high job demands compared to only 9%, and 27% in the “No depression (very low symptoms)” trajectory. Similarly, a previous study found that high physical and psychological job demands were associated with a more pronounced retirement-related improvement regarding self-rated health (Westerlund et al., 2009). On the other hand, several of the job stressors were associated with the trajectory with most severe depressive symptoms which support a long-term mental health effect of earlier psychosocial stressors (Virtanen et al., 2015; Wahrendorf, Blane, Bartley, Dragano, & Siegrist, 2013).

Perceptions of high job demands, job strain, low workplace social support, low rewards, effort-reward imbalance and low procedural justice were significantly predicting the probability of following the depressive symptom trajec-
tories, while perceptions of low job control and high work effort did only significantly predict some of the trajectory groups. Especially, the risk estimates of belonging to the trajectory with highest depressive symptom scores (“Moderate depression”) and the trajectory that decreased most (“Moderate to no depression”) were higher, for those who were perceiving a “risky” level of the psychosocial working characteristics prior retirement. The associations were generally robust even when adjusting for sex, age, occupational position and civil status, indicating that these factors did not seem to explain these associations to a large extent. In summary, these job stressors seemed to be associated with a more negative, as well as positive course of depressive symptoms across retirement.

Methodological considerations

In all studies, longitudinal study designs were applied using at least four waves of the SLOSH study. In each of the four studies different choices and considerations have been made in order to conduct the studies in the best possible way given our data and research questions. In this section, some of these considerations and potential threats will be discussed.

Systematic errors

Systematic error, or the corresponding term bias, is about lack of validity, meaning that the study or method does not measure what it intends to measure (Ahlbom & Norell, 1990). There are many different causes of bias and some of them will now be discussed in relation to the studies.

Confounding

Confounding occurs when exposed and unexposed groups differ regarding the occurrence of another factor which increases or decreases the risk of the outcome, and this difference is not taken into account (Ahlbom & Norell, 1990). Confounding is a major source of systematic error and thus a threat to the validity in observational studies. Identifying all potential confounders and being able to control for them, and thus reduce bias is challenging, and in some cases not even possible. In study I, II and IV we adjusted for a number of potential confounders which were available in our data and we adjusted for these variables by adding them to the regression models. The selection of potential confounders was similar in these studies, and was based on variables described as confounders in the literature (e.g. Bonde, 2008), and testing
whether these variables were statistically associated with the exposure(s) and the outcome. We explored newer methods for selecting confounders like Directed Acyclic Graphs (DAG), but decided to not rely on DAGs because they are not ideally suited for the perspective of trajectories. The reason for this is that once the trajectories are identified, they represent the development of a variable over time, and not variable(s) measured at different time points. This makes it difficult to draw directed arrows (indicating the causal direction) between trajectories and other variables. There could be residual confounding, due to e.g. factors such as personality, or physical or mental health problems which were not measured and might have influenced our estimates of associations. This will be further discussed in the coming section.

The decision whether or not to adjust for occupational position (as a proxy for socioeconomic position) was not clear cut. We did adjust for occupational position in study II, III, and IV, but not in study I. The reason for not adjusting for it in study I was that occupational position was not statistically associated with the risk of major depressive symptoms (i.e. ≥17). However, in the other studies occupational position was associated with both (at least some of) the psychosocial work stressors as well as with depressive symptoms. Especially, perceiving low job control was more common among unskilled, skilled workers, and assistant non-manual employees, while high demands on the contrary was more common among intermediate non-manual employees and professionals/upper-level executives. This is in line with research showing that e.g. low job control and low reward are more prevalent among lower status groups (Bosma, Peter, Siegrist, & Marmot, 1998; Siegrist et al., 2004). Socioeconomic position has been suggested to be both considered as a mediator, or an effect modifier in the relationship between psychosocial working conditions and health (Marmot, Siegrist, & Theorell, 2006). Effect modification could e.g. occur because those with low SEP have an increased vulnerability to adverse psychosocial working conditions and thereby have more adverse health effects. Evidence of a mediating effect of SEP has been found stronger than a modifying effect (Hoven & Siegrist, 2013). On the other hand, it is also likely that psychosocial working conditions is a mediator, or a modifier in the relationship between SEP and health and that e.g. low job control accounts for some of the associations between low SEP and health problems, as has been observed regarding e.g. coronary heart disease (Marmot, Bosma, Hemingway, Brunner, & Stansfeld, 1997). This illustrates that the relationships between work stress, SEP and health are likely to be complex. Additional analyses in study II did not show that occupational position interacted with demands, control or social support to modify the association with depression trajectories. Therefore, it might be more likely that occupational position functions as a
mediator, or a confounder, than an effect modifier. Adjusting for SEP can be a way of dealing with the social distribution of psychosocial working conditions, because an observed association between e.g. low job control and depression could be due to the fact that those with low job control also have low socioeconomic position and that factors related to the socioeconomic position are more important in explaining the health outcome (Marmot et al., 2006). However, one can also argue that it may be over adjustment to adjust for SEP, and that part of the association is taken away by adjusting for SEP if SEP serves as a mediator. Because we were most interested in whether these psychosocial working conditions were prospectively associated with depressive symptoms, independent of what type of occupation or socioeconomic position individuals held, the main analyses were mostly adjusted for occupational position. It should also be noted that adjusting for occupational position in study I did not alter the results.

In study III, however, we were able to control for all time-stable individual confounders including factors such as sex, genetics, childhood conditions, personality and reporting style, of which some were available in SLOSH while other factors were not. Thus, we did not actively select potential confounder variables and added them to the models, as in the other studies. By controlling for time-stable individual characteristics, the associations found in study III are less subject to bias due to confounding, and therefore more likely to represent causal associations, than studies not able to control for time-stable factors. This was one of the main reasons why we applied dynamic panel models with fixed effects in study III. However, it should be noted that we did not adjust for time-varying confounders, such as income using this method.

Common method bias
Common method bias, or common method variance may arise if a common way of measuring exposure and outcome is used, like in our case, using self-report measurements for psychosocial working conditions and depressive symptoms. This variance attributable to the measurement method rather than to the construct that the measure represents, can impact the observed relationship between predictor and outcome in organizational and behavioral research (Podsakoff et al., 2003). For example, individuals may have a general tendency to report their conditions in a negative way, so that ratings of the work environment and mental health are exaggerated. Thus, the associations observed do not really reflect a true relationship where a poor work environment affects depression negatively, but rather a negative reporting style and this could cause bias, more specifically overestimations of the associations. This potential bias could be present in study I, II and IV, but is less likely in study
III. In study III it was possible to control for factors like reporting style along with other observed and unobserved time-stable individual characteristics using fixed effects. In study III, the results also differed from results based on more traditional regression models and this may partly be explained by stable characteristics which were not controlled for using traditional regression models. In study I, because the associations were no longer statistically significant when adjusting for baseline depressive symptoms, it seems plausible that common method bias could have been present. However, in all studies we separated the measurement of exposure and outcome in time, by a time lag and could thereby reduce the risk of common method bias (Podsakoff et al., 2003). In addition, some work indicate that this type of bias is not a major problem when studying job strain and effort-reward imbalance in relation to coronary heart disease (Bosma et al., 1998; Stansfeld, Fuhrer, Shipley, & Marmot, 1999) or work characteristics in relation to psychiatric disorder (Stansfeld et al., 1999).

Selection bias
Another type of bias, namely selection bias could be present if the association between exposure and outcome differs between those who participate in the study and those who do not, and this could distort the results. Selection can occur during the recruitment of participants, when participants drop-out from the study or when there is missing data on certain items or measures. SLOSH is based on Swedish Work Environment Surveys and in turn SWES is based on Labor Force Surveys, which consists of a random sample of the Swedish population, and this may decrease the initial risk of selection related to recruitment of participants in SLOSH. However, about 50 to 64% of those invited from LFS to SWES agreed to participate. Then, the response rates of those in SWES who participated in the SLOSH follow-ups have varied from 65 to 48% across the data collections. As described in the SLOSH cohort profile, a general tendency in SLOSH is that among the SWES participants, women (compared to men), older (compared to younger), those married/registered partner (compared to unmarried), university educated (compared to lower education), and people born in Sweden were more likely to participate in the first SLOSH wave compared to those who did not participate (Magnusson Hanson et al., 2018). In addition, those who dropped out after the first SLOSH wave differ somewhat from those who participated in several SLOSH follow-ups. For example, those responding several times were in general more likely to be women, married, highly educated, having less health risk behaviors and less likely to have symptoms indicating major depression (Magnusson Hanson et
It is common that those who participate in surveys like SLOSH in general have a better health compared to those who do not participate.

As shown in the cohort profile, among those responding to the “worker questionnaire”, exposure to low social support was only slightly less common among those responding several times, while exposure to effort-reward imbalance was slightly more common among those responding several times (Magnusson Hanson et al., 2018).

It is clear that those participating in SLOSH from the start and also those who participated in several waves, are somewhat different from people who did not participate or only participated few times. However, for selection bias to be present, not only the distribution of exposure or/and outcome, but the association between exposure and outcome has to be different in those that are analyzed compared to those who did not participate or respond, and thus are not analyzed.

We conducted some sensitivity analyses to assess potential selection bias. In study I, we included individuals who responded to at least one “worker questionnaire” during waves 1–4, answered either the “worker” or “non-worker” questionnaire in wave 5, and who did not have major depressive symptoms (≥17 on the SCL-CD6) in waves 1–4. Among those 777 excluded due to having depressive symptoms ≥17, there were larger proportions of individuals who perceived high demands and low control than among those not reaching this depressive symptom level. We conducted a sensitivity analysis in which we did not exclude those 777 participants and the results regarding associations between demand-control trajectories and depressive symptoms were similar to the original results, thus decreasing the risk of selection bias.

In study II, we included individuals responding to the “worker” questionnaire at baseline, responding to questions about depression at least once during waves 3–6, and were 54 years or younger in wave 1. Those who were excluded due to not working at baseline and/or not responding to depression items might be individuals with higher depressive symptoms and perhaps who perceive more stress (which is related to why they were not working), and if this is the case we might have underestimated the associations between baseline job stressors (demand, control and support) and subsequent trajectories of depressive symptoms.

In study III, we included individuals responding to the “worker” questionnaire in wave 3, and in at least one more wave during waves 4–6, and who also responded to the depression questions in waves 3–6. A sensitivity analysis including also those without complete data on depressive symptoms in waves 3–6 showed very similar results as the main analyses. In addition, mean
values of depressive symptoms and work stressors were nearly identical comparing the main sample and the sample including individuals with incomplete depression data, indicating low risk of selection bias.

In study IV, we included individuals for whom we could observe a retirement transition between waves 2 and 6, who did not report transitions from retirement back to paid work, and who reported depressive symptoms in at least four waves. Future sensitivity analyses could indicate whether individuals without four waves with measurements of depressive symptoms would differ compared to those fulfilling this inclusion criteria.

The results of the sensitivity analyses in our studies did not indicate selection bias. However, it cannot be excluded due to e.g. recruitment or drop-out.

**Misclassification**

Another type of systematic error is misclassification and occurs when subjects are incorrectly classified as exposed/unexposed or as having the outcome/not having the outcome. *Non-differential* misclassification occurs when the probability of misclassifying the exposure or the outcome is independent of other factors, and this can lead to an underestimation of the strength of the observed association (Ahlbom & Norell, 1990). *Differential* misclassification is when the probability of misclassifying the exposure or the outcome is dependent on other factors in the study, possibly resulting in either over- or underestimation of the observed association (Ahlbom & Norell, 1990).

Misclassification of the exposure to psychosocial work characteristics and of the outcome depressive symptoms in our studies cannot be ruled out. First, how the exposure and outcome were measured could affect the risk of misclassification. Using self-reports has its limitations (also discussed in the “Limitations” section). Factors like personality, mood, expectations, previous experiences, or health status could influence the ratings of the work environment, which in turn could result in non-differential and differential misclassification, and thus yield under- or overestimated effects (Rugulies, 2012). Misclassification of the exposure to work stressors could be differential if people who e.g. overreport work stress have more mental health problems. This relates to common method bias which was previously discussed. Non-differential misclassification of the exposure could occur if individuals in general tend to, for instance exaggerate the perceived work stress regardless of their mental health status and other factors. This seems less likely. When it comes to depressive symptoms, misclassification is probably more likely due to using self-reported data compared to clinical assessment which would be more objective and serves as the “gold standard” for assessing depression. Because mental health disorders like depression are often stigmatized, there is a risk.
that people underreport symptoms and that social desirability also contributes to underreporting. Underreporting thus seems more likely than overreporting. It is difficult to know whether misclassification of depression would be differential or not, but probably non-differential to a higher extent than the exposure, and thus resulting in underestimations of associations.

Second, how the exposures and outcome were operationalized could also have affected the risk of misclassification. Measuring a construct by using several questions that forms a scale, which we did, can be beneficial because it is more likely to capture the underlying concept of interest. In study I, II, and IV we dichotomized the job stressors as high or low by splitting at the sample median. This is a straightforward and practical way, and easy to interpret. On the other hand, it is a crude measure with less information compared to a continuous scale. As an example, job strain was operationalized by median split of demands and control, and defined as the combination of high demands and low control. Because most individuals center around the median and not in the extreme ends of the distribution, groups might not be that different from each other and thus result in a low exposure contrast. Alternative operationalizations that create more exposure contrast may result in stronger associations (Landsbergis et al., 1994). Median-split operationalization may therefore have caused underestimations of the associations. However, in study III we used continuous scales and not median split. In study I, even though the trajectories were labelled according to median split, the trajectories were based on continuous scales of job demands and job control and not defined by median split.

Regarding depressive symptoms, we used a continuous scale for depressive symptoms (ranging from 0–24) in study II, III and IV, while in study I, depressive symptoms were dichotomized to indicate the presence/absence of major depression using the cut-off point ≥17. This cut-point was identified by Receiver-Operating-Characteristic (ROC) as optimal for major depression (sensitivity 0.68, specificity 0.98) (Magnusson Hanson et al., 2014). What is more, the SCL-CD6 has shown higher unidimensionality, indicating that the items capture the same underlying concept, than e.g. the Centre for Epidemiological Studies-Depression Scale (CES-D), which is commonly used, and may therefore be a better severity measure (Magnusson Hanson et al., 2014).

Random errors
Contrary to systematic error, random error has to do with lack of precision and is more likely when the sample size is small, and thus the power to detect
an effect becomes smaller. Confidence intervals (CI) can be used as an indicator of precision, with wide CIs indicating low precision (Ahlbom & Norell, 1990). We analyzed samples of different sizes in the four studies (ranging from 1735 to 7949 individuals). Overall, the CIs were pretty narrow, but in some instances, they were wider, e.g. in study II, one risk ratio of belonging to the “Persistent severe” depression trajectory was 7.52, with the CI of 4.39–12.88 in model 1, indicating some uncertainty around the estimate. A general pattern of wider CIs regarding trajectory groups including few individuals was observed in study I, II and IV. One solution could have been having a higher cut-off for the minimal trajectory group size when selecting the optimal trajectory model. However, we decided to consider trajectory groups of at least >1% of the sample, if fit indices were fulfilling and those models contributed with new distinctive patterns, compared to models with fewer (and perhaps larger) trajectory groups. Overall, the sample sizes were relatively large and the estimates could generally be considered rather precise in the studies, and thus the risk of random error is considered rather small.

Causality

As discussed in the introduction it is not yet clear to what extent associations between psychosocial work stressors and depression are truly causal. Studies investigating these associations are most commonly observational and not experimental which makes causal inference difficult, and even more so in studies with a cross-sectional design. Several methodological problems like confounding, common method bias, reverse causation etcetera contribute to this difficulty. As shall be discussed further, we applied longitudinal designs in all studies. This made it possible to have temporal separation of exposure and outcome, to control for baseline depression, and to investigate changes, accumulation and duration of exposure/outcome and thus come closer to a causal interpretation. In study III where we could also control for time-stable confounders (including unobserved variables), we came closer to being able to draw causal conclusions. However, because we cannot rule out different biases as discussed, and due to some limitations of our studies which will be further discussed, it is still difficult to confidently infer causality of the associations.

External validity

External validity, or generalizability of the findings has to do with how representative the sample is, and to what extent the results can be generalized across
populations. SLOSH is an approximately representative cohort of the Swedish active workforce, and thus results from studies using SLOSH data can be generalizable to various occupations and sectors (Magnusson Hanson et al., 2018). However, because participants from SWES were originally gainfully employed, there is a risk of a healthy-worker selection at baseline which may accumulate over time (Magnusson Hanson et al., 2018). In addition, as discussed in relation to selection bias, compared to those who only respond to SWES, those who also respond to SLOSH are in general more likely to be female, older, married, university educated and born in Sweden (Magnusson Hanson et al., 2018). This should be kept in mind when considering the generalizability.

In our four studies we only included a limited proportion of all participants in SLOSH according to different inclusion criteria, e.g. we only included participants who had responded at least once to the “worker questionnaire”, responded in certain waves, and/or responded to certain questions. In study IV, we only included participants who had retired during a certain time period. Nevertheless, our study samples were rather similar in terms of some demographic variables, depressive symptoms, and exposure to job stressors as compared to those individuals who participated in the first SLOSH wave, as was shown in Table 2. This means that our study sample could be regarded approximately as representative as the SLOSH population at the beginning. The demographic profiles in our samples could, on the other hand indicate that there is a selection of individuals who are healthier compared to the general population and that the prevalence of exposure to psychosocial work stressors and depressive symptoms respectively, are therefore somewhat underestimated. Generalizing the findings to other countries than Sweden may be somewhat limited due to differences in the labor market, work environment and many other contextual factors that are specific for Sweden such as having strong unions.

The Job Demand-Control-(Support) model

The Job Demand-Control-(Support) model is likely the most studied and influential occupational job stress model which has survived for about 40 years. Nevertheless, the model has been subject of debates and has been questioned. It is beyond the scope of this thesis to go into depth in this debate, but some issues deserve to be discussed.

One issue concerns interaction, and how to translate the hypotheses into statistical models, specifically if an interaction term should be added to the models, in addition to the main effects. As presented in the introduction, two
hypotheses have come to stem from the JDC(S) model: the (iso)strain hypothesis and the buffer hypothesis. Empirical support for multiplicative interaction effects as predicted by the buffer hypothesis has been less common compared to support for additive effects (de Lange et al., 2003; Häusser et al., 2010). It has e.g. been discussed whether the job strain model can be considered to be supported without a significant multiplicative interaction (Ingre, 2017). One suggested explanation for this interaction issue is somewhat unclear formulations regarding interaction in early publications, as discussed by e.g. de Lange et al. (2003), who considered both main effects (only) or multiplicative interaction effects as support for the strain hypothesis of the JDC(S) model in their review. On the other hand, other reviews distinguished between support for the strain hypothesis and support for the buffer hypothesis (Häusser et al., 2010; Van der Doef & Maes, 1999).

The relative lack of evidence for the buffer hypothesis cannot really be said to disprove the hypothesis since most published studies have not (properly) tested the interaction between demands and control. It therefore remains an open question whether or not the health outcomes of interest are due to the job strain (or iso-strain) interaction per se, rather than due to the main effects.

Another issue concerns how to define job strain and many alternative ways exist, of which the most common is to use the median split to first define high job demands and low job control, thereafter categorizing people into groups (Courvoisier & Perneger, 2010; de Lange et al., 2003; Landsbergis et al., 1994). In our studies, we have investigated what we refer to as job strain, using the quadrant method, i.e. comparing job strain (or high strain), active, and passive groups with low strain. What we mean by job strain is the combination of having high job demands and low job control. How we defined and tested job strain is thus in line with strain hypothesis rather than the buffer hypothesis. We do not claim that we assume an interaction between demands and control. We chose to operationalize job strain in this way for several reasons. First, as the empirical evidence has evolved, it seems to have become praxis to use this method and we want to contribute to, and be able to compare our findings to the existing literature. Second, to properly investigate if there is an interaction between demands and control requires enough power (Aguinis & StoneRomero, 1997) and careful thought (VanderWeele & Knol, 2014), which is beyond the scope of this thesis. Furthermore, it was not our intention to critically assess the job strain model per se or how it is operationalized.

Given the lack of a standard operationalization of job strain, and the ongoing debate about testing main or combined effects of demands and control, we
have in this thesis also investigated job demands, job control and social support as separate exposures. Moreover, the current evidence in the literature does not give a clear indication whether it is high job demands, low job control or low social support that is the strongest and most consistent risk factor for depressive symptoms.

Strengths and limitations

The strengths and limitations of this thesis, whereof some already have been implicitly mentioned (especially in relation to systematic errors), will be explicitly described and summarized in the following section.

Strengths

One main strength is that longitudinal study designs with multiple repeated measures were applied in all studies using data from at least four waves and spanning over 6–12 years. Longitudinal designs are required to be able to draw causal conclusions, even though they are not alone a guarantee for causal conclusions (Taris & Kompier, 2003). However, longitudinal designs allow for temporal precedence of the exposure as well as the possibility to examine reciprocal and reverse effects, which was done in study III, examining cross-lagged effects. Several repeated measurements also provide more information about the variables of interest and their relationship over time, increasing the study quality (de Lange et al., 2003). Analyzing several waves of data allowed us to examine the dynamics (i.e. duration/accumulation/change) of exposure to demands and control in relation to depression (study I), and how psychosocial working conditions were associated with the course of depressive symptoms (i.e. a long-term effect) (study II & IV). These aspects have previously been scarcely examined, probably due to lack of several repeated measurements. Study IV also had the advantage of being able to study how the removal of exposure to psychosocial work stressors due to retirement affected depressive symptoms, almost like a natural experiment design, even though individuals to some extent, can choose when to retire.

Longitudinal data was also a requirement of the two main statistical methods used. These have several advantages. Group-based trajectory modeling is a way of identifying meaningful groups in data over time, providing easily understood graphical summaries of complex data, and thus creating comprehensible descriptions of individuals over time (Nagin, 2005). The other method, dynamic panel modeling with fixed effect had the major benefit of
making it possible to control for time-stable individual characteristics (even unmeasured factors) thus reducing the risk of confounded associations. This was done for associations in the “standard” direction (from work stress to subsequent depressive symptoms) as well as for reverse associations (from depressive symptoms to subsequent work stress).

Another strength is the use of data from the SLOSH study. SLOSH consists of a large and fairly representative sample of the Swedish working population who are followed repeatedly over many years, regardless of employment status in the follow-ups. Using SLOSH with its large number of participants, increases the statistical power and thereby precision, as well as the generalizability of the findings.

Limitations
In all studies, we solely relied on self-reported data, in the form of self-administered questionnaires. Self-reported data can be described as subjective which could, but does not necessarily have to be a limitation. As mentioned in the section about systematic errors, ratings of the psychosocial work environment (and depression) can be influenced by many different factors and there is a risk of misclassification. Common method bias could also be a consequence of assessing both the exposure and outcome with self-reports. On the other hand, self-reports can be seen as valuable in the sense that the workers themselves are most likely those who know their own work environment best (Rugulies, 2012). It has also been assumed that it is the individual perception of psychosocial risk factors that plays a key role in producing strain (Rick et al., 2001), and not the more objective psychosocial work environment. In terms of measuring depression (or depressive symptoms), self-reported symptoms using questionnaires may not optimal, but the “gold standard” clinical assessments, would unfortunately not be feasible in a large cohort like SLOSH.

SLOSH data is collected biennially. This time lag of two years might not be optimal for studying relationships between work stressors and depressive symptoms. However, how long the optimal time lag is for studying these relationships is not clear from previous research. It seems plausible that the effects of psychosocial working conditions on mental health may occur within less than two years and that any effect could already have disappeared when measuring depressive symptoms after two years. If that would be the case, then our associations could be underestimated. A too short time lag on the other hand, might also underestimate effects if the outcome has not yet
evolved. Ideally, it would be preferable to have more frequent data collections, but this would of course be at the expense of resources as well as more pressure put on the participants to fill out the questionnaires more frequently.

Even if there are benefits of using group-based trajectory modeling, there are also limitations of this approach. What has been learnt from conducting three studies using GBTM is that it might not completely make sense to model trajectories across calendar time in a group with widely varying ages and without a relation to any natural starting point of the trajectory related to time, age, stage of working life, or life events. The exception was study IV where depression trajectories across retirement were modelled. There is a risk that interesting patterns go undetected in our analyses. It should be kept in mind that trajectories show average patterns and that individual patterns may differ (Tu, Tilling, Sterne, & Gilthorpe, 2013). In addition, our trajectories were rather stable and it would have been even more interesting to analyze their predictors or consequences had they showed more changes over time. This would have allowed for better understanding of associations regarding change and accumulation of exposure.

Another limitation is that there is some missing data in all studies, either that individuals did not participate in all waves, or that the individuals did not respond to all questions, which has been discussed in relation to potential selection bias. Missing data could potentially increase the risk of systematic, as well as random error. However, the Group-based trajectory modeling can handle missing data to some extent using maximum likelihood estimation, as can the dynamic panel models with fixed effects, by using full-information maximum likelihood. A further limitation is that in some SLOSH waves a number of questions have been either changed or removed. As discussed, even though SLOSH is rather representative of the Swedish workforce, there might be a healthy worker selection from start and attrition being more likely for individuals with poor health etcetera, thus decreasing generalizability. In addition, the response rates in SLOSH have decreased over the years, decreasing power as well as potentially the generalizability. However, expecting a very high response rate in surveys like SLOSH during these days is unfortunately optimistic.
Conclusions

In this thesis, a number of psychosocial risk factors at work were investigated as predictors of depressive symptoms. Using data fairly representative of the Swedish workforce from the SLOSH study between 2006 and 2018 the findings of thesis showed that:

Study I
Repeated exposure to high strain (high job demands and low job control) and active (high job demands and high job control) jobs across six years was associated with subsequent major depressive symptoms, compared to low strain jobs (low job demands and high job control). However, after adjusting for depressive symptoms at baseline, these associations were not statistically significant.

Study II
High job demands and low social support, but not low job control, predicted a worse course (higher or increasing symptoms) of depressive symptoms across six years, indicating that exposure to these job stressors may have long-term consequences for depressive symptoms. In addition, negative changes in job demands, job control and social support were associated with increased symptoms, indicating that the onset of poor working conditions could also have negative consequences for depressive symptoms.

Study III
Only more work efforts predicted a higher level of depressive symptoms measured later, when controlling for time-stable characteristics, suggesting a causal association between work effort and depressive symptoms. Further, depressive symptoms did not predict work stressors measured later, and thus, did not indicate reverse associations. These findings suggest that psychosocial work characteristics affect depressive symptoms more immediately, or with a short time lag.

Study IV
Retirement seemed to have a small but positive effect on depressive symptoms in general. Further, high job demands, job strain, low social support, low rewards, effort-reward imbalance and low procedural justice were associated with a more negative course of depressive symptoms across retirement. However, these work stressors were also associated with a positive course of depressive symptoms. Especially, for a small group with high levels of work
stress before retirement, the retirement transition was related to a large decrease in symptoms. This indicates that the relief from poor psychosocial working conditions at retirement may improve depressive symptoms.

According to the findings of this thesis, especially the perceptions of high job demands, low workplace social support and high work effort seem to be risk factors for depressive symptoms, and influence the course of symptoms over time. No clear conclusion could be made about repeated exposure to job demands and job control. However, a change in certain work stressors seemed to be associated with a change in depressive symptoms and the relief from work stress at retirement seemed to decreased the symptoms. These results contribute to strengthen the evidence of causality between certain work stressors and depression. Even though this thesis did find support for prospective associations between certain psychosocial work characteristics and depressive symptoms, it cannot be concluded with absolute confidence that these risk factors cause more depressive symptoms.

Relevance and implications for public health

Eliminating, or improving poor psychosocial working conditions could have the potential for decreasing the level of depressive symptoms in the working population. However, because depression has complex and multifactorial causes it is unrealistic to believe that the workplace alone would be able to eliminate all (modifiable) risk factors for depression. Viewed within a broader picture of accumulating evidence for the detrimental effects of poor psychosocial working conditions on mental health, the findings of this thesis suggest that considering these factors at the workplace is important. In 2016, the Swedish Work Environment Authority provisions about organizational and social work environment (AFS 2015:4) came into effect, with the purpose to promote a good work environment and prevent risks of ill health (Swedish Work Environment Authority, 2015). These provisions regulate the knowledge requirements, goals, workloads, working hours and victimization, and thus they consider the psychosocial working conditions addressed in this thesis to a large extent. It is the employer who is responsible for the provisions being followed and this includes e.g. making sure that managers and supervisors have knowledge of how to prevent unhealthy workloads and having objectives for the work environment aimed at promoting health and counteract ill health. In addition, employees should be given the possibility of taking part in producing such objectives. I believe that the introduction of these provisions was
an important initiative in order to promote healthier work environments. However, a better implementation of the provisions and improved systematic work environment management is probably still needed at many workplaces.

Also, a growing number of intervention studies to improve mental health show that workplace interventions can be effective (Joyce et al., 2016), even though the support for effectiveness of workplace interventions has not been completely consistent. Organization level intervention studies have, e.g., found some evidence that improving the job demands and social support has beneficial health effects (Egan et al., 2007). Primary interventions have integrated approaches targeting psychosocial risk factors at work in order to improve mental health at work, consisting of both individual and organizational components (Corbière et al., 2009). It has been suggested that using the Job Demand-Control-(Support) and Effort-Reward imbalance models in preventive intervention can be advantageous since they can fulfill requirements of the organization and individual (Corbière et al., 2009). For example, a stress management intervention focusing on improving ERI, showed that improvements in ERI following the intervention was associated with lower anxiety and depression seven years later (Barrech et al., 2017). Another health promotion intervention was found to effectively improve the sense of control over the job and ability to meet mental demands of work, and reduced the probability of being absent due to depression (Sun, Buys, & Wang, 2013). More evidence of such interventions is needed, but might provide promising possibilities in the future. The results of this thesis support the call for increased attention to factors such as demands, supportive work environment, and efforts aligned with rewards in further intervention studies (Couser, 2008). Social support has also been found important e.g., in terms of returning to work after sick-leave due to common mental disorders (Andersen, Nielsen, & Brinkmann, 2012). A benefit of focusing on workplace social support is that everyone in an organization has the possibility to contribute to workplace social support by creating a pleasant and supportive atmosphere. This responsibility does not only have to lie on the managers of the organization. In addition, it does not have to cost much or encompass reduced workload and productivity to increase the workplace social support.

Finally, I believe that it should be acknowledged at workplaces that poor psychosocial working conditions can be risk factors for depression. In addition, it should be acknowledged that psychosocial working conditions are modifiable and that there could be a lot to win from improving them. Improving psychosocial working conditions has not only potential economic benefits for society as a whole, but also important benefits, not the least in terms of health, for individuals and organizations.
Future directions

This thesis has contributed to filling some gaps in the work stress – depression literature by applying longitudinal methods and certain statistical methods, using fairly representative and large samples of the Swedish working population. However, some questions and issues still remain. Although, the work herein contributed to strengthen the evidence regarding causality, further intervention studies would be preferable to support the results. Some results in this thesis seemed to indicate that effects of work stressors are relatively short-term. A recommendation for future research therefore includes studies with more frequent measurements and thus shorter time lags between the measurement of exposure and outcome. Even though not feasible in large epidemiological surveys, more objective assessments of depressive symptoms like clinical interviews would also be preferred. In addition, due to relatively few studies investigating cumulative or changing exposure, there is a need for more such studies to be able to draw firm conclusion, especially in terms of the effects of cumulative exposure. It would also be interesting to examine people who change job and thereby change their exposure to work stressors (e.g. increasing, decreasing or stable) and observe their trajectories of depressive symptoms. As mentioned, trajectories might be more useful if they are related to some distinct change or event. Another interesting direction is natural experiments, or quasi-experimental designs, in which e.g. political decisions would change the level of job demands or other job stressors. This could strengthen causal inference in the absence of randomized controlled trials, which are hardly feasible regarding job stressors. Also, the influence of stable individual characteristics may deserve increased attention. Additional studies using structural equation modeling methods like dynamic panel models with fixed effects, addressing bias due to confounding, would be advantageous. Considering the extended working life and the public health burden due to stress-related and mental disorders, I really believe this area of research must to continuously invested in.
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