



FINAL SCIENTIFIC REPORT:
Working conditions and health inequalities,
evidence and policy implications

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**Hoven H, Siegrist J. Work characteristics, socioeconomic position and health: a systematic review of mediation and moderation effects in prospective studies. *Occup Environ Med* 2013;70(9):663–9.

*Lunau T, Wahrendorf M, Dragano N, Siegrist J. Work stress and depressive symptoms in older employees: impact of national labour and social policies. *BMC Public Health* 2013;13(1):1086.

*Lunau T, Siegrist J, Dragano N, Wahrendorf M. Educational differences in work stress: Does the policy context matter? *Resubmitted after revision* 2014.

**Montano D, Hoven H, Siegrist J. Effects of organisational-level interventions at work on employees' health: a systematic review. *BMC Public Health* 2014;14:135.

**Montano D, Hoven H, Siegrist J. A meta-analysis of health effects of randomized controlled worksite interventions: Does social stratification matter? *Scand J Work Environ Health* 2014;40(3):230–4.

**Montano D. Upper body and lower limbs musculoskeletal symptoms and health inequalities in Europe. An analysis of cross-sectional data. *BMC Musculoskelet Disord* 2014; *In press*.

**Montano D. Chemical and biological work-related risks across occupations in Europe: a review. *J Occup Med Toxicol* 2014;9:28.

*Wahrendorf M, Siegrist J. Proximal and distal determinants of stressful work: framework and analysis of retrospective European data. *BMC Public Health* 2014; 14:849

**Hoven H, Wahrendorf M, Siegrist J. Occupational position, work stress and depressive symptoms: a pathway analysis of longitudinal SHARE data. *Journal of Epidemiology and Community Health* 2015. doi:10.1136/jech-2014-205206.

Executive summary

In this final scientific report of research accomplished within Work Package 3 of DRIVERS ('Work and Health Inequities, including Policy Recommendations') we demonstrate how the three main project aims have been accomplished. These aims are: (1) to establish an updated knowledge base on associations of work, social inequality, and health; (2) to synthesise current evidence on feasibility and outcomes of work and health-related interventions at different levels, by critically evaluating applied methodologies and by comparing the methods of improving intervention effectiveness; and (3) to develop and apply a theoretical model linking national labour and social policies to the quality of work and their effects on unequal health.

With findings drawn from systematic reviews, and from secondary data analyses performed on the basis of newly available data from selected European surveys, we update and extend the knowledge base on associations of social inequalities, work and health in several respects (aim 1).

First, we document new evidence of social inequalities in exposure to a stressful work environment that are generally apparent as social gradients, with higher exposure rates among people in lower occupational positions. This is demonstrated for distinct chemical, physical and biological hazards, for relevant aspects of atypical employment (especially job instability), and for a health-adverse psychosocial work environment, as defined by two complementary theoretical models, demand-control and effort-reward imbalance.

Second, with innovative findings of elevated health risks resulting from exposure to a stressful psychosocial work environment, specifically low control and effort-reward imbalance, we provide a significant contribution towards explaining health inequalities among working populations. Our findings confirm that stressful work in part mediates the pathway leading from disadvantaged occupational positions to higher disease risks. Additional evidence points to a moderating role of low occupational position, where the effects of adverse work on employees' health are much stronger than those observed among more privileged working groups.

Third, by combining aim 1 with aim 3, we perform a series of empirical tests of a conceptual model that links national labour and social policies with unhealthy work. Our findings show that distinct well-developed labour and social policies at the national level are strongly associated with improved levels of psychosocial working conditions in respective national working populations. This holds particularly true for active labour market policies targeting the integration of disadvantaged groups of adult men and women.

Empirical support in favour of this model has direct policy implications, as our results indicate that social gradients of unhealthy work tend to be less pronounced in countries where these policies are widely implemented. Moreover, the strength of associations between stressful work and health (depressive symptoms) seems to be attenuated by well-developed social and labour policies. These novel findings extend the traditional frame of analysis of social inequalities in work and health beyond the micro-social and meso-social levels of single organisations and enterprises to include the potential impact of distinct macro-social welfare policies.

Finally, with regard to the second aim of our research programme, i.e. a synthesis of evidence concerning intervention methods and findings, our results reveal that there is a considerable potential of reducing work-related exposures to occupational hazards and, therefore, of reducing the work-related burden of disease. In view of the social gradient of unhealthy work this would result in a sizeable reduction of social inequalities in employed people's health across Europe. However, as evidenced by our systematic reviews and meta-analysis, a small part of intervention research only

addressed the structural, organisational dimension of worksite health promotion programmes. Moreover, studies of lower-skilled occupational groups and their health benefits were largely absent in the reviewed literature. Therefore, the implementation of health-promoting working conditions among less privileged working populations deserves high priority.

These arguments lend support to the proposition of distinct recommendations for policy, practice, and further research. In the final chapter of this report, a series of such recommendations derived from our research achievements is presented. These recommendations provide entry points for reducing health inequalities among working populations across Europe by strengthening fair employment and working conditions.

Part I. Background

1. Introduction

In this final scientific report of research accomplished within Work Package 3 of DRIVERS ('Work and Health Inequities, including Policy Recommendations') we demonstrate how the three main project aims have been accomplished. These aims are:

1. to establish an updated knowledge base on associations of work, social inequality, and health;
2. to synthesise current evidence on feasibility and outcomes of work and health-related interventions at different levels, by critically evaluating applied methodologies and by comparing the methods of improving intervention effectiveness;
3. to develop and apply a theoretical model linking national labour and social policies to the quality of work and their effects on unequal health.

These aims are linked to the following statements reflecting well established facts. The first statement maintains that significant health inequalities still prevail across European countries, and that these health inequalities at population level become most apparent if analysed in the frame of a society's socioeconomic and socio-cultural structure. The second statement indicates that a substantial part of these inequalities is avoidable in principle, and that specific features of people's social environment, including their employment and working conditions, contribute to the development of unequal health. Therefore, in a third statement it is concluded that improvements at the level of social determinants of health – in our context at the level of distinct employment and working conditions – are promising drivers of reducing health inequalities.

It is a relevant task of scientific research in the field of epidemiology and public health, and specifically of social epidemiology, medical sociology and occupational health, to provide further robust evidence on these statements. A large body of knowledge related to the first statement has been established during the past three decades, indicating pervasive – and sometimes even widening – social inequalities in health between and within European countries [1,2]. Importantly, the problem of inequality in health is not confined to the poorest members of society, but there is a social gradient of morbidity and mortality across the whole of a society. With each step one moves up on the social ladder, the better one's health [3]. Social gradients of health were repeatedly documented in all European countries, using educational attainment, occupational position, or income as indicators of people's social standing [4,5]. While there has been much concern with the effects of material deprivation accounting for the worse health of the poor compared to that of those not in poverty, the social gradient of health implies a wider range of health-adverse conditions.

In essence, turning to the second statement, more recent research was able to disentangle the complex web of causation of unequal health such that four partly independent clusters of determinants were identified. A first cluster concerns differential health care provision. Unlike countries such as the United States of America, most European countries provide extensive health care to the whole of their populations. Therefore, the explanatory contribution of unequal access to, or quality of, care in these latter countries was shown to be rather limited [6]. A second cluster relates to social inequalities in health-adverse behaviours or lifestyles, in particular poor diet, smoking, alcohol consumption, lack of physical exercise and overweight. These behaviours were shown to explain a substantial proportion of the social gradient of specific chronic diseases (esp. coronary heart disease, metabolic disorders, lung cancer, liver cirrhosis) and of elevated all-cause mortality risks [7]. To a large extent, these behaviours are transmitted to children and adolescents through socialisation practices within socio-cultural environments characterised by restricted access to a society's opportunity structure [8]. This latter finding points to a third significant cluster of social determinants of health, adversity in early life. With the advent of life course epidemiology evolving from pioneering

findings of birth cohort studies, new evidence on short- and long-term impact of material and psychosocial deprivation during pregnancy and early infancy on health became available. In addition to irreversible damage produced by toxic exposures during pregnancy and by genetic vulnerability, an accumulation of disadvantage during trajectories into adult life was observed, shaping the social gradient of health and disease over the life course [9].

Exposure to adverse material and psychosocial circumstances in adult life was established as a fourth cluster of factors determining unequal health. Poor housing or being exposed to occupational hazards at work are examples of adverse material circumstances, whereas social isolation, low degree of autonomy and decision latitude in important areas of everyday life, and lack of recognition and reward of efforts spent, are examples of psychosocial adversity [10,5].

Our research conducted in the frame of DRIVERS is embedded in this fourth cluster of social determinants of health, with an explicit focus on employment and working conditions. Here, we contribute robust knowledge on the importance of work and employment for unequal health, (a) by conducting systematic reviews and meta-analyses of findings from available studies devoted to this topic, and (b) by performing our own statistical analyses of data available from cross-sectional and longitudinal studies on working conditions and health outcomes in different European countries (aim 1). In the Results section of this report, we first define distinct physical, chemical and biological hazards at work which affect workers' health and which are more prevalent among lower socioeconomic status groups, thus contributing to the explanation of unequal health (Section 3.1). We then address critical employment conditions and wage inequalities, and specifically stressful psychosocial work environments that are analysed in terms of two complementary theoretical models of stressful work, the demand-control model [11] and the effort-reward imbalance model [12]. Again, a social gradient of this adversity is demonstrated, and selected findings on elevated morbidity risks among exposed workers are reported (Section 3.2 and 3.3). In a next important step, pathways leading from socioeconomic position to increased work-related risk of disease are analysed, addressing the two complementary hypotheses of mediation and moderation (Section 3.4).

With the advent of this new knowledge, efforts of preventing work-related ill health and disease were developed, aiming at reducing the burden of unequal health in employed populations (third statement). To this end a broad spectrum of intervention studies was reviewed, targeting different occupational groups and different levels of intervention (individual behaviour, interpersonal processes, organisational changes). In the next chapter of our Results section we provide an updated review of findings derived from randomised controlled intervention studies on this topic, and we evaluate the results of organisation-level interventions, taking the varying quality of study designs into account (Chapter 4; aim 2). As a result, it can be stated that evidence on intervention effectiveness is limited so far, reflecting both distinct shortcomings of this research area as well as limited impact on health reductions as long as interventions are restricted to the micro-level of single enterprises/organisations.

In this Introduction, before describing the methods used by our team to produce this new knowledge (Chapter 2), and before presenting and discussing the results in more detail (Chapter 3, 4), we propose a conceptual framework that links more distal factors, specifically national labour and social policies, to the proximal conditions of work and employment and their effects on unequal health (aim 3). This framework is briefly explained here, but is substantiated with preliminary empirical evidence in Section 3.5.

1.1 A conceptual framework

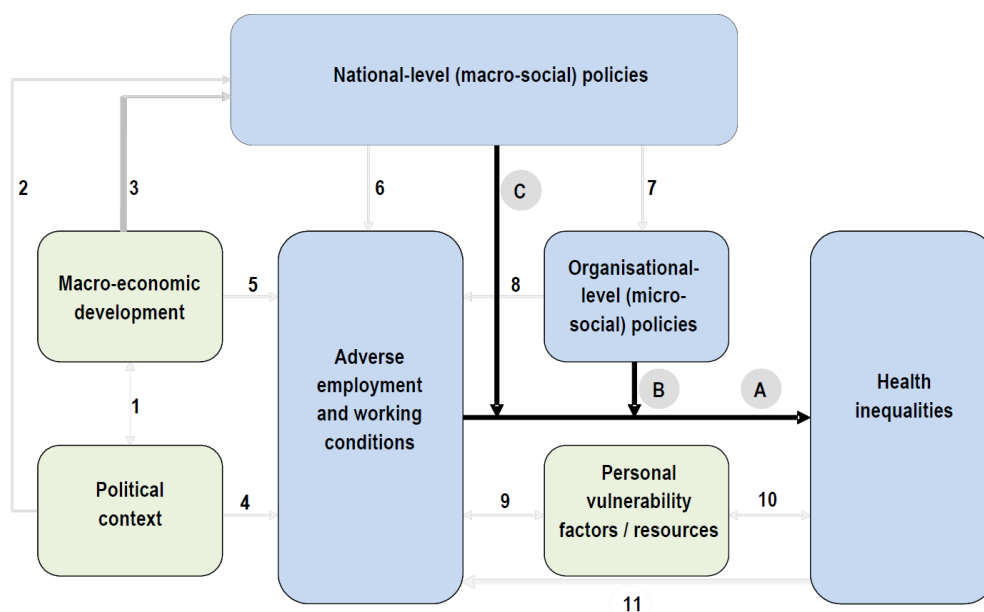
A complex web of causation links employment and working conditions with unequal health. In Figure 1, a conceptual framework is outlined that specifies major pathways. Three pathways are considered to be of critical relevance to our research within Work Package 3 (WP3) of DRIVERS (A,B,C in bold, Figure 1). In order to assess their significance, the remaining associations indicating broader (upstream) determinants of employment and working conditions and of policies (implemented to reduce their adverse effects on health) need to be briefly considered as well. Moreover, several indirect effects on health are obvious, mediated by the working persons' vulnerability factors and resources [13].

Pathway 1 points to the powerful bi-directional links between macroeconomic development and macro-political contexts. Evidently, a stable and favourable macro-political context may stimulate and promote economic growth. Conversely, economic growth, if developed in sustainable ways, can contribute to political stability and progress. However, political upheaval or anomie exerts opposite effects, at least in a short- and medium-term perspective (see e.g. effects of financial crisis in European countries since 2008) [14].

Pathway 2 displays the effects of distinct macro-political contexts on the development of policies at national level, i.e. welfare, health, and labour policies. These policies include unemployment benefits, pension insurance, sickness pay, and occupational health and safety measures, amongst others. A broad body of research demonstrates that distinct political systems tend to develop distinct welfare state regimes. For instance, in Scandinavian countries, a 'social democratic welfare state model' was identified, distinct from a 'conservative-corporatist' welfare regime that is more prevalent in continental west- European countries (e.g. France, Germany), and from a 'liberal' regime that dominates in the United Kingdom and the United States [15].

However, welfare regimes are also strongly influenced by economic developments (Pathway 3). For instance, a political context shaped by a neo-liberal economy that favours rapid expansion of trans-national trade, labour and capital markets is likely to limit social and welfare policies and to weaken the regulatory power of the state.

Figure 1. The conceptual framework: Employment and working conditions and health inequalities [13].



At several levels, a country's political system has direct impact on the national labour market, on the development of industries, on the qualification of workers or on the quality of working conditions (Pathway 4). The extension or reduction of the public employment sector, or the size of the national budget attributed to the labour sector, are examples of this impact.

It is obvious that macroeconomic developments act as major upstream factors on employment and working conditions and their effects on the health of working populations. This holds true for all European countries (Pathway 5). A similar argument concerns Pathway 6 that points to the effects of national labour and social policies on employment and working conditions. These macro-social policies favour or inhibit the development of organisational-level (micro-social) policies that influence the quality of work and employment at the local level, i.e. at the level of organisations, corporations, specific business sectors or specific occupational groups (Pathway 7). Despite their restricted impact, these micro-social policies contribute to the development of health-promoting work and employment (Pathway 8). In the long term, they may eventually produce significant positive effects on the quality of work and employment at national level through processes of diffusion of innovation.

As mentioned, some associations delineated in Figure 1 are bi-directional. Amongst others, this holds true for the relation between exposure to adverse employment and working conditions and vulnerability of the working persons (Pathway 9). On one hand, occupational hazards and stressors are handled differently by working people, depending on an individual's coping resources, capabilities and personal vulnerabilities. On the other hand, personal capabilities and vulnerabilities determine occupational trajectories and related exposures to hazards and stressors at work, acting as selection factors in this framework. For instance, unfavourable occupational trajectories are often triggered by adverse early life circumstances that transfer social inequalities in work-related health across generations. Similarly, bi-directional effects are observed between personal coping resources or vulnerability and health (Pathway 10). Strong socio-emotional support outside work or favourable personal resources, such as self-efficacy, optimism, and self-esteem, are examples of protective factors that can mitigate the effects of adverse exposures on health. Finally, poor health amongst working people can aggravate work and employment, and thus further increase social inequalities (Pathway 11).

By far the most important pathway in the context of WP3 of DRIVERS concerns the association of unequal exposure to adverse work and employment conditions with unequal health (Pathway A). With the first aim of our project, i.e. to establish an updated knowledge base on associations of work, social inequality and health, we address this topic. As was mentioned, we conducted systematic reviews of epidemiological studies that analysed associations of adverse work with health inequalities, and we performed secondary data analysis of selected cross-sectional and longitudinal studies on working conditions and health outcomes from different European countries.

With the second aim of our project, i.e. to synthesise current evidence on feasibility and outcomes of work and health-related interventions at different levels, we deal with Pathway B. Organisational-level interventions in enterprises and businesses aim at promoting the health of working people by improving working conditions as well as health-related behaviours, with the intention of reducing health inequalities. In our project we deal with this challenge by providing an updated review of findings derived from randomised controlled intervention studies that estimate effects on workers' health, and we evaluate the results of available organisation-level interventions.

Pathway C concerns the impact of distinct national labour and social policies on the quality of work and employment and, indirectly, on the health of working people. There is reason to believe that this pathway holds special promise in reducing health inequalities, although current scientific evidence is limited. With our project we provide new empirical support in favour of this core assumption underlying Pathway C.

In summary, the conceptual framework depicted in Figure 1 illustrates the complex web of causal pathways between work, employment and social inequalities in health. At the same time, it posits that three such pathways are of primary importance for research that aims to provide evidence for stakeholders who are responsible for developing and implementing respective policies (Pathways A, B, C). It is obviously not possible to test this complex model within the frame of a single empirical study or by a set of interrelated investigations. However, we maintain that at least one relevant conceptual and methodological challenge inherent in this approach can be resolved with the help of newly available empirical information. It concerns the demonstration of independent effects of proximal (individual life history) and distal (national labour and social policies) determinants of health-adverse working conditions, and specifically of stressful psychosocial work environments. The following paragraph summarises our main arguments, and Section 3.5 provides detailed empirical support in favour of these arguments.

We maintain that the strength and quality of a large part of the scientific evidence presented and discussed in this report justifies the development of distinct recommendations addressed to governments and other bodies responsible for the implementation of labour and social policies. To a lesser extent, we also included recommendations to practitioners and the scientific community.

1.2 Proximal and distal determinants of stressful work

In current research on work and social inequalities in health two shortcomings are obvious. First, with a few exceptions [16–20], research on this topic did not address the processes operating in individual workers before entering the labour market [21]. It is likely that exposure to stressful work later on results from distinct selection processes, specifically from those reflecting early disadvantage in childhood and adolescence. Working people who were deprived from those material and psychosocial resources during their childhood that are critical for successful cognitive, emotional, and social development of core capabilities and coping skills are less likely to successfully enter the labour market and to end up in occupational positions that are characterised by a high quality of work [22,23]. This early disadvantage in developing capabilities and skills required for successful careers is more prevalent in families with low socioeconomic status. Thus, differential socialisation and education provides a major pathway of transmission of social inequality of opportunities across generations. We integrate this aspect into our approach by focusing on a potential impact of social deprivation in early life – the quality of people’s achieved main job later on. We also maintain that the link between early life deprivation and poor quality of one’s main job is in part mediated by a disadvantaged access to the labour market.

A second shortcoming in current research on work and social inequalities in health concerns the lack of consideration of potential impact of more distal determinants of quality of work, specifically the impact of national labour and social policies that aim to reduce precarious and unhealthy employment and working conditions. Preliminary evidence indicates that the average level of stressful work among employees of a country is closely associated with the extent to which such policies are implemented. In particular, in countries with well-established active labour market policies lower average levels of stressful work were observed, compared to those in countries with less well developed policies [24,25]. These findings suggest that such distal contextual factors need to be taken into account in a comprehensive analysis of determinants of stressful work [26–28]. Among these contextual factors, two types of labour and social policies are of special interest – protective policies that offer social provision to deprived or disabled people through compensation, and integrative policies that promote return to work and maintenance of jobs [29]. Therefore, we integrate these distal determinants of stressful work into our approach by extending the analysis to cross-national comparative research. Variations in these national labour and social policies enable us to analyse whether and to what

extent these policies can protect workers from exposure to fierce market forces, thereby mitigating the severity of stress at work. We assume that in the absence of such protective and integrative policies vulnerable workers may suffer from further aggravation of their amount of work-related stress.

By including these proximal and distal determinants of quality of work and employment we may be able to assess the burden of stressful work in a more accurate way than was previously done. It should be emphasised that we are in a privileged position of testing such an extended framework with reference to a recently available data set from a large cross-national study, the Survey of Health, Ageing, and Retirement in Europe (SHARE) (see Methods section). This survey provides a detailed retrospective assessment of respondents' previous lives, thus extending the time window from participants' current situation and recent past to previous stages of their life course, including childhood conditions and information on entire employment histories. Moreover, as the survey was conducted in 13 European countries, ranging from Scandinavia to Mediterranean and Eastern European countries, we were able to collect comparative information on distinct indicators of labour and social policies, specifically the two indicators of integration and compensation policies constructed by OECD for each country under consideration, and to include this information in a multilevel analysis.

Taken together, the SHARE data set offers an opportunity to analyse the following three hypotheses. First, we assume a dose-response relationship between the degree of childhood adversity and the degree of stressful work experienced later on (hypothesis 1). Second, we assume that this association is partly mediated by a disadvantaged access to the labour market (hypothesis 2). Our third hypothesis relates to the contextual factors. Given the fact that SHARE provides data on national policies from 13 European countries, we test the assumption that the average level of stressful work among participants in a country is closely related to the extent to which protective and integrative policies are implemented at national level. Less developed policies go along with higher average levels of work-related stress (hypothesis 3). To our knowledge, this is a unique opportunity of testing a set of new hypotheses that broaden the conceptual framework of analysing associations of work and employment with unequal health. In Section 3.5 we provide empirical data on these hypotheses.

2. Methods

The research methods of Work Package 3 (WP3) of DRIVERS were selected in order to accomplish the three major aims mentioned in the Introduction. These methods correspond in general to:

1. Established research methodology of systematic reviews and meta-analysis in epidemiology (two systematic reviews [30,31] and one meta-analysis [32]).
2. Current methods of statistical analysis for cross-sectional and longitudinal data.

2.1 Methodology of systematic reviews

The systematic reviews and meta-analysis conducted in the WP3 of DRIVERS screened the following databases: ASSIA: Applied Social Sciences Index and Abstracts (SciVerse), Business Source Premier (EBSCO), Cochrane Central Register of Controlled Trials (CENTRAL), Econlit (EBSCO), PubMed (PMC), Scopus (SciVerse), Social Science Citation Index (Web of Knowledge), Sociological Abstracts (ProQuest), and WISO: Wirtschaftswissenschaften. The search was restricted to original papers in peer-reviewed international journals in English, German, French, and Dutch language,

published between January 1980 and December 2012. Therefore, neither conference papers nor government-commissioned reports were considered.

The systematic search in databases was amended by search in systematic reviews, meta-analyses, consulting of experts, and search in relevant websites. As a quality checklist for reporting the PRISMA statement was implemented in all three systematic reviews [33]. The evaluation of intervention effects in the meta-analysis was based on the GRADE approach for intervention studies in epidemiology and clinical trials [34]. In the narrative systematic review on organisational-level workplace interventions [31], a quality checklist based on quality criteria from the Cochrane Collaboration was adapted [35].

In general, the search strategy defined for the systematic review [31] and the meta-analysis [32] on workplace interventions had the following logical structure: Health outcomes AND Occupational characteristics AND Workplace interventions AND Time (January 1980 – December 2012). A complete list of the keywords and queries is reproduced in the Appendix 1 of [31].

2.2 Survey data

2.2.1 European Working Conditions Survey (EWCS)

The EWCS is a cross-sectional survey of workers in the European Union conducted every five years since 1990. The sampling scheme of the EWCS is a (multistage stratified) random sample of employees and self-employed people aged 15 and over whose usual place of residence is in one of the countries included in the survey and who were employed the week that preceded the beginning of the interview [36]. The survey consists of a standardised questionnaire focusing on the working conditions and health status of workers across Member States of the EU and some other countries such as Norway, Switzerland or Turkey [37]. The survey conveys information on major issues such as employment situation, the work environment and organisation, and the quality of work and employment.

Data from the EWCS was analysed in WP3 of DRIVERS mainly to estimate (1) the probability of reporting musculoskeletal symptoms given exposure levels to several work-related risks [38], (2) the prevalence of several health problems and exposure to work-related hazards across occupational groups (Section 3.1), (3) the wage differentials between occupational groups given exposure levels to work-related risks (Section 3.2.3), and (4) the prevalence of musculoskeletal problems, stress levels and days absent from work (Chapter 4).

2.2.2 Survey on Health, Ageing and Retirement in Europe (SHARE)

SHARE is the first cross-national research project comparing data on health, quality of life, socioeconomic and social conditions among older people (50 plus) in European countries with a longitudinal perspective [39]. We used data from four waves collected in 2004-2005 (first wave; 11 countries), 2006-2007 (second wave; 14 countries), in 2008-2009 (SHARELIFE; third wave; 14 countries), and 2010-2011 (fourth wave; 16 countries). Data collection is based on probability household samples using Computer Assisted Personal Interviews (CAPI). The third wave (termed SHARELIFE) is a separate retrospective survey collecting details on participants' life course. It includes details on previous working careers and childhood conditions [40]. Retrospective data are collected with the life-grid approach, where recall and timing of major information is supported by a graphical representation of the respondent's life which is filled during the interview. Despite obvious limitations, this retrospective assessment offers several advantages. First, it represents an economic way of collecting longitudinal information. Second, it guarantees comparable information referring to different time points in respondents' lives. Furthermore, validation studies revealed high accuracy of

recalled information, in particular when asking about socio-demographic conditions [41,42] and employment histories [43,44]. SHARELIFE data was used in the research work of WP3 to study the associations between disadvantaged work in mid-life and mental health in older age (Section 3.2.2) and the investigation of proximal and distal determinants of stressful work (Section 3.5.1). Several studies within this report are based on SHARE data from different waves, this includes a study on associations between work stress and mental health (Section 3.3.3), an investigation of mediation effects of the association between occupational position and mental health (Section 3.4.2), and the impact of national labour and social policies on work and mental health (Section 3.5.2 and 3.5.3).

2.3 Methods of statistical analysis of survey data

2.3.1 Multilevel analyses

Multilevel regression analyses (also known as mixed models or random-effects models) are appropriate regression models for data involving some form of clustering (e.g. repeated measurements, spatial and/or geographical clustering, persons within the same household, etc.) since they take into account interdependencies of single observations in order to obtain unbiased variance estimators [45,46]. In the research papers conducted within WP3 of DRIVERS all multilevel analyses defined country as a clustering variable for the estimation of random-effects intercepts [47–49,21,38]. In addition, regression analyses of the EWCS datasets included regional clustering and random slopes for selected macroeconomic indicators (see [38], the regression analyses on wage differentials in Section 3.2.3 and Figure 24).

2.3.2 Pathway analyses

To study causal pathways, more specifically the interrelated structure of the association between occupational position, work stress and mental health, pathway analyses are conducted in Section 3.4.2. This enables us to investigate if the social gradient of mental health can partly be explained by psychosocial work stress. Pathway models rather than ordinary regression analyses allow us to separate and quantify direct and indirect effects and, importantly, to estimate linear and probit regression models simultaneously.

Part II. Results

3. The social gradient of unfair employment and health

3.1 Physical, chemical and biological hazards

In spite of significant advances in occupational health and industrial hygiene practices in Europe during the last decades of the 20th century, physical, chemical and biological work-related hazards still account for a considerable proportion of work-related diseases and fatalities [50–52]. The adverse health effects associated with continuous exposure to those hazards may result in serious outcomes such as cancers, allergies, lower fecundability, genetic damage in the offspring, infectious diseases and musculoskeletal disorders. Even though our knowledge on the causal pathways leading from exposure to disease has expanded substantially in the last decades, there are still several challenges concerning occupational health and safety. (1) Chemical substances are ubiquitous; they are used in a huge variety of production processes and industrial sectors thereby increasing the number of workers exposed and the duration of exposure. (2) The increasing number of substances registered under the REACH legislation (about 12,185 in July 2014), the costs of adequate toxicological testing of 30,000 commonly used chemicals (circa 9.5 billion EUR and 54 million vertebrate animals [53]), and the potential health effects of their combination. (3) The deficient compliance of enterprises and inadequate knowledge of toxicological effects of substances utilised in the work tasks [50]. (4) The persistence of substantial exposure to biomechanical and physical risk factors leading to the onset of musculoskeletal disorders [38].

From the results of several epidemiological studies it has been recognised that the burden of exposure, however, and the corresponding incidence and prevalence rates of adverse health outcomes such as cancer, asthma and musculoskeletal disorders, are unequally distributed across occupational groups [54–56,52,57]. In the context of the health inequalities mentioned in the Introduction section, a work environment involving higher exposure to physical, chemical and biological hazards is an important contributor to the development of unequal health. In so far as it is legally prescribed that the work environment should be designed in accordance with the principles of disease prevention and available scientific knowledge (Directive 89/391/1989), it is implied at the same time that there is urgent need of updating the assessment of exposures to known occupational hazards, evaluating the potential health risks of common and new economic activities, and to consider the intervention strategies for reducing the intensity and duration of exposure for the different occupational groups.

In WP3 of DRIVERS we contributed to some extent to the accomplishment of these tasks by providing two scientific papers on (1) the distribution of specific chemical and biological risks across occupations, (2) their health effects on workers, (3) some common economic activities where these hazards are utilised, (4) some data on societal costs of the corresponding work-related adverse health outcomes, (paper 1), and (5) a cross-sectional study on the risk factors associated with upper and lower limb musculoskeletal symptoms across occupations (paper 2). Taking the International Standard Classification of Occupations 2008 (ISCO-08 and ISCO-88 for data collected before 2008) as a basic classification scheme, we aimed to capture the distribution of exposures to known physical, chemical and biological hazards across occupations. This was done by identifying the economic activities and corresponding major occupational groups that may be associated with a higher risk of exposure to carcinogens, sensitisers, mutagens, reprotoxic substances, biological hazards and biomechanical/physical hazards (see scientific papers [58,38] for methodological details). An overview of the results of this research is summarised briefly in the next sections. The classification of occupations corresponds to the following major categories: ISCO 1: managers, ISCO 2: professionals, ISCO 3: technicians and associate professionals, ISCO 4: clerical support workers,

ISCO 5: service and sale workers, ISCO 6: skilled agricultural, forestry and fishery workers, ISCO 7: craft and related trade workers, ISCO 8: plant and machine operators and assemblers, ISCO 9: elementary occupations (see Section 3.3.2 for details).

3.1.1 Carcinogens

Taking into account carcinogens of group 1 of the IARC classification only, 42 chemical substances can be identified for which there is sufficient evidence of causality between exposure and cancer. The most frequent cancer sites associated with exposure to these substances are lung (19 substances), bladder (12 substances), scrotum (4 substances), paranasal sinuses (3 substances), and skin (3 substances). The economic activities in which exposure to carcinogens occur are highly diverse and include (i) manufacture of rubber, plastics, dyes, steel, inks, textiles, paper and batteries, semiconductors, glass, and cement, (ii) construction activities such as building demolition, roofing, painting, and stonework, (iii) such processes or work tasks involving incomplete combustion of organic material such as coal gasification, coke production, and diesel exhaust, and (iv) mining activities involving nickel, lignite and haematite mining. As a consequence, exposures are concentrated in the ISCO groups associated with tasks usually performed in the craft, manufacturing, construction and mining sectors (see Table 1).

Even though economic analyses of the societal costs of work-related cancer in Europe are limited, Binazzi and colleagues [59] estimated the annual burden of occupational cancer in Italy for the year 2006 to lie between 8,000 and 8,500 deaths. The corresponding direct costs (i.e. treatment costs) of occupational cancer have been estimated at 456 million EUR or about 57,000 EUR per case. Indirect costs resulting from the potential years of working life lost (PYWLL) ranged between 320 and 590 million EUR. In Spain, 9,469 work-related cancer deaths were estimated for the year 2004. Indirect costs from PYWLL may lie between 34,000 and 62,000 EUR per case based on the overall estimates for occupational diseases [60].

3.1.2 Sensitising substances

Sensitising substances refer to those substances (or agents) capable of inducing an immunological response to an otherwise innocuous agent [61]. Some associated adverse effects include asthma, allergic or irritant contact dermatitis, and atopy. Depending on the tissues and / or body structures affected, two major groups of sensitising substances are usually identified: skin and airway sensitisers. Based on toxicological evidence a total of 143 skin and airway sensitisers have been identified which are commonly used in (i) the rubber industry as antioxidants, accelerators, and vulcanization agents, (ii) the production of dyes, epoxy resins, textiles and paints, (iii) the cosmetic, food and pharmaceutical industry, and (iv) the production of herbicides, fungicides and other pesticides. The burden of exposure, however, is greater for technicians and operators (ISCO 3 and 8), agricultural and service workers (ISCO 5 and 6).

Regarding the societal costs of occupational skin diseases related to exposure to skin sensitisers, in 2013 the direct and indirect costs of occupational hand eczema in Germany per worker diagnosed and treated were on average 2,646 EUR (95% CI 2,265–3,027 EUR) and 6,152 EUR (95% CI 4,508–7,797 EUR), respectively [62]. In Italy, the societal costs of severe chronic hand eczema refractory to standard therapy amounted in average to 5,016 EUR per person-year (min. 411 EUR, max. 27,648 EUR) [63]. Additional costs may also occur in cases of occupational retraining, job change, or adverse psychosocial effects [64].

Table 1. Number of chemical and biological hazards to which workers may be exposed in each major ISCO occupational group. NA: Not available. Source [58].

Hazard type	ISCO 0	ISCO 1	ISCO 2	ISCO 3	ISCO 4	ISCO 5	ISCO 6	ISCO 7	ISCO 8	ISCO 9	Industrial uses or work settings	Some implied costs
Carcinogens	NA	7	16	106	1	21	10	106	37	8	Manufacture of rubber, plastics, dyes, steel, inks, textiles, paper and batteries, semiconductors, glass, and cement, in construction activities such as building demolition, roofing, painting, and stonework, in such processes or work tasks involving incomplete combustion of organic material, and mining activities involving nickel, lignite and haematite mining.	Annual societal costs of occupational cancer: 126000 EUR per case
Skin sensitisers	7	16	106	1	21	21	10	106	11	11	In the rubber industry as antioxidants, accelerators, and vulcanization agents, in the production of dyes, epoxy resins, textiles, paints, cosmetics, foods; in the pharmaceutical industry, and the production of pesticides.	Annual societal costs of hand eczema: 8798 EUR per case
Airway sensitisers	NA	2	14	NA	NA	8	2	15	1	1	Production of plastics, paper, resins, textiles, cosmetics, dyes, and in the metallurgic and food industry	Annual societal costs of occupational asthma: 2900 EUR per case
Mutagenic (category 2)	NA	NA	5	NA	NA	1	NA	5	1	1	Production of plastics, textile fibres; as additives and intermediates	Societal costs associated with heritable diseases
Toxic for fertility	1	1	1	10	NA	1	2	3	11	3	Production of plastics, inks, textiles, pigments, adhesives; as intermediates and solvents	Societal costs of reduced fertility
Toxic for development	1	1	1	31	NA	3	9	10	32	17	Production of adhesives, textiles, dyes, insecticides, lubricants, varnishes, cutting fluids, cements, cellulose; in the rubber and plastics industry; as solvents	Societal costs of congenital malformations
Biological	1	23	21	21	NA	18	20	10	4	17	Healthcare, biotechnology, agriculture, forestry, outdoor tasks, military	Societal costs of several infectious diseases
Total hazards	10	50	210	1	47	66	41	210	58	693		

The societal costs of occupational asthma, one of the most frequent occupational diseases in Europe, have been estimated for the United Kingdom from data of the Survey of Work-related and Occupational Respiratory Disease (SWORD). The average direct costs per annum per case range from £530 to £715, whereas the indirect costs range from £1,525 to £1,685. The total present value costs of an average case to society lies between £120,000 and £130,000 per annum [65].

3.1.3 Mutagenic and reprotoxic substances

Mutagenic substances refer to substances giving rise to an enhanced occurrence of genetic mutations that may be transmitted to the offspring. Reprotoxic substances refer to substances with toxic effects on reproduction. For lead and second-hand tobacco smoke there is consistent evidence of increased risk of adverse pregnancy outcomes such as preterm birth and low birth weight [66–68]. Although decisive evidence of the existence of mutagens is still lacking, some substances such as cadmium, nickel, olaquinox and trymethyl phosphate have been suspected of eliciting heritable mutations [58,69]. Estimates of the association between occupational exposure to pesticides and fecundability among fruit and greenhouse workers resulted in a substantial reduction of fecundability, especially when considering studies with improved assessment of occupational pesticide exposure [70]. Concerning genotoxic effects of pesticides in germ cells, two meta-analyses confirmed an excess risk of childhood leukaemia and lymphoma for maternal exposure to pesticides [71,72]. The most common industrial uses of mutagenic and reprotoxic substances are related to the manufacture and/or use of adhesives, resins, additives, coatings, pigments, inks, polymers, papers, organic solvents, pesticides and woods and textiles. The occupational groups that may be at risk of increased exposure are technicians (ISCO 3), operators (ISCO 8), skilled agricultural workers (ISCO 6), workers in elementary occupations (ISCO 9) and professionals (ISCO 2).

3.1.4 Pathogens

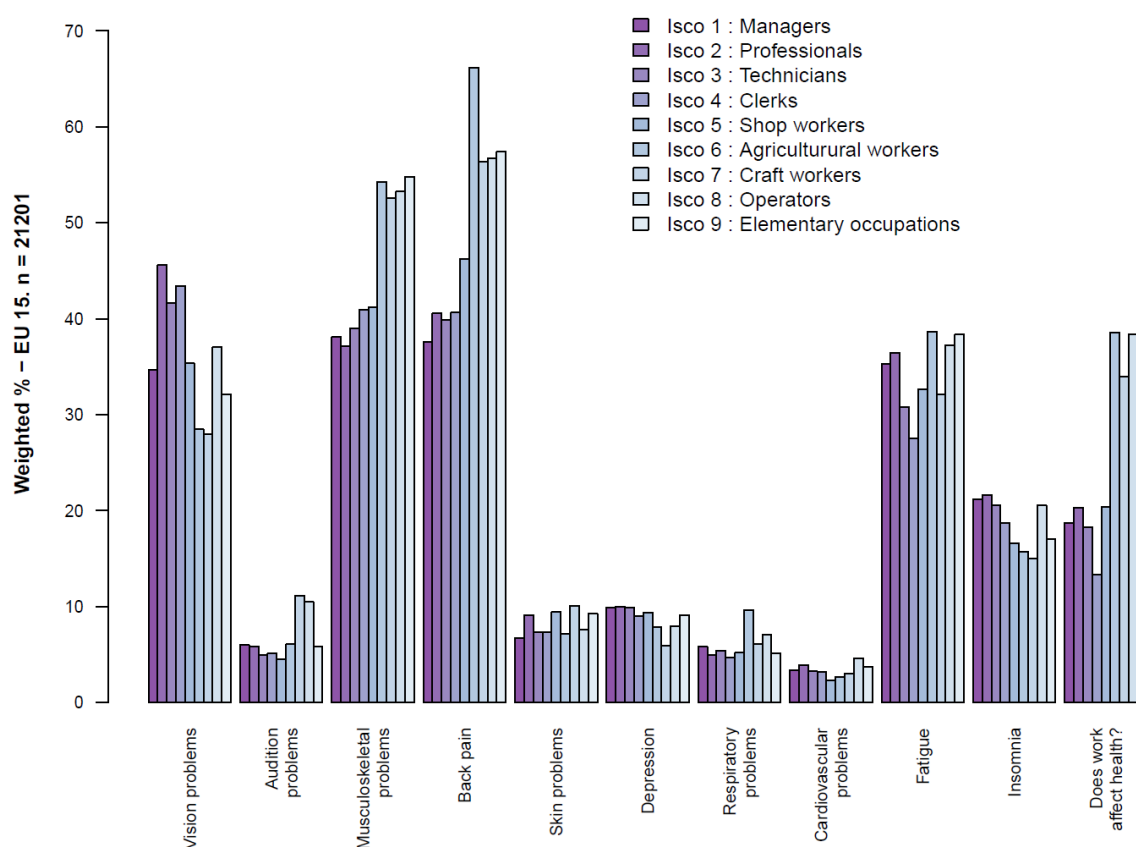
According to Directive 2000/54/EC on the protection of workers from risks related to exposures to biological agents at work, biological agents include only cellular or non-cellular microbiological entities capable of replication and of provoking infection or other diseases. From an occupational health perspective at least 50 pathogens have been identified that not only can cause disease, but also represent a serious hazard to workers (pathogens in group 2 and 3 of the Directive 2000/54/EC). The distribution of biological hazards across occupational groups differs largely from the distribution of allergens, carcinogens, mutagens and reprotoxic substances discussed previously (see Table 1). Professionals (ISCO 2) and technicians (ISCO 3), especially in the healthcare and biotechnology sector (physicians, nurses, dentists, medical residents, microbiologists, medical technicians), are exposed to at least 23 and 20 pathogens respectively. Skilled agricultural workers (ISCO 6), service workers (ISCO 5), and workers in elementary occupations (ISCO 9) follow with exposure to at least 19, 18, and 16 pathogens respectively.

The high concentration of biological hazards in the healthcare and biotechnology sectors and agriculture are related principally to the nature of work tasks (e.g. patient care, outdoor work, biotechnology), the environmental and the social context in which work is performed (e.g. hospitals, forests, laboratories), and several characteristics of biological agents such as the routes of exposure, the pathogenicity, the mechanisms of transmission (e.g. oral, percutaneous, stings), the mechanisms of dissemination (e.g. water, soil, air), the natural habitat of the biological agents, the particular characteristics of pathogen hosts and/or pathogen vectors and the clinical picture of the disease [58]. The adverse health outcomes associated with exposure to pathogens are widely varied and include viral diseases such as hepatitis B, C, influenza and HIV, bacterial infections such as tuberculosis, Lyme disease and Q fever, parasitic infections and allergenic reactions.

3.1.5 Biomechanical / physical factors and musculoskeletal disorders

Biomechanical and physical risk factors play a decisive role in the incidence of musculoskeletal disorders (MSD). Even though these group of diseases have a multifactorial aetiology (i.e. there are several causes leading to the onset of disease), an extensive body of knowledge has provided evidence of an excess risk of MSD after exposure to a variety of factors such as repetitive movements, high-force demands, awkward or extreme positions, rapid work pace, extreme temperature, insufficient recovery time, mechanical pressures and segmental or whole body vibrations [73–75]. Musculoskeletal disorders are the second most frequent medical cause underlying disability benefit claims in OECD countries [76], and the most frequent occupational disease in Europe [52]. Moreover, as reported in Figure 2 with data from the European Working Conditions Survey (EWCS) 2010, the prevalence of self-reported health problems in the former EU-15 countries is highest for musculoskeletal symptoms including back pain.

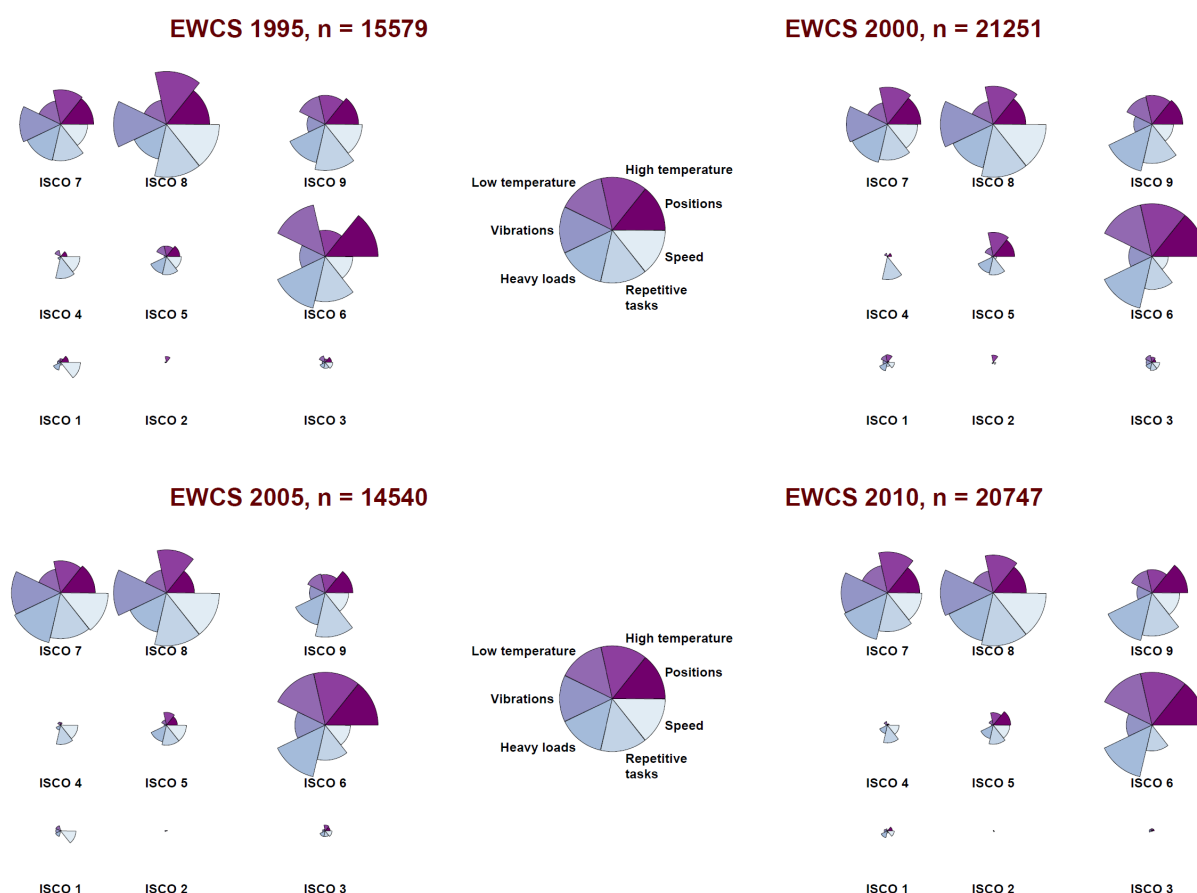
Figure 2. Prevalence of self-reported health problems among workers in the EU-15. EWCS 2010. Weighted proportions.



Some analyses of survey data have suggested that the risk factors of MSD are unequally distributed across occupational groups and concentrate among service and sales workers (ISCO 5), elementary occupations (ISCO 9), plant and machine operators (ISCO 8) and skilled agricultural workers (ISCO 6) [52,38,77]. Using data from EWCS waves 1995 to 2010 it is possible to estimate the self-reported exposure prevalence for several risk factors across occupational groups, and the resulting unequal distribution of risks. To this end, we estimated the relative magnitude of the proportion of workers exposed “All the time” and “Almost all the time” to the following biomechanical/physical risks: too high or too low temperatures, painful positions, working at high speed, repetitive hand or arm movements, carrying heavy loads and vibrations from machinery or other sources [38]. Figure 3 depicts as a polar plot the relative proportion of workers exposed to the corresponding risk factors across major ISCO-88 groups. The bigger the proportion of workers exposed frequently to a certain risk factor for a given

occupational group in comparison with the other ISCO groups, the bigger is the area of the corresponding circle segments. A visual inspection of Figure 3 shows that workers in ISCO groups 6, 7, 8 and 9 report the highest frequency of exposure to tiring positions, extreme temperatures, carrying or moving heavy loads, working at very high speed, and repetitive tasks. Service workers in ISCO group 5 report being exposed very frequently to tiring positions and carrying heavy loads. In contrast with this concentration of exposures among workers in ISCO groups 6 to 9, the burden of exposure of managers, professionals, technicians and clerks (ISCO groups 1, 2 and 3) is substantially lower. Moreover, a comparison of results across EWCS waves shows that the distribution of frequent exposures has remained largely stable.

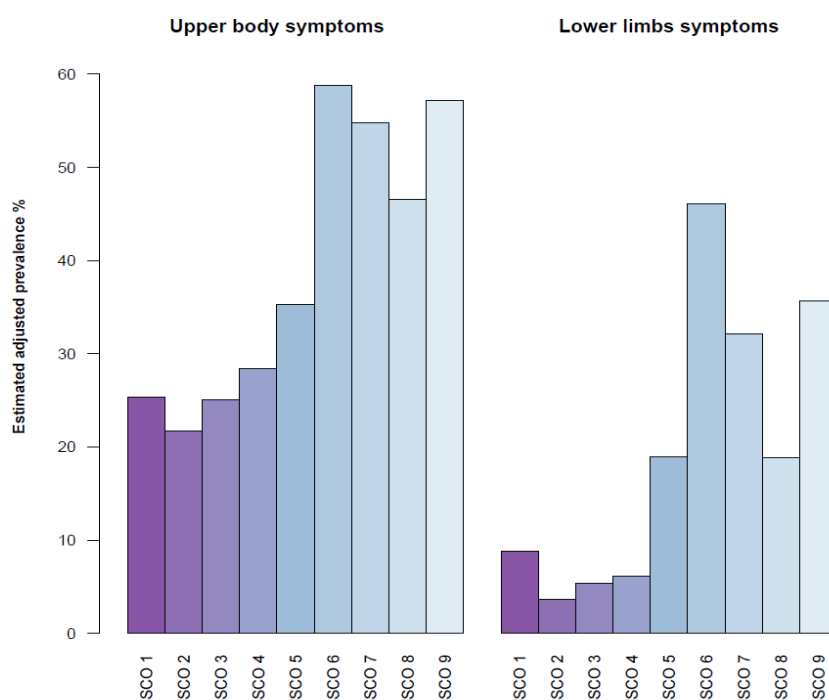
Figure 3. Polar plots representing the relative proportion of workers reporting very frequent exposure to physical risk factors by ISCO-88 occupational groups in the former EU-countries [38].



Taking into account that (1) a higher frequency of exposure to risk factors increases the probability of experiencing musculoskeletal symptoms (or disorders), and (2) these risk factors are highly concentrated among certain occupations, it is to be expected that the prevalence of musculoskeletal symptoms should reflect the distribution of exposures observed in Figure 3. In fact, it is expected that the occupation-specific prevalence rates depicted in Figure 2 should be consistent even after controlling for several other characteristics of the workers, the companies and other relevant confounders. Based on the models and methods described elsewhere [38], the probability of reporting musculoskeletal symptoms across occupational groups was predicted from the EWCS 2010 after adjusting for the risk factors mentioned above, several other confounders and national and regional differences. The results summarised in Figure 4 suggest that even after accounting for several known risk factors, confounding factors and national and regional differences, there are still huge differences in the prevalence rates across occupations. Since the predicted prevalence rates reflect systematic

factors determining the occurrence of symptoms, these estimates should encourage the development of intervention programmes targeting workers at high risk of MSD.

Figure 4. Predicted prevalence rates of upper body and lower limbs symptoms by ISCO-88 occupational groups from the EWCS 2010. Adjusted for several biomechanical / physical risk factors, age, company size and several other confounders. For details see [38].



3.2 Precarious work, unemployment and wage inequalities

3.2.1 Background

Participation in, or exclusion from the labour market determines a wide range of life chances including health and wellbeing that are mainly mediated through regular wages and salaries. Adverse effects on health produced by the exclusion from work and employment are most visible amongst those who experience long-term unemployment. The prevalence of unemployment is unequally distributed across society, with those in lower socio-economic positions at higher risk. This fact contributes to the manifestation of social inequalities in health. The evidence linking unemployment with elevated morbidity and mortality risk is impressive despite methodological challenges of disentangling selection effects from causation effects. As this topic was not covered in a systematic way by our research we refer readers to recent literature reviews [78–80]. Results of these studies indicate elevated risks of cardiovascular morbidity and mortality, depression, suicide, and injury among formerly employed people exposed to long-term unemployment, compared to those in continued employment. In addition, critically high levels of health adverse behaviours were reported. High levels of unemployment are particularly worrying among young adults in south European countries, resulting in part from the recent financial crisis. Although the burden of disease attributable to youth unemployment is at the moment not clearly visible, these chronic stressors exert strong impacts on young people's life chances and quality of life [81].

As there is no clear-cut dichotomy between continued employment and long-term unemployment, many employment conditions are defined by 'atypical work'. This umbrella term includes several types of less stable, less regular employment, such as temporary work, informal work, and precarious work characterised by high instability, exposure to downsizing, merging and outsourcing, and occupational careers with recurrent periods of redundancy. A vast amount of literature has demonstrated health-adverse effects of job instability and job insecurity [82,83] as well as downsizing [84]. Health-adverse effects of job insecurity were also studied as part of theoretical models of work stress, in particular the effort-reward imbalance model (see below 3.3).

Again, atypical and precarious work is much more common amongst adult populations with low skill level and low educational degree. Socioeconomic and socio-cultural deprivation during childhood and adolescence often triggers disadvantaged labour market trajectories, with negative long-term effects on health and wellbeing. Findings from birth cohort studies underline these long-term effects in convincing ways [85]. As documented in the previous section unskilled or semi-skilled workers and employees in low occupational positions are more often confined to jobs with physical, chemical or biological hazards or heavy workload compared to those with more qualifications. Thus, we observe a social gradient of cumulative disadvantage of the quality of work and employment.

This cumulative disadvantage can be traced through the employment trajectories of working people, e.g. by applying job exposure matrices to distinct occupational cohorts or by collecting retrospective data from older people's occupational history over their life course. Either approach contributes important information on health effects attributable to such cumulative exposure and, thus, adds to a still modest evidence base of the impact of adverse work and employment conditions in early adult and mid-life on variations in physical and mental health in older ages. To shed some light on this latter aspect, we conducted secondary data analyses using the second approach, retrospective life history data, in the frame of the SHARE survey. Main results from these analyses are reported in the next section.

3.2.2 Disadvantaged work in mid-life and mental health in older ages

We used data from the Survey of Health, Ageing and Retirement in Europe (SHARE) collected in 2006-2007 (second wave) and in 2008-2009 (SHARELIFE; third wave) (for a short sample description see Methods). By combining these two waves of SHARE we were in a position to analyse associations of working conditions at previous stages of respondents' life course (assessed retrospectively) with their current health status (at the age of interview, at least 60 years or older). In this case, the sample of our analyses was restricted to those who already left the labour market at age 60 or older (at wave 2, the time when their mental health status was assessed). Moreover, in order to be included in this sample, participants had to report a substantial period of employment during mid-life and had to be free from long-term sickness absence during their working life. These restrictions resulted in a final sample of 4,822 men and 3,787 women recruited from 13 European countries [47].

As a theoretical background to these analyses we focused on work-related experiences in mid-life, as this stage – covering a period from about 40 to about 55 years – is considered a time when core social roles in adult life are acquired and executed, thus influencing quality of life and related opportunities in current and later stages of the life course. In addition to material working conditions health-conducive psychosocial work environments during mid-life are important as well. These environments can be analysed with the help of distinct stress-theoretical models. Two such models are of particular significance in this respect, demand-control and effort-reward imbalance. While they are described in more detail below (Section 3.3.1), we briefly explain their main characteristics here.

The demand-control model posits that jobs with high psychological demands and low level of autonomy or control are stressful and adversely affect health [11]. Several studies document that low

control is a stronger predictor of poor health than high demands, justifying its use as a main explanatory construct in our analyses [86]. As a complementary model, effort-reward imbalance addresses the work contract and the principle of social reciprocity lying at its core [12]. Rewards received in return to efforts spent at work include money, esteem, and career opportunities (job promotion and job security). The model proposes that the frustration of legitimate rewards generates psychobiological stress responses with adverse long-term effects on health. Both models cover different, but equally relevant aspects of the workplace, where lack of control and lack of reward matter most. In this study we extend these stress-theoretical notions by delineating mid-life working conditions that prevent the continued experience of control and reward, especially by identifying trajectories defined by blocked careers (failure of promotion and related relative deprivation) or by involuntary job loss and marked job instability (threats to acquired social status).

We tested the hypothesis that extended experience of low control and low reward at work during mid-life is associated with an elevated risk of poor mental health at time of retirement (respondents' age at wave 2 of SHARE), and we assessed poor mental health by measuring the presence and intensity of depressive symptoms (using validated cut-points of the EURO-D depression scale (for details and the following results see [47])). This hypothesis was confirmed in bivariate analyses indicating a higher prevalence of depressive symptoms among those with low control and low reward, those who were locked in occupational positions without career prospects, and those who had been laid off during mid-life. As exemplified in Figure 5, findings were confirmed at the level of countries, using low reward at work as an indicator for men and women. Importantly, low reward was measured by two 4-point Likert scaled items, one assessing the recognition deserved was received and the remaining one assessing whether the salary was adequate, considering all efforts and achievements. The bivariate findings were further substantiated by multivariate analyses applying multilevel models, taking important confounders into account (for detailed results see [47]).

Figure 5. Frequencies of increased depressive symptoms after labour market exit according to low reward (No/Yes) during mid-life across SHARE countries (N = 8609). Source: [47].



3.2.3 Wage inequalities in the European Union

The microeconomics of wage setting processes: new insights

The empirical analysis of price-setting behaviour of firms in Europe has revealed important insights into the microeconomic foundations of wage-setting processes. Some of the major findings from this body of evidence pose several challenges to macroeconomic and labour market policy. First, goods and service markets are best described as monopolistic competitive [87], i.e. the usual assumption of perfect competition does not coincide with real price-setting behaviour. The majority of firms set their price as a profit margin (i.e. a mark-up over marginal costs). In the context of wage setting, this monopolistic competitiveness may have a substantial impact on average wage levels by enhancing some form of monopsony power of enterprises, i.e. the number of firms demanding workers are very few (monopsony) so that employers may have such a negotiating advantage over job seekers that wage levels may fall far below their marginal revenue product [88]. Econometric analyses have not only confirmed a high level of monopsony power of employers in Western labour markets (wage markdown range of about 20% to 80% from the expected value under perfect competition), but also a statistically significant positive association between unemployment rates, monopsony power and lower wages [89,90].

Second, enterprises in the euro area are much more inclined to increase their prices in response to shocks leading to profit losses (e.g. rising costs of materials and labour) than to shocks leading to profit gains (e.g. decreasing labour and financial costs) [87,91]. This proclivity of enterprises to increase prices in reaction to increases in fixed and variable costs is actually reflecting their mark-up strategy and the fact that profit rates are being determined *ex ante*. At the macroeconomic level this

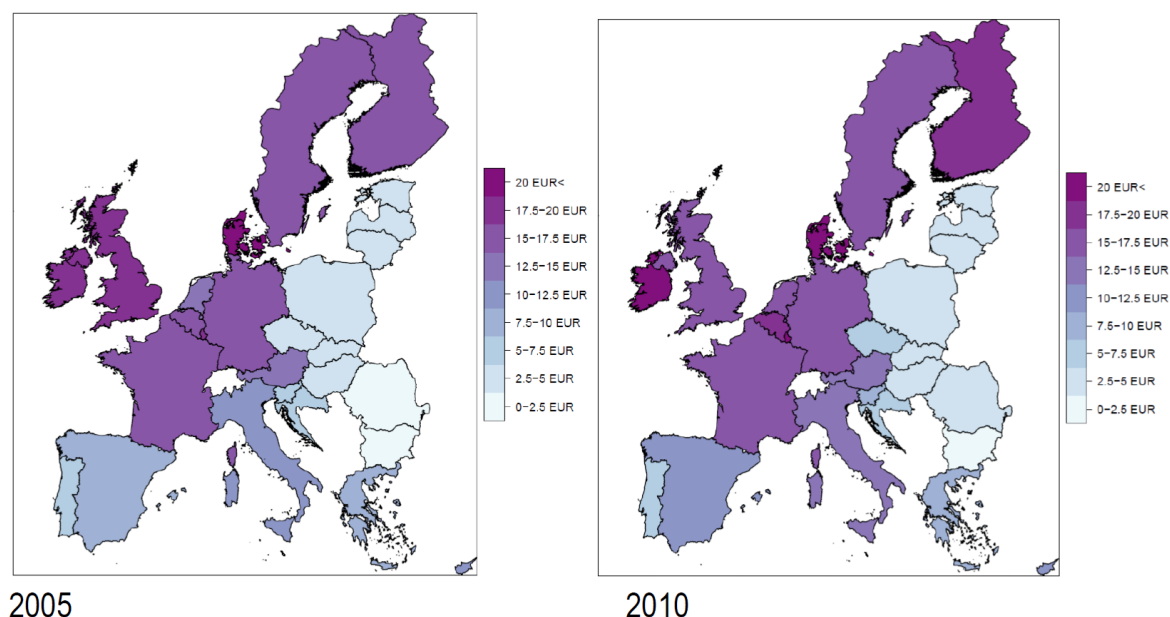
implies that on average firms are expected to neutralise wage rises by inflating their prices and/or squeezing the wage share [92]. Third, wages are less frequently changed than prices in European firms. About one-third of firms only report having an internal policy adapting wages to inflation [93]. Hence, since wages are actually 'stickier' than prices, the effects of reductions in real consumption wages may endure for several years affecting above all workers in low-wage economic sectors. Fourth, given that variable wage components constitute an important part of the overall labour cost bill, European firms have a relatively large spectrum of strategies for adjusting non-wage labour costs [94]. Hence, the assumed negative effect of downward wage rigidity and minimum base wage levels has likely been overestimated in traditional labour market policies and theories. Fifth, the internal wage structure of enterprises determines to a large extent the wage level of newly hired workers more than external labour market conditions in several European countries [95]. Some causes leading to the preponderance of internal wage structure are the proportion of workers covered by a collective wage agreement, fairness arguments, and expected negative effects of wage differentiation on morale and effort of incumbent workers [95].

Comparative regional and national inequalities

The microeconomic foundations of wage-setting processes are essential components for improving our understanding of the mechanisms leading to wage inequalities. Even though several factors such as human capital, productivity and technology conditions of single economic sectors in the EU countries, expected and realised profit rates, marginal product and revenue rates and industrial innovation, shape to a large extent the absolute, relative and average wage levels, the persistence of large wage inequalities between and within EU countries poses a serious challenge to future social policy. The fact that average real wages have declined in 21 Member States [96] may have serious negative consequences for the living and health conditions above all for workers in low-wage economic sectors.

To begin with, it is clear that there are large inequalities of average wage levels between Member States (see Figure 6). These differences are somewhat constant over time in spite of nominal wage increases [96], and are in part explained by wage rigidities, several institutional characteristics of European labour markets, and productivity differences between Member States. The distribution pattern of wages in Figure 6 reveals large wage differentials between EU countries. At least three major groups can be identified: (1) high-wage countries (e.g. Scandinavian countries, the UK, France, Germany, Belgium and the Netherlands), (2) medium-wage countries (e.g. Spain, Portugal, Italy), and low-wage countries (e.g. Bulgaria, Romania, Poland and the Baltic States).

Figure 6. Mean hourly wages from data of enterprises with 10 employees or more in the EU-28 countries. Averages estimated from regional data by NUTS 1 regions where available. Source: Eurostat, earnings tables, variables: earn_ses06_rhr and earn_ses10_rhr.

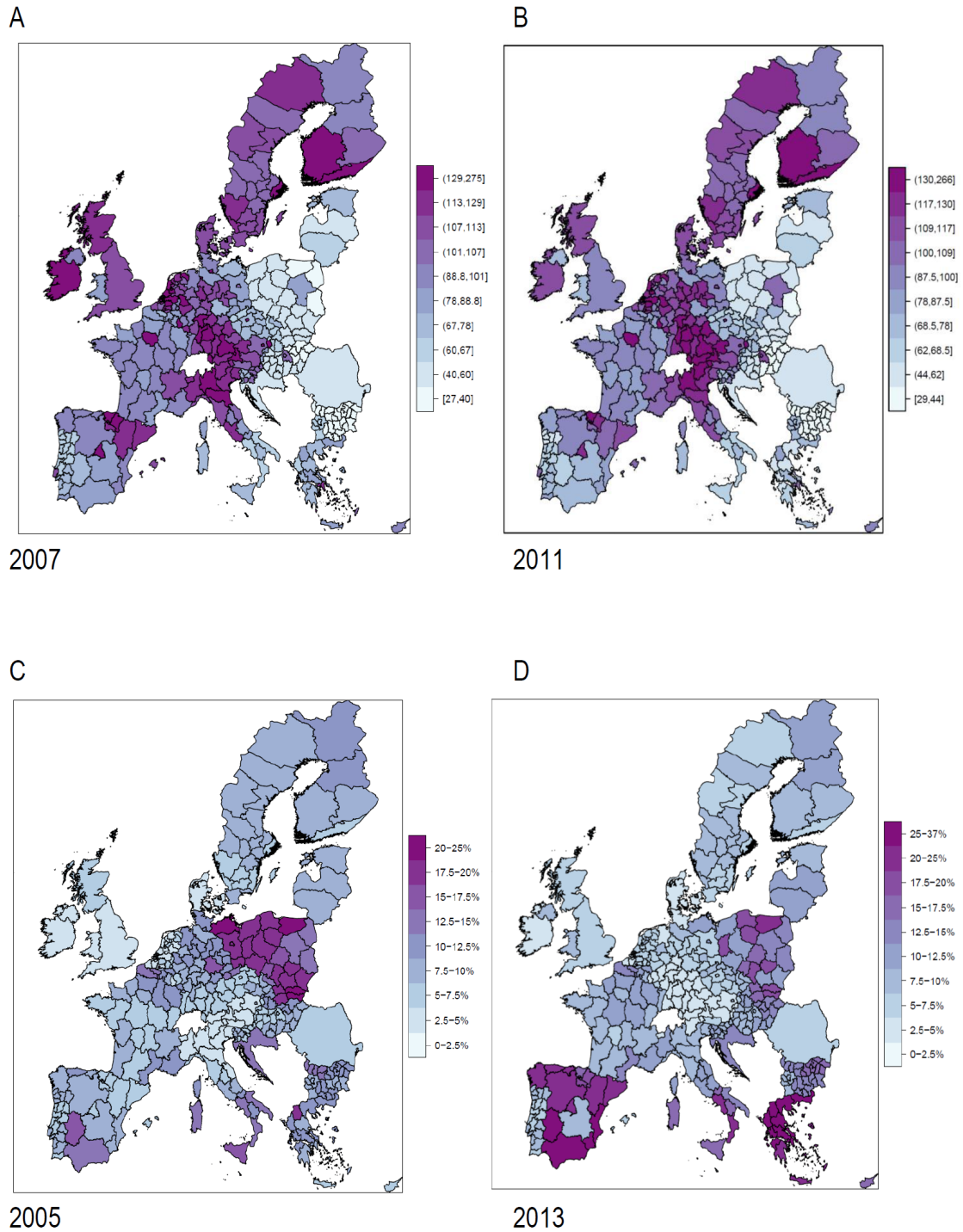


Moreover, further analysis of labour market and macroeconomic indicators at the regional level indicate that these cross-country wage differentials are embedded in complex structural conditions. In Figure 7 these associations are analysed in some detail. In panels A and B the deciles of the regional Purchasing Power Standard (PPS) per inhabitant in percentage of the EU average in 2007 and 2011 are depicted (EU average = 100). In general, regions with high PPS values correspond roughly to high and medium-wage countries in middle Europe, Scandinavia and north European islands. Within countries, however, the distribution pattern of PPS seems to be mirrored rather by the regional unemployment rates depicted in panels C and D in Figure 7. Hence, regions with high unemployment rates are associated with lower PPS and tend to be concentrated in low-wage countries. The magnitude of these associations can be further estimated by the Pearson correlation coefficients of the selected variables depicted in Figure 6 and Figure 7 (see Table 2 **Table 2**).

Table 2. Pearson correlations of unemployment rates, PPS and mean hourly wages in the EU-28 countries. Correlations of wages and regional data were calculated by estimating country averages of unemployment rates and PPS values. Source: Eurostat: earnings tables, variables: earn_ses06_rhr and earn_ses10_rhr; labour market tables, variable: une_rt_a.

	Regional data			National data	
	Unemployment 2005	Unemployment 2013	PPS 2007	Wages 2005	Wages 2010
Unemployment 2005				-0.49	-0.49
Unemployment 2013	0.48			-0.40	-0.43
PPS 2007	-0.44	-0.37		0.73	0.75
PPS 2011	-0.39	-0.43	0.98	0.70	0.73

Figure 7. Panels A and B: regional Purchasing Power Standard (PPS) per inhabitant in percentage of the EU-28 average, EU average = 100. Source: Eurostat, national accounts tables, variable: nama_r_e2gdp. Panels C and D: regional unemployment rates 2005 and 2013 in the EU-28 countries. Unemployed persons comprise all persons 15 to 74 years of age who were not employed during the reference week, had actively sought work during the past four weeks and were ready to begin working immediately or within two weeks. The unemployment rate is the number of people unemployed as a percentage of the labour force. Source: Eurostat, labour market tables, variable: une_rt_a.



Since the PPS values are expressed as price adjusted percentages of the EU average, the positive correlations between PPS and mean hourly wages imply larger real wage levels. Furthermore, the magnitude and direction of the correlations point to the dependency noticed already by Keynes between the volume of employment, aggregate income (here in terms of PPS) and wage levels for a given productivity and technology level ([97], chapter 3).

Occupational wage inequalities: empirical evidence

Since goods and services markets are actually characterised by imperfect competition, employers are to a large extent able to define and apply independently their own internal pay structure (see above). Given that different types of labour, skills and production processes yield different output levels, employers have a large array of instruments by means of which large wage differentials between levels of the internal pay structure can be determined. This enables employers to attract and select certain types of workers while holding at the same time lower (or higher) wage levels for certain groups of employees within firms. Some of the most widely used instruments (or a mixture of them) for setting internal wage levels are efficiency wages, skills-based and job-based pay structure, and pay-for-performance schemes [98]. On the aggregate level, individual skills, job tasks and economic activity are some of the factors systematically associated with particular wage levels.

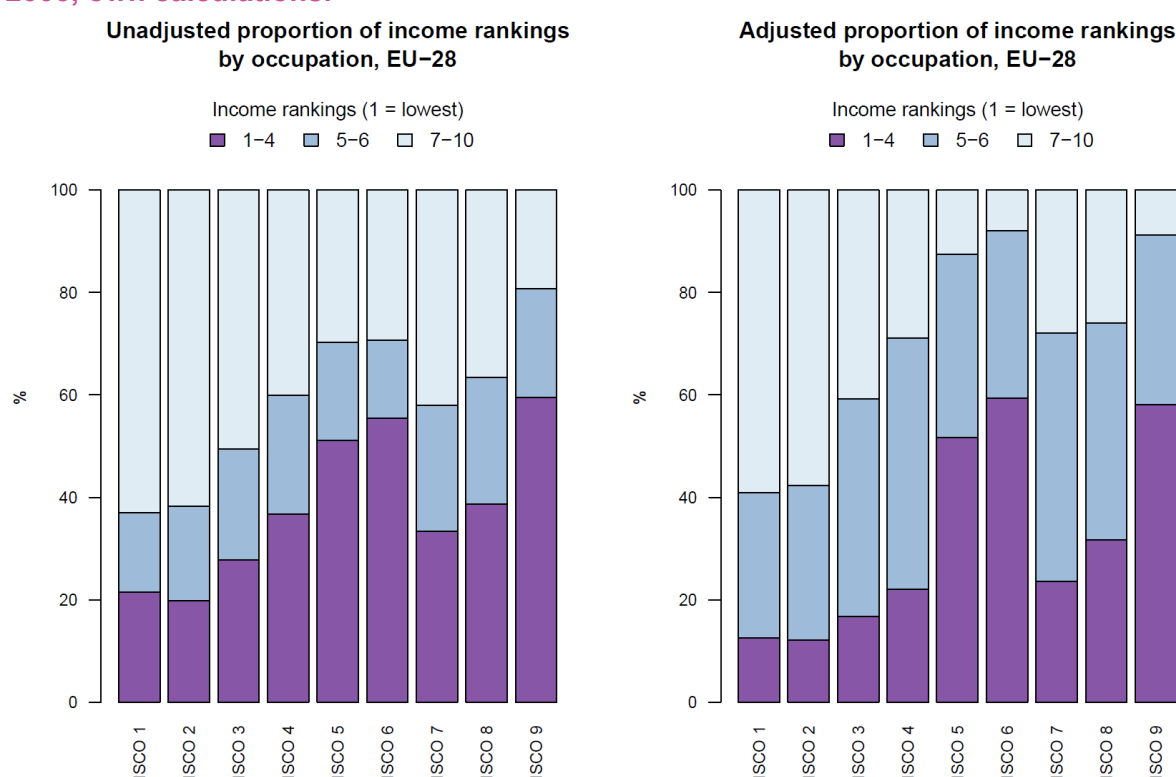
In this final report, we use data from the European Working Conditions Survey 2005 (EWCS 2005) in order to estimate the magnitude of these occupation-specific wage differentials and to assess to what extent wage inequalities might be associated with health inequalities. To this end, we use information on income collected in the EWCS 2005 by the question: “Presently, what is on average your net monthly income from your main paid job?”. Response categories correspond to 10 categories ranging from 1 (lowest income group) to 10 (highest income group) in each EU-28 country. For instance, respondents in Belgium could rank their own net income in 10 categories ranging from “Less than 850 EUR” to “More than 1,600 EUR”. Thus, income information in the EWCS 2005 was not collected as nominal wages but as a wage income ranking. Even though this data collection procedure does not allow the calculation of point estimates of wage levels, it is informative in the sense that relative wage income levels are captured allowing a straightforward cross-country comparison of relative wage income position. In order to improve the accuracy of the estimates discussed in the next sections 2,303 missing values on income information were imputed by the method of chained equations by taking into account a large amount of personal information such as age, sex, country and several variables covering the health status of respondents [99] (details can be obtained from the authors).

In Figure 8 the frequencies of income rankings by major ISCO occupational groups are reported. The left panel depicts the crude estimates of the frequencies of income rankings by major ISCO occupational groups in the EU-28. These crude estimates suggest large wage differentials between ISCO groups. While about 60% of managers and professionals (ISCO 1 and 2) report wages in the highest income groups (ranks 7 to 10), about 55% of service and sale workers, skilled agricultural workers and those in elementary occupations (ISCO 5, 6 and 9) and about 33% of technicians, clerks, craft and trade workers and operators (ISCO 3, 4, 7 and 8) report net wage levels in the lowest income groups (1 to 4).

Since the crude income estimates reported in the left panel of Figure 8 do not take into account (1) demographic characteristics, (2) skill levels, (3) economic activity, (4) working conditions and (5) national and regional income differences, unemployment and PPS levels, they are certainly biased. In order to obtain better estimates of the occupational income differences, we estimated a generalised linear regression model with nested random effects [46] (complete results available from the authors). The dependent variable was the income ranking as described above and it was treated as a metric variable. The fixed effects of the model included independent variables adjusting for the factors (1) to (4) such as age, educational level, years of experience, company size, economic sector of the firm,

self-reported exposure to work-related physical and psychosocial hazards (see section 3.1 for some of those variables), regional unemployment rates and PPS values, and national average hourly wages. The random effects part of the model included a nested structure of regions within country and regional PPS values, unemployment rates and national wage levels (see Figure 6 and Figure 7 above). By marginalising on the regional and national random effects it is possible to obtain adjusted predicted values of the income rankings (see [100] for estimation procedures). In the following paragraphs, the adjusted estimates refer thus to the predicted values obtained from the mixed regression model defined previously.

Figure 8. Proportions of the wage income rankings of European workers by major ISCO occupational groups. Adjusted estimates in the right panel correspond to the predicted values based a generalized linear mixed model (see text above for details). Adjustment includes age, sex, educational level, region, country, regional unemployment levels and regional PPS values, country-specific mean hourly wages, firm size, economic activity and several working conditions variables. Complete results available from the authors. N = 25377. Source: EWCS 2005, own calculations.



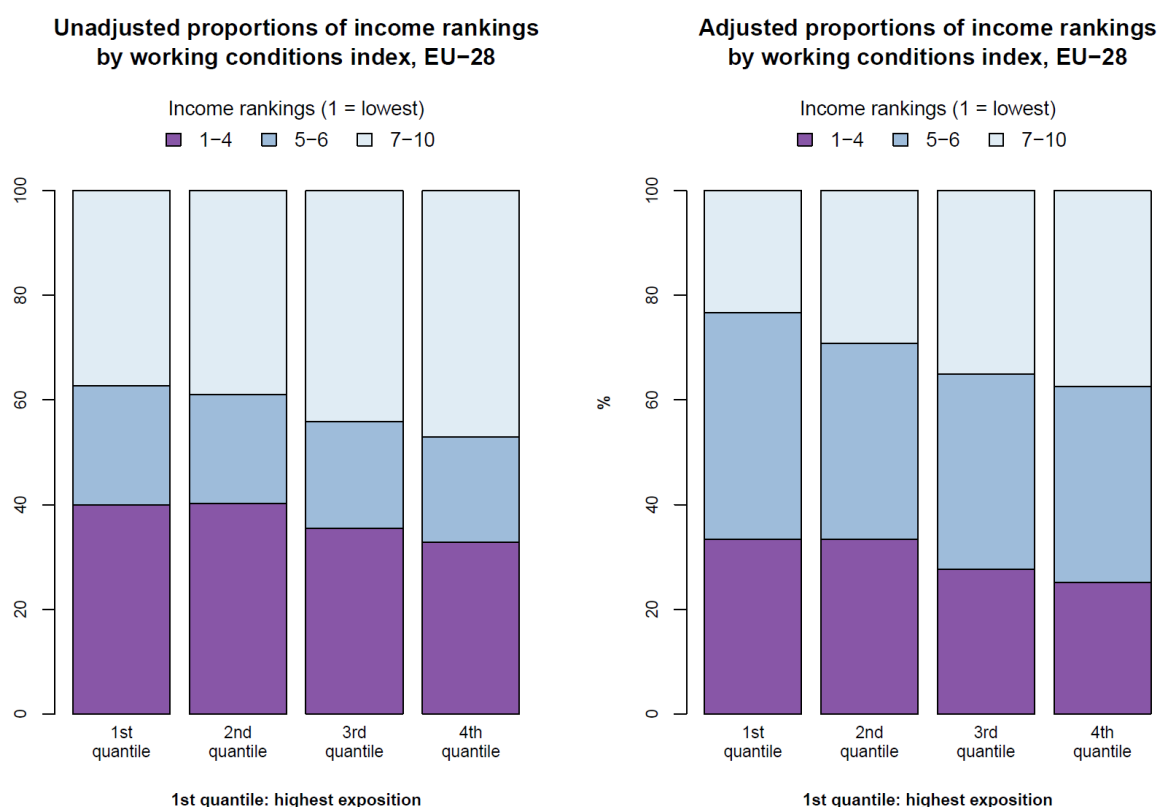
In the right panel of Figure 8 the predicted income rankings by occupation are reported. Notice that the main difference between the unadjusted and adjusted income estimates is related to an increase of the proportion of the middle ranks 5 to 6. The predicted estimates are thus identifying a larger proportion of workers with average wages. In addition, the adjusted estimates seem to be pointing out that the expected number of managers and professionals (ISCO 1 and 2) in the lowest income ranks (1-4) is actually lower than the crude estimates. In contrast, for the rest of occupations (ISCO 3 to 9, especially ISCO 5, 6 and 9) the expected number of workers in the highest income ranks is actually lower. Hence, the systematic wage differentials captured by the regression model are implying that (1) managers and professionals are more likely to earn more, and (2) all other workers are more likely to earn less. The adjusted estimates net of educational level differences, economic activity, and regional and national specificities, may be pointing to the impact of variable wage components granted to workers of ISCO groups 1 and 2 such as bonuses and other goal-specific financial incentives [101].

Working conditions and wage inequalities

In Section 3.1.5 it was shown that the prevalence of health problems and the burden of exposure to occupational hazards are concentrated in ISCO groups 6 to 9. At the same time, workers in these occupational groups are over-represented in the lowest wage levels across European countries. Within the framework of the neo-classic paradigm in economics the theory of equalizing differences has been proposed in order to explain why workers accept jobs involving higher health risks. Under the usual neo-classical assumptions of perfect information on the demand and supply side, free decision power of market participants, and free economic transaction ability, it has been assumed that employers must pay a wage premium to workers undertaking onerous jobs or, in general, jobs implying exposure to health-adverse working conditions [101]. Without such a “compensating wage differential” there would be no incentive for job seekers to accept jobs involving a higher burden of exposure. However, empirical evidence on wage differentials confirms rather the opposite: workers employed in jobs involving frequent exposure to several work-related hazards earn on average less than workers who are not frequently exposed [101]. Even though it has been argued that the analysis of cross-sectional data does not capture ‘the right sign’ of compensating wage differentials due to some sort of ability bias (i.e. more able workers would have higher wages and better working conditions [104-106]), the assumptions of the theory (e.g. perfect competition and perfect information in the goods and services markets) do not correspond to the real processes of price and wage setting. Moreover, given the existence of a non-negligible degree of monopsony power of employers discussed above, it is unlikely that employers in economic sectors characterised by low-profit rates and higher prevalence of work-related risks increase their labour costs or invest in occupational safety, since this might imply a substantial reduction of profit margins.

In this final report, we find evidence that jobs involving frequent exposure to a wide array of work-related health risks are paid less. To this end, we continue our analysis of the EWCS 2005 dataset and regression models mentioned above and estimate a working conditions index capturing an overall level of exposure. We considered the following work-related risks: exposure to painful positions, noise, too high or too low temperatures, dangerous chemical substances, carrying heavy loads, working at high speed, performing repetitive hand or arm movements, standing for long time periods, exposure to fumes and dusts and working to tight deadlines. In the EWCS 2005 these variables range from 1 (“All the time” = highest degree of exposure) to 7 (“Never” = no exposure). The working conditions index for each observation was built by normalising each variable as a fraction of its range with the formula $(x_i - x_{min}) / (x_{max} - x_{min})$, where $x_{min}=1$ and $x_{max}=7$, and calculating the sum of scores for each observation. The range of the working conditions index is thus 0 (highest exposure) to 12 (lowest exposure).

Figure 9. Proportions of the wage income rankings of European workers by levels of working conditions. N = 25377. Source: EWCS 2005, own calculations



In Figure 9 the proportions of income rankings by the quintiles of the working conditions index are reported. The left panel with the crude estimates reveals an inverse proportional association between burden of exposure and wage income, i.e. a higher exposure to work-related hazards correlates with lower wage incomes. The right panel of Figure 9 reports the adjusted wage income estimates as in the previous section. The estimates from the fully adjusted model predict even lower wage income ranks for a higher level of exposure, and higher wage income ranks for a lower level of exposure. Moreover, since the proportion of workers in the middle income ranks 5 and 6 increases whereas the proportion of workers in the lowest income ranks 1 to 4 decreases for a decreasing exposure level, the strength of the inverse proportional association is expected to be even larger.

3.3 Stressful psychosocial work environment

3.3.1 Theoretical models

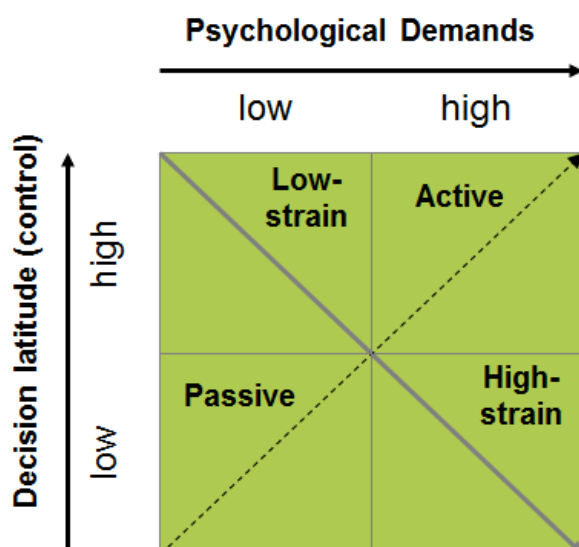
In the conceptual framework depicted in the Introduction a major pathway links unequal exposure to adverse work to unequal health. We already demonstrated that exposures to health-adverse physical, chemical, and biological hazards at work are more prevalent among lower socioeconomic status groups, thus increasing their burden of work-related disease. We also showed that these latter population groups are more often experiencing lower wage incomes and critical employment conditions, such as atypical or precarious work, including job instability and unemployment. With significant changes in the organisation and management of work, in the composition of the workforce, and in the economic context of work and employment, in particular in view of economic globalisation, the demands and threats increasingly challenge or even overtax working people's capacities of successfully coping with them. These demands and threats affect primarily the human brain by inducing mental and emotional load and related stress responses. Therefore, modern working and

employment conditions are characterised by distinct adverse psychosocial work environments, in addition to the traditional work environments characterised by material hazards.

Obviously, an adverse psychosocial environment at work cannot be identified by direct physical or chemical measurement. Theoretical concepts are needed to delineate particular stressful job characteristics so that they can be identified at a level of generalisation that allows for their use in a wide range of different occupations. These concepts can be translated into measures with the help of social science research methods (standardised questionnaires, observation techniques, etc.) that meet the criteria of adequate reliability and validity of data collection. A variety of concepts that encapsulate adverse psychosocial work environments have been developed in occupational health psychology and sociology, social epidemiology, and organisational sciences (for reviews, see [107,108]). However, only a few have been tested with convincing study designs (e.g. longitudinal observational investigations of initially healthy employed populations) and have addressed the social gradient in work and health. Amongst these, two models have been established in international research, the demand-control model and the effort-reward imbalance model, and more recently, a third model, organisational justice, has received special attention.

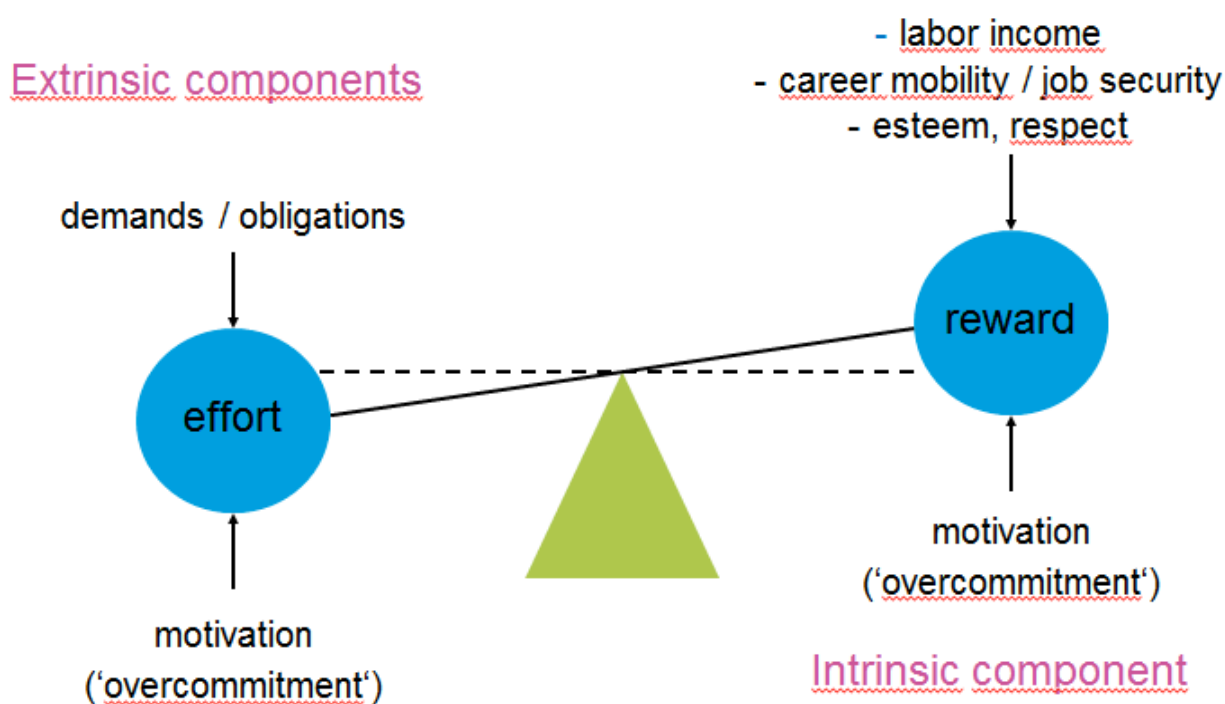
The demand-control model (see) [11,109] posits that stressful experience at work results from a distinct job task profile defined by two dimensions: the psychological demands put on the working person and the degree of control available to the person to perform the required tasks. This latter dimension is labelled 'decision latitude.' Jobs defined by high demands in combination with low control are stressful because they limit the individual's autonomy and sense of control whilst generating continued pressure ('high job strain'). Under these conditions, following the experience of control and mastery, it is expected that excessive arousal of the autonomic nervous system would occur without any compensatory relaxation response. Conversely, 'active jobs' are expected to be health-protective as they are defined by challenging demands that go along with a high degree of decision latitude and learning opportunities, enabling individuals to experience positive stimulation, success, and self- efficacy. A third dimension, social support at work, was added to the original formulation. In this formulation, the highest level of strain would be expected in jobs that are characterised by high demand, low control, and low social support at work or social isolation ('iso-strain jobs') [110]. Extensive tests of the demand-control-(support) model showed that the concept, in its fully developed form, does not always predict poor health but that this is more often the case if single components are analysed, and specifically the component of low control at work (see below).

Figure 10. The demand-control model. Source: [11].



A complementary model, effort-reward imbalance (see Figure 11), is concerned with stressful features of the work contract [12]. This model builds on the notion of social reciprocity, a fundamental principle of all types of transactions that are characterised by some form of utility. Social reciprocity lies at the core of the work contract which defines distinct obligations or tasks to be performed in exchange with adequate rewards. These rewards include money, esteem and career opportunities (promotion, job security). Contractual reciprocity operates through norms of return expectancy, where effort spent by employees is reciprocated by equitable rewards from employers. The effort-reward imbalance model claims that lack of reciprocity occurs frequently under specific conditions. Failed reciprocity, in terms of high cost and low gain, elicits strong negative emotions and associated stress reactions with adverse long-term health consequences (see below). 'High cost-low gain' conditions at work occur frequently if employed people have no alternative choice in the labour market. This is often the case amongst those with low socio-economic position or low level of skills, amongst elderly workers and, more general, in a highly competitive labour market. In addition, a distinct personal pattern of coping with demands, termed over-commitment, can aggravate the imbalance between efforts and rewards.

Figure 11. The effort-reward imbalance model. Source: [12].



More recently, the concept of organisational justice was linked to health outcomes in epidemiological studies. It distinguishes between three components of justice at the organisational level: distributive (the perceived fairness of the distribution of valued resources), procedural (perceived fairness of processes used to decide on relevant matters), and interactional justice (perceived fairness of being treated in organisations, e.g. from superiors and colleagues) [111,112]. The main effects of each one of these components on health are postulated, such that higher injustice goes along with higher risk of disease.

There is some overlap between distinct components of each one of the three models (specifically 'demand' and 'effort', or 'reward' and 'distributive justice'), but each approach was shown to explain elevated health risks independently [113]. Importantly, the notions of low control and low reward are

rooted in fundamental neuroscience research on links between social environment, emotional experience and activation of brain circuits [114]. Therefore, the models representing these basic notions deserve special attention. The models mentioned are measured by psychometrically validated, standardised questionnaires that are available in different languages. The reliability and factorial structure of respective scales, their discriminant and criterion validity have been repeatedly confirmed [115-118].

Several attempts were made to integrate elements of these models and to supplement them with additional components (see e.g. [119,120]), but current scientific evidence is largely based on the models described. Yet, it should be mentioned that these models were developed in a specific context of economic and socio-technical development and may need further adjustment in view of far-reaching recent changes in the nature of work and employment. For instance, a critical appraisal concludes: “In the post-neo-Fordist era, with the flattening of organisational hierarchies and the spread of self-managing work teams, the demand-control pathway between occupational status/class and stress may be less significant. Rather, access to standard employment versus contingent employment appears to be the new pathway, and job and financial security associated with non-standard employment the primary source of stress” ([121], p. 168).

In the frame of the DRIVERS project the models of demand-control and effort-reward imbalance were given priority for the following reasons. First, the amount of empirical evidence on their health-adverse effects is far broader than is currently the case for any other stress-theoretical model related to work and employment. Second, for both models it was repeatedly shown that their distribution across employed populations follows a social gradient (see below). This is considered an essential prerequisite of including them into analyses of social inequalities in work-related health. Third, in the cross-national studies which we were able to include in our research programme, in particular the SHARE survey, these models were repeatedly measured, at least in abbreviated versions, and thus offer important comparable information which can be linked to health outcomes.

In the following paragraphs we first provide some empirical evidence of the social gradient of a health adverse psychosocial work environment. We then present some of the most recent findings of our secondary data analyses on associations between work stress and health which were performed in the context of the current research programme. Here, two health outcomes are considered, depressive symptoms and limited functioning/ disability.

3.3.2 The social gradient of stressful work

In order to better understand the links of social position, psychosocial working conditions, and health, we set out to distinguish jobs according to three complementary sociologically relevant classification systems that enable us to explore the social gradient of stressful work. Each of these measures focuses on different aspects of the occupation and follows a different theoretical approach to describe individuals' social position based on their occupation. The first concept draws on people's occupational class. It categorises individuals according to particular aspects of the work setting and the labour market situation. The internationally most used occupational class scheme for modern societies is the Erikson–Goldthorpe–Portocarero scheme (EGP scheme) [122]. It has been widely used in comparative analyses and classifies individuals according to the following factors: (i) being an employer versus employee, (ii) performing manual work versus non-manual work, (iii) working in an agricultural or non-agricultural setting, and (iv) having a 'service' versus a 'labour' type of employment contract. The second sociological concept of classifying occupations refers to the occupational status, reflecting the prestige assigned to an occupation. In contrast to 'occupational class' (which emphasises specific aspects of labour market participation), status refers to the respect or 'social honour' that is attributed to a specific job by society at large. Along these lines, each job is classified on a 'prestige' scale. The Standard Index of Occupational Prestige Scale (SIOPS) [123] is one such

scale. Importantly, in order to allow cross-national comparisons, this scale summarises the available national prestige scales into one international scale, where each job is assigned a prestige value on a continuous scale, with higher scores representing jobs with a higher status. With respect to work stress, the occupational status is expected to be related to the level of non-material recognition – an important dimension in the effort-reward imbalance model.

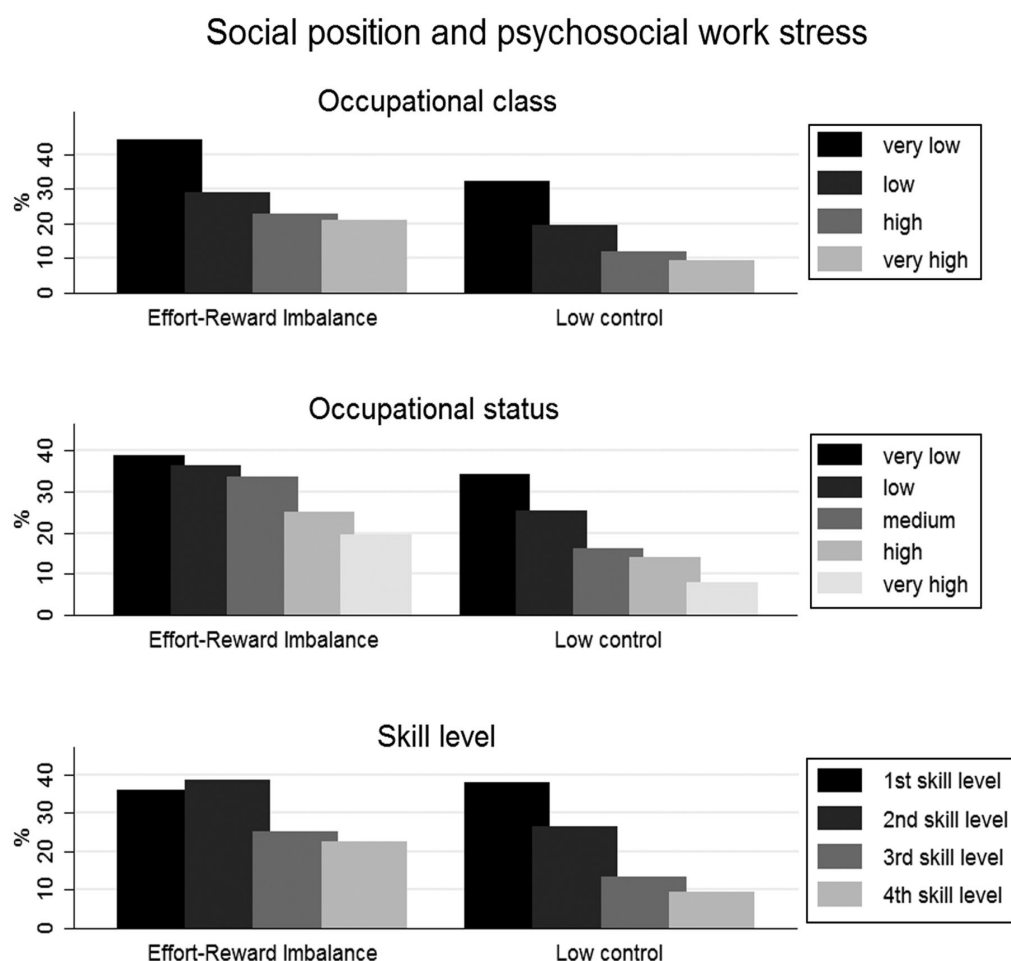
Finally, as a third occupational classification, the skill level of an occupation will be used. This measure represents the first dimension to regroup different occupations in the International Standard Classification of Occupations (ISCO) classification of occupations, developed by the International Labour Office. The ISCO classification allows classifying jobs into 390 different categories where the broad hierarchical structure is based on four different skill levels. This skill level refers to skills required in the job for a competent performance of the tasks and duties. Importantly, the skill level is not necessarily obtained by formal education, but can also be acquired through experience and informal training. As a consequence, the skill level might differ from existing educational attainments of the worker. As such, the skill level is a measure that is more closely related to the occupation than is the case with educational attainment. With regard to work stress, a high skill level is thought to be related to higher non-physical demands, as well as to higher levels of autonomy and control.

In sum, these three measures are supposed to represent distinct aspects of the occupation, where occupational class focuses on the work setting of an occupation, occupational status on the existing prestige assigned to a job, and last, the skill level on intellectual demands within the occupation. Against this background, using three different occupational classifications and two established models of psychosocial stress at work, we aim to answer the question whether these three different occupational classifications represent a coherent social gradient of work-related stress.

In answering this question we relied on data from 11 European countries represented in the SHARE study described in the Methods chapter. First wave data were collected in 2004-2005, but an updated release of data including a set of detailed information on workers' occupation was used (see [124]). All employed participants aged 50 – 64 years with complete information on all variables were included, resulting in a sample of 6,398 respondents. Weights were applied within the analyses to compensate for unit non-response. Work stress was measured by abbreviated versions of original scales of the demand-control and effort-reward imbalance models. Given the limited amount of space in the SHARE questionnaire, we were forced to select best items on the basis of factor loadings on respective original scales. In previous analyses, these measures and the applied procedure have successfully been associated with mental health [24] (see also below 3.3.3). With regard to the demand-control model, the measurement was restricted to the control dimension (for details of measurement and analyses see [124]).

In Figure 12, a clear social gradient of work stress is observed in all three occupational classifications. The gradient is slightly steeper in case of low control compared to effort-reward imbalance, and it is more pronounced if the first two occupational classifications are applied.

Figure 12. Prevalence of stressful work (effort-reward imbalance; low control) according to three occupational classifications; N = 6398 employed men and women aged 50-64 from SHARE (based on weighted data). Source: [124].



3.3.3 Associations with mental health and disability

Mental health

A substantial number of epidemiological studies demonstrated associations of both models of a stressful psychosocial work environment with a broad spectrum of health outcomes. Most convincing evidence so far relates to elevated risks of coronary heart disease [125-127] and of depressive disorders [13]. Additional support was found for metabolic disorders [128], limited functioning [129], musculoskeletal complaints [130], alcohol dependence [131], and asthma [132], among others. Moreover, sickness absence and disability pension were associated with stressful work [86]. In the restricted frame of the current work programme only a limited test of health outcomes was available as our primary intention was to provide evidence at the European level, i.e. for a range of different countries. In a majority of cases, epidemiological cohort studies, the gold standard of respective research, are conducted in a single country, or even within a single company, thus suffering from reduced generalisation. As clinically relevant depressive symptoms and measures of functional limitations (pointing to disability) were the main health-related outcomes of SHARE, and as this latter study provides the main empirical basis of our European wide analyses, this section is limited to most recent findings linking stressful work with these two health outcomes.

While about a dozen prospective epidemiological studies have confirmed links of the demand-control model and/ or the effort-reward imbalance model with increased risks of depression, these studies were mostly restricted to single countries. We therefore set out to test the hypothesis in a comparative frame by including data from four longitudinal ageing studies with information from 17 countries: the SHARE study (Release 2.3.0, with data collected in 2006), the English Longitudinal Study of Ageing (ELSA; [133]), the US Health and Retirement Study (HRS; [134]), and the Japanese Study of Aging and Retirement (J-STAR; [135]). The four studies were developed in close coordination concerning design and measurement. In addition to measures of the components of the two work stress models and of depressive symptoms, age, gender, education, employment status and working hours were considered as confounders (for details see [136]).

Concerning statistical analyses, multivariate logistic regression models were calculated to estimate odds ratios and 95% confidence intervals of depressive symptoms according to the two independently analysed measures of work stress, effort-reward imbalance and low job control. Models were calculated for each work stress scale separately and adjusted for the confounding factors mentioned above. Given the multilevel structure of the European data, we applied multilevel methods where individuals (level 1) are nested within countries (level 2). These analyses were applied to the full cross-sectional data set (see Figure 13). In a final step, given the fact that SHARE, ELSA and HRS provided additional consecutive data from a measurement wave two years later, we applied these models in a longitudinal design where stressful work, assessed in 2004, was related to depressive symptoms, assessed in 2006. In the first one of two models of this longitudinal analysis, effects were adjusted for additional covariates, whereas in a second model they were additionally adjusted for baseline depressive symptoms measured in 2004. By doing so, model 2 estimates how the work stress measures are associated with changes in depressive symptoms between 2004 and 2006 (see Table 3). In keeping with the important notion of globalisation of stressful work and its potential impact on mental health, we present the odds ratios separately for the three main world regions from which data are available, Europe, USA, and Asia (Japan) in cross-sectional analysis and the first two regions in longitudinal analysis.

To test our hypothesis, multivariate logistic regressions were calculated separately for the three regions of the world. Figure 13 presents the results from cross-sectional data. Accordingly, odds ratios of depression were significantly elevated among men and women experiencing work stress in terms of high effort-reward imbalance in all three regions, compared to those who were free from stress at work. The strongest association was observed in the USA, followed by Europe and Japan. A similar trend was obvious for the complementary measure of work stress, low control. However, after adjusting for confounders the association was no longer statistically significant in Japan. Findings from longitudinal analyses are displayed in Table 3, with the restricted sample of employed and self-employed men and women from 13 countries. Significantly elevated odds ratios of depression, assessed in 2006, are observed among men and women with a high level of work stress in terms of effort-reward imbalance and low control, assessed in 2004. Gender-specific analyses showed no statistically significant differences in effect sizes. Concerning the two statistical models, all odds ratios in the second model are attenuated once baseline depression in 2004 has been taken into account. In this case, elevated odds ratios for both work stress models remain statistically significant in the combined European samples (SHARE and ELSA). Here, an odds ratio of 1.51 (effort-reward imbalance) and of 1.42 (low control) respectively is observed.

Figure 13. Associations of work stress with depressive symptoms (multivariate logistic regression analyses). Odds ratios and 95% confidence intervals (CI). Cross-sectional data from 2006. Odds Ratios are adjusted for gender, age, education, employment status, working hours. Given the multilevel structure of the European data, we applied multilevel methods where individuals (level 1) are nested within countries (level 2). N = ERI, N=1510, 10047, 1083; Low control, N = 1560, 10342, 1226, respectively. Source: [136].

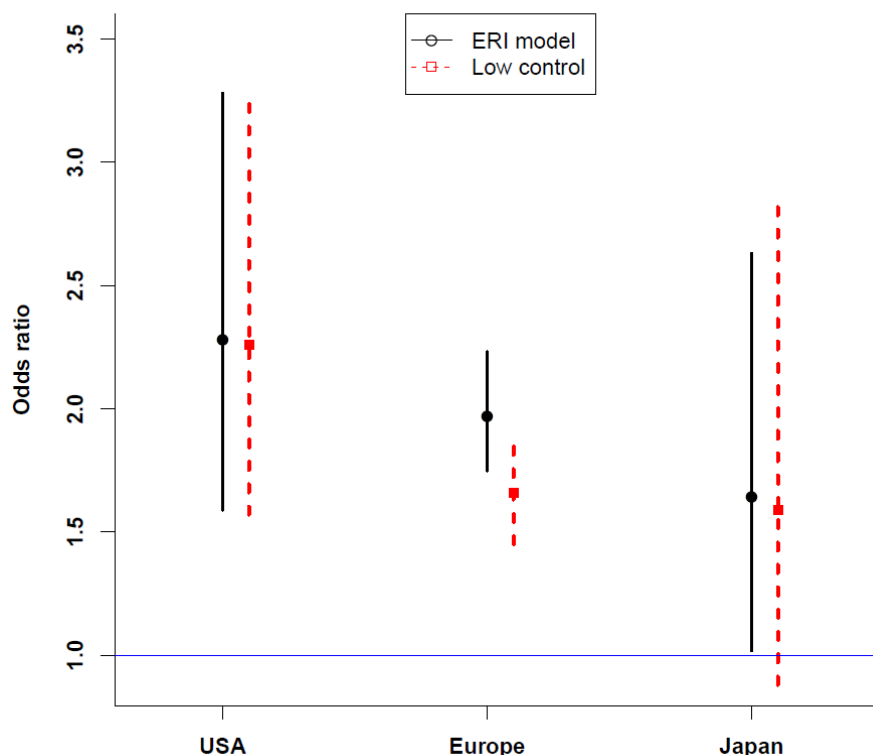


Table 3. Work stress and depressive symptoms. Odds ratios and 95% confidence intervals (CI). Longitudinal data. Odds Ratios are adjusted for gender, age, education, employment status, working hours in model 1. In model 2 outcome depression at follow up is additionally adjusted for depressive symptoms at baseline. Given the multilevel structure of the European data, we applied multilevel methods where individuals (level 1) are nested within countries (level 2). * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Source: [136].

			Depressive Symptoms (2006)	
			USA	EUROPE
Effort-reward imbalance (2004)	Model 1		1.94 (1.21 – 3.13) **	1.79 (1.53 – 2.09) ***
	N=		683	6063
	Model 2004	2 + symptoms	1.53 (0.91 – 2.57)	1.51 (1.28 – 1.78) ***
Low control (2004)	N=		673	6034
	Model1		1.65 (1.03 – 2.63)*	1.57 (1.34 – 1.84) ***
	N=		714	6246
	Model2	+ symptoms 2004	1.46 (0.88 – 2.45)	1.42 (1.20 – 1.68) ***
	N=		704	6213

Disability

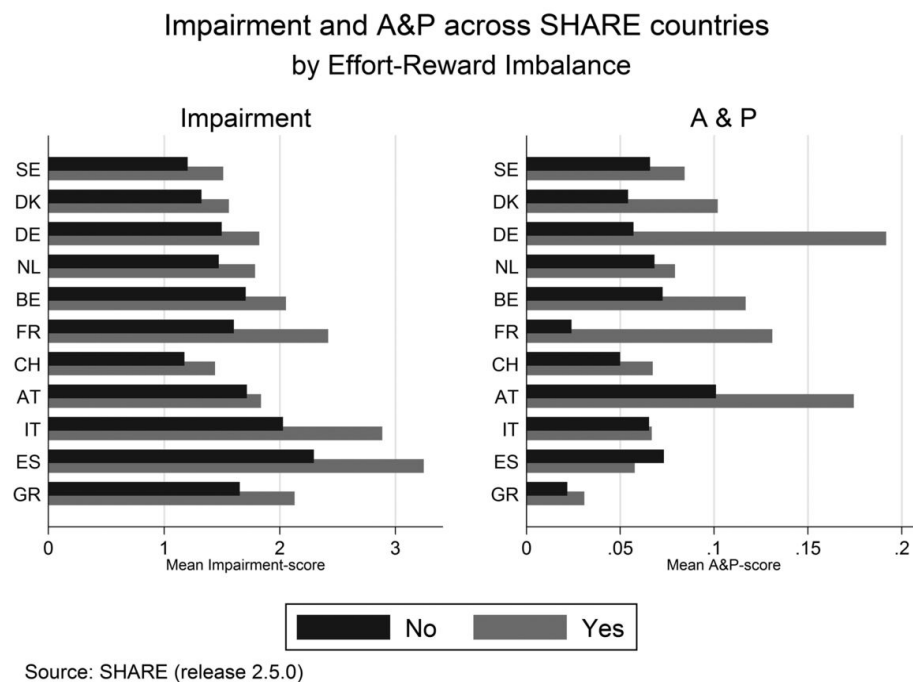
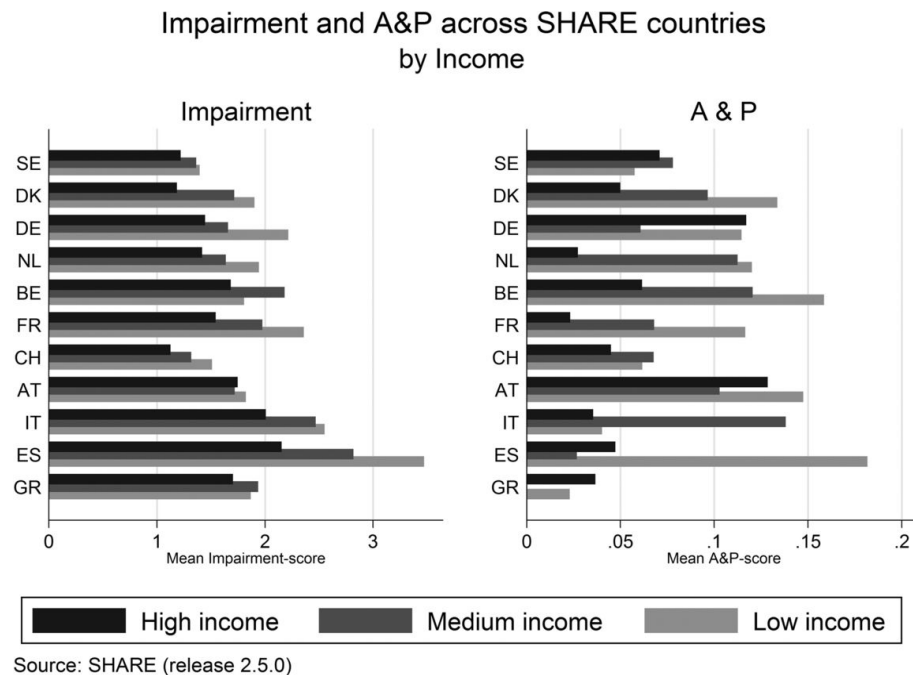
Disability is another important health outcome included in the cross-national longitudinal studies mentioned. Here, we focus our analysis on data from the European SHARE study. Reduced health functioning and disability are major determinants of involuntary early exit from the labour market and provide a major burden in ageing societies [137]. It has already been documented that disability prevalence follows a social gradient, leaving men and women in lower socioeconomic positions at higher risk (see [129]). However, studies demonstrating an impact of disadvantaged working conditions on elevated disability risks are rare, and this also holds true for adverse psychosocial work environments. Therefore, we tested associations of work-related factors with disability in a prospective study design, using comparable indicators, based on a large sample of male and female employees in early old age from 11 European countries (the SHARE study). More specifically, we test the hypothesis that exposure to a stressful psychosocial work environment as measured by low control and effort-reward imbalance (assessed at wave 1) contributes to later disability (assessed 2 years later at wave 2).

To identify and measure core aspects of the complex construct ‘disability’ our approach was based on work resulting in the International Classification of Functioning, Disability and Health (ICF) [138]. Disability is no longer interpreted as a fixed attribute of an individual, but rather as a dynamic continuum of experiences at different levels (bodily impairment, restrictions in activity and social participation). As disability results from an interaction of vulnerable individuals with a broad range of environmental factors including working conditions, it seems mandatory to assess this condition in a multidimensional, quantitative frame of analysis. At least two crucial components need to be distinguished, the level of bodily impairment and the level of restriction in activities and social participation, since ‘people with the same impairment can experience very different types and degrees of restriction, depending on the context’ [139]. Therefore, embedded in the framework of ICF, we developed two indices of disability: one measuring impairment and another measuring restriction in activity and participation (A&P). Based on principal component analysis of items measuring functional limitations within the SHARE questionnaire, we constructed sum indices for impairment and A&P restrictions (for details see [129]).

Data were obtained from the first two waves of SHARE (Release 2.5). Because we were interested in associations between working conditions in late midlife in wave 1 and disability in wave 2, we excluded people not aged 50–64 years at wave 1 ($n=8196$), and those reporting no employment at baseline ($n=12\,485$) from the longitudinal sample. Moreover, we conducted a complete case analysis, thus excluding respondents with missing data on any of the variables ($n=2636$). This resulted in a final sample size of 4,864 respondents. In order to compensate for unit non-response, and for attrition between the first and the second waves, calibrated longitudinal weights were applied. These weights are defined for the longitudinal sample only and are calculated for each country separately (for details see [129]).

In this report we restrict the presentation of findings to the level of bivariate analysis. As we are interested in the social gradient of disability and in the association of stressful work with the two disability indices, we present respective bars for the single European countries included in SHARE. As shown in Figure 14 (top panel), we observe a social gradient that is consistent across all countries, using income as an indicator of socioeconomic position. Less clear findings are obvious in case of A&P restrictions. Concerning the second aspect, higher scores of the two disability factors among men and women experiencing chronic stress at work are obvious. Again, relatively consistent trends are observed across the countries under study, as exemplified by measuring work stress in terms of effort-reward imbalance (ERI) (Figure 14, bottom panel).

Figure 14. Mean disability scores (in wave 2) according to income (in wave 1, top) and effort-reward imbalance (in wave 1, bottom) across Survey on Health, Ageing and Retirement in European countries (n=4864). Means are based on weighted data. Source: [129].



Based on two summary indices of impairment and restrictions of activities and participation, we found preliminary evidence that employed older men and women in lower socioeconomic positions (as measured by income) and those who experience stressful work (as measured by low control and effort-reward imbalance) exhibit significantly elevated disability scores after two years, compared to their baseline levels. Effects were more consistent for impairment than for restrictions in activity and participation, and they were stronger in case of effort-reward imbalance than in case of low control at work. In addition, in multivariate regression models we explored to what extent the association of

socioeconomic position with disability is mediated by work stress, and we found partial support of this hypothesis which will be briefly discussed in the next section (see below 3.4).

In conclusion, reduced mental health in terms of depressive symptoms and elevated scores of two important indicators of disability were found to be associated with an adverse psychosocial work environment in older employed populations in a number of European countries and, in part, in the US and in Japan. Findings were confirmed in cross-sectional and longitudinal analyses and remained significant in almost all cases after adjustment for relevant confounders. This new evidence is particularly relevant in the context of DRIVERS as both health problems are widely prevalent in employed populations of older age and as the manifestation of both health problems follows a social gradient, leaving those in lower socioeconomic positions at higher risk. In a next step we therefore need to study the pathways linking socioeconomic disadvantage and stressful working conditions with poorer health.

3.4 Pathways to unfair employment (mediation, moderation)

3.4.1 A systematic review

Social inequalities in health persist in modern societies. Attempts to reduce the social gradient in health depend on knowledge about potential causes. Among these, adverse working and employment conditions seem to play an important role in linking social inequalities with health. However, associations of socioeconomic position with health outcomes, whether measured by education, income, or occupational status, do not provide explanations of these links as they are purely descriptive. To provide such explanations, additional information is needed to shed light on the underlying pathways linking these two phenomena. Evidence on links between social inequalities, working conditions and health is of practical interest as it offers insights into entry points for preventive activities at work that aim to reduce health inequalities. In a systematic review performed in the context of DRIVERS, two complementary questions were analysed: first, to what extent can adverse working conditions account for the health differences observed between the socio-economic positions (the so called mediation hypothesis)? And second, is stressful work equally harmful for all employees, irrespective of their occupational class, or are those working in less privileged conditions more vulnerable to inherent health-reducing effects than those who are better off (the so called moderation hypothesis)? Answering these questions provides a challenge to scientific inquiry.

Occupational health research has tackled this latter challenge by applying two strategies of analysis: mediation and moderation. The mediation hypothesis claims that the strength of association between socioeconomic position (SEP) and health is abolished or substantially weakened if the effect of work characteristics on health is estimated in multivariate regression models. A respective reduction in effect size is interpreted as partial explanation of the social gradient of health by the work characteristic under study [140]. Traditionally, in a majority of cases, epidemiological studies tested the mediation hypothesis by applying stepwise multivariate regression analysis. However, pathway analysis or structural equation modelling seem more appropriate statistical approaches as they allow for combined estimation of the direct and indirect effects of SEP and work characteristics on health [141].

According to the moderation hypothesis, the effect of a predicting variable (work characteristic) on a criterion variable (health) varies according to the level of a third variable (SEP). In this case, stronger effects of adversity at work on health are expected among employed people in less privileged as compared to more privileged socioeconomic conditions. To this aim, stratified analyses are performed, and an interaction term (of work and SEP on health) is assessed. Despite the direct policy implications of this latter approach – higher susceptibility to the exposure among people with low SEP points to priorities in administering interventions – the moderation hypothesis has been tested less

frequently than the mediation hypothesis in research on work characteristics and social inequalities in health (see below).

To the best of our knowledge, no systematic review focusing exclusively on prospective observational cohort studies that tested the mediation and moderation hypothesis of the social gradient of health with reference to work characteristics is available so far. In this contribution, we set out to fill in this gap. Our main aim was to document whether and to what extent findings from prospective studies lend support to the two hypotheses (mediation and moderation), even given considerable heterogeneity of work-related exposures and health outcomes in these studies. As both hypotheses address potential entry points for preventive activities at work that aim at reducing health inequalities [142], it is important to assess the quality of available empirical evidence.

This systematic review was performed by observing the criteria defined in the PRISMA statement [33]. Detailed information about eligibility criteria concerning sample, information sources and data extraction as well as data analysis are given in [30]. We restricted the review to prospective observational cohort studies as we aimed at targeting best available quality of data with regard to potential causal associations in epidemiological studies [143]. Therefore we excluded cross-sectional studies. We also excluded longitudinal studies with a follow-up duration less than one year as a short time interval confers a high risk of reverse causation. At study entry, participants had to be free from the disease outcome under study, or baseline health measures had to be adjusted for in subsequent analyses. Furthermore, we undertook a quality assessment regarding appropriate handling of adjustment procedures for relevant (e.g. socio-demographic) confounders and appropriate statistical methods (e.g. test for interaction in moderation analyses). To prevent multiple consideration of the same study in different papers, we selected the paper with highest data quality (e.g. validity of outcomes and exposure, duration of longitudinal study and general quality assessment), but we included more than one report from the same study (in case of the British Whitehall II and the French GAZEL study) if different health outcomes or different work characteristics (e.g. different work stress models) were tested. We included studies of working age populations who were employed at entry. Studies with a sample size of $n < 1.000$ were excluded for reasons of limited statistical power.

The results of this review are as follows: Starting from 7,264 initial records 443 records were evaluated in detail, but in the end only 26 reports fulfilled all selection criteria to a sufficient extent. Overall, it is apparent that relatively few papers investigated these mediation or moderation effects in the frame of cohort studies, whereas separate effects of socioeconomic, or of work-related, factors on health have been explored abundantly.

Mediation

We first summarise the results related to the mediation hypothesis. In 13 studies, the most widely used model of a health-adverse psychosocial work environment, demand-control (or its single dimensions), was studied as the mediating construct. Two studies tested the effort-reward imbalance model in addition to the demand-control model, and one study analysed the effort-reward imbalance model exclusively. One study tested a Job-Exposure-Matrix considering psychosocial working conditions. Seven studies analysed physical demands or biomechanical strains in addition to the demand-control model, whereas one study was restricted to physical exposures and chemical substances. This latter study was the only one that included a large number of European countries, while the remaining studies were conducted in single countries of Northern, Southern or Western Europe or Canada.

Health outcomes in these studies can be divided into more objective and more subjective measures. The former include cardiovascular diseases, lung cancer, disability pension and sickness absence, whereas the latter mainly concern self-rated health, depression, low back pain, or functional limitations.

All studies report a social gradient of health. In addition, poor working conditions are more prevalent among employed people with low skill level or low occupational standing. Related associations with health are generally higher in reports that used self-reported health outcomes compared to those using medical diagnoses. Crucial information about the mediation hypothesis is provided by comparing the percentage reduction in odds ratio (OR) or hazard ratio (HR) between the first step of a regression model (SEP and health) and the second step of the model, adjusting additionally for work characteristics. In a majority of cases, a per cent reduction between the two ORs or HRs is observed, as assumed by the mediation hypothesis. However, the amount of per cent reduction, i.e. the strength of a mediation effect, varies considerably. In general, mediation effects are more consistently observed in studies based on employment grade as a measure of social inequality, compared to those using alternative SEP indicators. Concerning a comparison of mediation effects between studies using more objective versus subjective health outcomes, an interesting finding becomes obvious. With two exceptions, mediation effects tend to be somewhat stronger if objective health outcomes are analysed. It appears that studies that combine psychosocial and physical work stressors achieve relatively strongest mediation effects, although only two studies analysed these two effects separately. As the demand-control model was applied in a majority of studies, no comparison of mediation effects with alternative psychosocial exposures was possible. Some study results confirm that this model, or its single components, makes a distinct contribution towards explaining the social gradient of health.

Moderation

Five of the nine studies included in this part of the review used the demand-control model, two studies were based on the effort-reward imbalance model, one study analysed several aspects of work-related social support, and one study applied a Job-Exposure-Matrix of different occupational solvents. Given the relatively small number of studies, a further differentiation according to SEP indicators or health outcomes is not feasible. It should also be kept in mind that any generalisation of findings related to the moderation hypothesis is limited by the fact that three out of nine reports are based on the same cohort, the British Whitehall II study. According to the moderation hypothesis, stronger effects of work characteristics on health outcomes are expected in low SEP as compared to high SEP groups. This hypothesis finds empirical support in four studies. Two of them tested the effort-reward imbalance model, one the demand-control model, and one the chemical exposure of different solvents. A fifth investigation reports that a mitigating effect of a favourable psychosocial work environment (social support and job security) on the amount of experienced distress is confined to the subgroup with low socioeconomic standing, while it is absent among higher SEP groups. Three of the four remaining studies observed higher ORs or HRs among more privileged as compared to less privileged occupational groups, thus contradicting the general hypothesis. However, in one of these studies this only holds true for men, and in another study this effect is restricted to one out of three work characteristics entering statistical analysis.

In view of the small number of studies and the heterogeneity of relevant measures, it is difficult to find a consistent pattern of results with regard to the moderation hypothesis. Yet, slightly more results are in favour of the hypothesis whereas negative findings from at least three studies challenge this assumption.

Commentary

While we found some empirical support in favour of either hypothesis, the degree of consistency of findings was clearly restricted, given the heterogeneity of measures applied in these studies. In contrast to the relative paucity of prospective investigations, many more cross-sectional studies were conducted addressing these questions. There is a remarkable contrast of the consistency and strength of reported effects between these two study designs as both hypotheses were more convincingly supported in cross-sectional studies. To date it is unclear whether methodological

problems, such as higher reporting bias or common method variance inherent in cross-sectional designs, account for this discrepancy. In view of the relevant contribution of employment and working conditions to social inequalities in health, there is an urgent need for further clarification of this divergent trend.

Given a high amount of heterogeneity and other limitations of the current state of prospective research on the mediation and moderation hypothesis, a call for a higher degree of standardisation and methodological sophistication in future research in this field is warranted. In particular, the following criteria might be observed in designing and conducting respective empirical studies.

First, studies should test an explicit theoretically justified hypothesis, rather than exploring what variables may produce statistically significant results. Second, there is a need to analyse the combined and separate effects of physical/chemical and psychosocial work characteristics and to base the measurement of the latter variables on theoretical models and their standardised assessment with psychometrically validated scales. Third, with regard to health outcomes, more emphasis should be put on objective outcomes. Moreover, study designs and statistical analyses should take account of the complexity and dynamics of work life in current societies. Among others, structural equation modelling, path analysis and multilevel analysis offer opportunities for respective extensions. Event history methods and multiple longitudinal exposure assessments are desirable. The same holds true for the inclusion of contextual measures of workplaces, firms, organisational environments and economic changes.

In conclusion, the current state of research, as reflected by findings from prospective observational cohort studies, provides some support in favour of the mediation and moderation hypotheses in analysing associations of work characteristics and SEP with health, but improved, more standardised scientific evidence will be needed to firmly instruct work and employment-related policies.

3.4.2 Mediation effects

Based on the results of the systematic review on mediation and moderation effects in prospective studies, we set out to strengthen evidence in favour of the mediation hypothesis. The systematic review revealed inconsistencies in prospective studies, mainly in terms of a lack of comparability between measures of socioeconomic position and employment conditions and in terms of a lack of longitudinal study designs. In our study described in this section (for details see Hoven et al.¹), we aim at contributing towards an updated knowledge base considering the research gaps observed in the systematic review on mediation effects as described above.

We study to what extent work stress contributes towards an explanation of the association between occupational position and mental health. More specifically, we systematically compare different measures of occupational position and work stress, resulting in the following four pathway models: Occupational position is measured by two complementary, internationally established categorisations of occupations – occupational class (EGP-scheme) and occupational status (SIOPS). Both measures are briefly described in section 3.3.2. As to work stress, we use two theory-based, internationally established measures – the effort-reward imbalance model and the demand-control model (for details see section 3.3.1).

Data was obtained from the first two waves of SHARE (for details see section 2.2.2). We made several restrictions. First, we included respondents only if they were employed at both waves.

¹ Hoven H, Wahrendorf M, Siegrist J (2015): Occupational position, work stress and depressive symptoms: a pathway analysis of longitudinal SHARE data. *Journal of Epidemiology and Community Health*. doi:10.1136/jech-2014-205206.

Second, because respondents aged 65 or older may have had more favourable working conditions ('healthy worker effect') and because their retrospective assessment of stressful work may be less reliable compared to those who are currently employed, we restricted the sample to men and women aged 50 to 64. Third, in order to reduce the risk of reverse causation, individuals with increased depressive symptoms at wave 1 were not included either. These restrictions resulted in a final sample with full available data of 1,658 men and 1,140 women. Pathway models were estimated to enable a combination of linear regression with probit regression, given the dichotomous outcome of depressive symptoms. Tests of significance of coefficients and indirect effects are based on bootstrapping procedure. We model relative direct and relative indirect effects of respective categories of occupational position relative to the most advantaged group, this latter group serving as reference category (as proposed by [144]).

Figure 15. Pathway analyses of the association between occupational class, work stress (ERI and low control) and increased depressive symptoms: adjusted for country-affiliation, sex, and age. Source: [1].

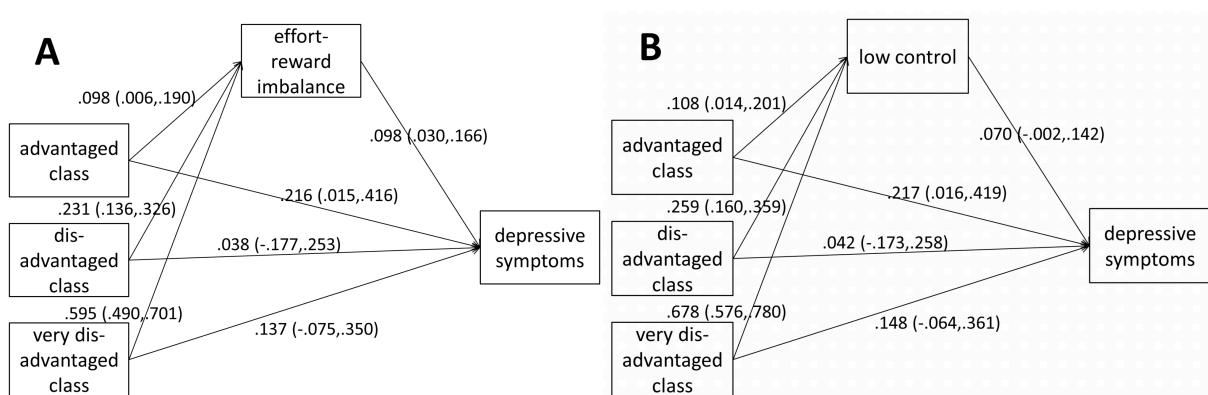
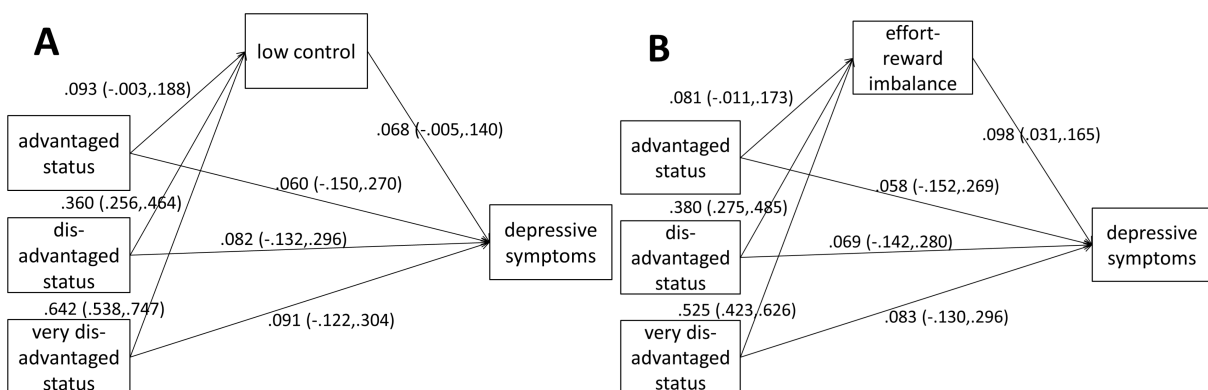


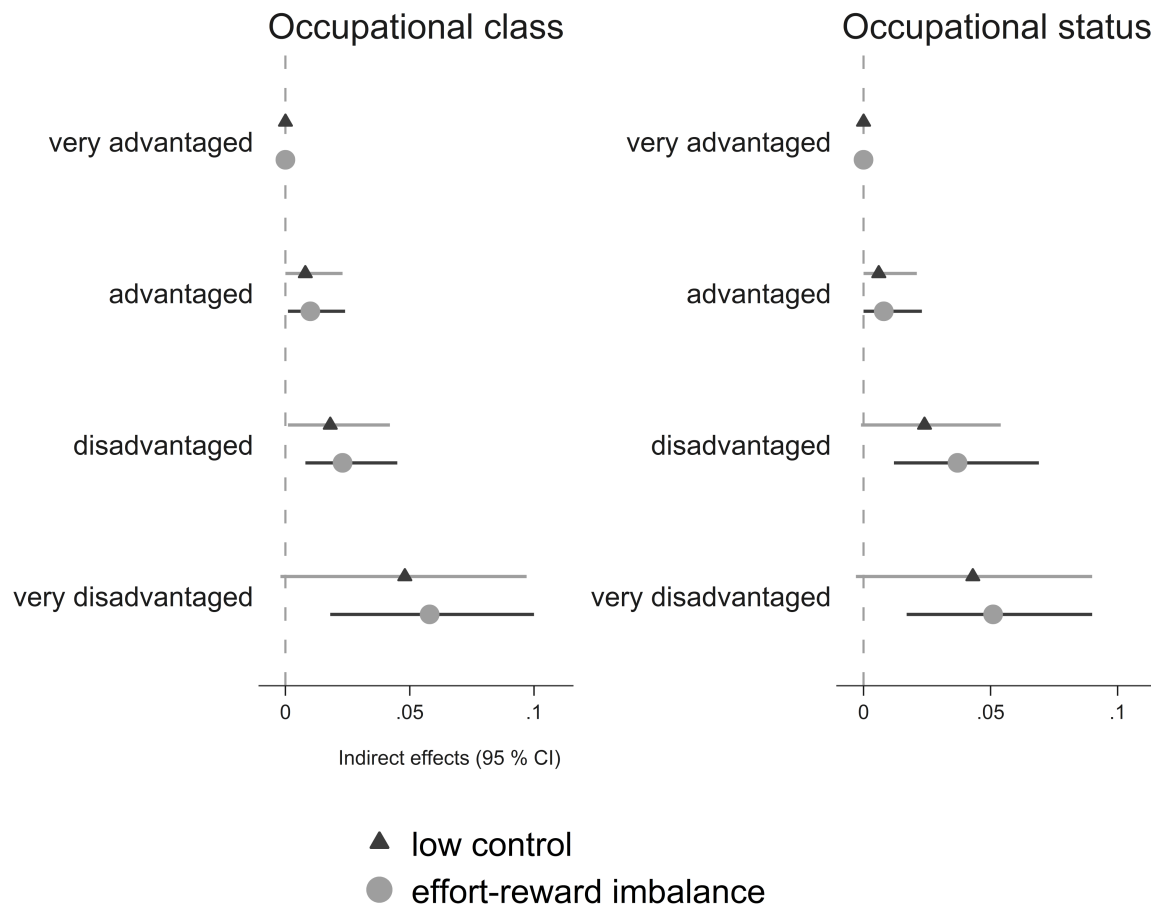
Figure 16. Pathway analyses of the association between occupational status, work stress (ERI and low control) and increased depressive symptoms. adjusted for country-affiliation, sex, and age. Source: [1].



In Figure 15 and Figure 16, pathway models of the association between occupational position, work stress and depressive symptoms are presented. Overall, all pathway models indicate significant associations between occupational position and work stress. Yet, the associations between work stress and depressive symptoms are significant only in case of effort-reward imbalance. The paths leading from occupational position to depressive symptoms (direct effects) are not significant. These results suggest a relevant contribution of work stress towards an explanation of the social gradient in health (mediation). Figure 17 visualises the quantification of such indirect effects. The structure of results does not significantly differ between the two measures of occupational position. As can be

seen, effort-reward imbalance, one of the two models of work stress, seems to mediate the associations between occupational position (both measures) and depressive symptoms. Effects are relatively weak but consistent. This is not the case for low control as the complementary measure of work stress.

Figure 17. Indirect effects of the association between occupational position and depressive symptoms via work stress. adjusted for country-affiliation, sex, and age. Source: [1].



To sum up, results of multivariate path analyses reveal a partial, although statistically significant contribution of work stress, as measured by effort-reward imbalance, on the association between occupational position and mental health. A similar, statistically significant mediation effect is not apparent in the path analyses measuring work stress by low control. The reason for this inconsistency is not clear. In part, it may be due to a less comprehensive operational measure of this mediating construct. Alternatively, low control may matter less than low reward if occupational status defines the relevant analytical classification scheme of occupational positions, whereas it may matter more if occupational classification is based on the more materialist notion of class. However, this assumption is not supported by our findings. The observed mediation effects do not significantly differ between the two measures of occupational position.

3.4.3 Additional evidence on mediation and moderation effects

Mediation

At least two original scientific papers dealing with this topic were published during our research programme where the principal investigator of Work Package 3 of DRIVERS was involved. Findings from these publications add to the evidence presented in the above systematic review although this work was not funded by DRIVERS. The first study was already discussed in the context of disability [129]. As mentioned, we analysed data from two waves of the SHARE study to explore the social gradient of disability and the association of stressful work with changes in scores measuring disability over time (Figure 14). With an additional research question we asked to what extent the association of socioeconomic position with disability is mediated by work stress.

To test this assumption Poisson regression models were calculated to predict disability in wave 2. Given the multilevel structure of the data, a random intercept multilevel model was estimated with individuals (level 1) nested within countries (level 2). This procedure allows for accurate adjustment for country affiliation. Maximum likelihood estimation is used for parameter estimation. Findings of these analyses are displayed on three consecutive models, all adjusted for age, gender and level of impairment at wave 1. This procedure allows for exploring to what extent the predicting variables are associated with change in disability between wave 1 and wave 2.

In Table 4, the results of the three models are given for the component of impairment. Similar results were obtained for the component activity and participation restrictions [129]. Model 1 investigates the joint effect of income and education (the SEP indicators) on impairment. In model 2, the joint effects of the two work-stress measures are presented. Model 3 includes all variables of the first two models simultaneously. Importantly, it is the aim of this additional model to examine potential mediation effects. These latter effects would be indicated by clearly attenuated effects of the two indicators of SEP, once the work stress measures are introduced in the model. In Table 4, incidence rates ratios are given together with the level of statistical significance and confidence intervals.

The results of Table 4 are as follows: In models 1 and 2, significant effects of gender (women), age (older), socioeconomic position (lower), and work stress (both measures) on impairment scores were confirmed in multivariate analysis. Turning to model 3, we observe an attenuated effect of the two indicators of SEP on impairment scores, compared to model 1. In case of education and income, incidence rate ratios are reduced from 1.19 to 1.16 and from 1.11 to 1.10 respectively. Although this statistical attenuation effect is modest, a partial mediation of the SEP – impairment association by stressful work can be assumed.

Table 4. Predictors of impairment: results of multilevel Poisson regression models: incidence rate ratios and significance level (n=4864). Source: [129].

Variables	Model								
	1			2			3		
	IRR	CI (95%)		IRR	CI (95%)		IRR	CI (95%)	
Sex									
Male									
Female	1.06*	1.01 to 1.11		1.06*	1.01 to 1.10		1.06†	1.01 to 1.11	
Age group									
<55 years									
55–59 years	1.07†	1.02 to 1.12		1.07*	1.01 to 1.12		1.07†	1.02 to 1.12	
60–65 years	1.11‡	1.05 to 1.18		1.13‡	1.06 to 1.20		1.12‡	1.05 to 1.19	
Education									
High									
Medium	1.08†	1.02 to 1.15					1.07*	1.01 to 1.13	
Low	1.19‡	1.12 to 1.27					1.16‡	1.09 to 1.24	
Income									
High									
Medium	1.07†	1.02 to 1.12					1.06*	1.01 to 1.12	
Low	1.11‡	1.05 to 1.18					1.10†	1.03 to 1.17	
Low control									
No									
Yes				1.10‡	1.04 to 1.15		1.07†	1.02 to 1.13	
Effort reward imbalance									
No									
Yes				1.12‡	1.07 to 1.17		1.10‡	1.05 to 1.15	
Prior impairment state	1.24‡	1.22 to 1.25		1.25‡	1.23 to 1.26		1.23‡	1.22 to 1.25	

Moderation

According to the moderation hypothesis, it is stated that the effect of adverse psychosocial working conditions on ill-health is stronger in lower occupational grades. As argued above, this hypothesis has not yet been tested to a sufficient extent although an obvious assumption posits that employees of higher occupational grade dispose of more resources, both at work and outside work, which buffer the effects of adverse working conditions, than is the case among employees of lower occupational standing. With respect to the effort-reward imbalance model, some evidence with regard to a moderation effect was demonstrated in the British Whitehall II study, where the effect of ERI on risk of myocardial infarction was considerably stronger among employees of lower occupational grade than among those of higher grade [145]. With regard to depression, we are not aware of any prospective

study that has investigated differential effects of psychosocial work environment exposures by occupational grade.

Therefore, two important aims of a large prospective study conducted in Denmark were: (i) to investigate the contribution of adverse psychosocial working conditions, conceptualised by the ERI-model, on risk of onset of severe depressive symptoms in a representative sample of the Danish workforce and (ii) to analyse whether the effect of ERI on risk of depressive symptoms is differential across occupational grades. It is this latter question which matters most in the current context of this report.

The Danish Work Environment Cohort Study (DWECS) is a longitudinal study on work and health in Denmark, initiated in 1990 [146]. The present analyses are based on DWECS 2000 (baseline) and DWECS 2005 (follow-up). In 2000, a representative sample of 11,437 Danish residents was approached, of which 8,583 (75%) responded to the survey. Among the respondents, 4,977 were gainfully employed with complete data on the ERI-measure. Of those, 3,470 (70%) responded to the follow-up survey. We excluded 646 participants who were no longer gainfully employed and 123 participants with missing values on key variables or with severe depressive symptoms at baseline, yielding a final study sample of 2,701 participants – 1,366 women and 1,335 men. Mean (SD) age was 40 (9.4) years [146].

We calculated odds ratios (OR) and 95% confidence intervals (CI) with multiple logistic regression models using ERI and occupational grade in 2000 as the predictors and onset of severe depressive symptoms in 2005 as the outcome. Covariates were included in two models: Model 1 was adjusted for gender, age, family status, health behaviours and survey method. Model 2 was further adjusted for self-rated health, sleep disturbances and non-severe depressive symptoms at baseline. ERI and occupational grade were adjusted for each other in both models.

To test the hypothesis of main interest, odds ratios and Rothman's synergy index were calculated to estimate the joint effect of high ERI and low occupational grade. We dichotomised ERI into low/medium vs. high, and occupational grade into high (grades I+II) vs. low (grades IV+V). The intermediate occupational grade category III was omitted. The combination of ERI and occupational grade resulted in four groups: (1) low/medium ERI and high occupational grade (reference group); (2) low/medium ERI and low occupational grade; (3) high ERI and high occupational grade and (4) high ERI and low occupational grade.

Table 5. Joint effect of ERI and occupational grade in 2000 on risk of onset of severe depressive symptoms in 2005 among 1729 employees of either low or high occupational grade from the Danish Work Environment Cohort Study. Logistic regression analysis: Model 1: Analysis adjusted is for gender, age, family status, survey method and health behaviours (smoking, heavy alcohol consumption, leisure time physical activity); Model 2: further adjustment for self-rated health, sleep disturbances and non-severe depressive symptom score (53–100) at baseline. Source: [146].

	At risk	Cases	Model 1	Model 2
	N	N (%)	OR (95% CI)	OR (95% CI)
Combination of ERI and Occupational Grade				
Low/Medium ERI & high grade (I+II)	652	17 (2.6)	1 (reference)	1 (reference)
Low/Medium ERI & low grade (IV+V)	611	19 (3.1)	1.36 (0.68–2.71)	1.45 (0.72–2.92)
High ERI & high grade (I+II)	313	14 (4.5)	1.83 (0.88–3.81)	1.26 (0.59–2.70)
High ERI & low grade (IV+V)	153	12 (7.8)	3.46 (1.56–7.68)	2.43 (1.07–5.53)

The results displayed in Table 5 demonstrate a significant, 2,4-fold increased relative risk of incident severe depression in the group defined by the joint presence of low occupational standing and high level of work stress compared to the more privileged group defined by high occupational position and absence of stressful work. Although the synergy index exceeded the value of 1.0 large confidence intervals of this estimate were observed.

The additional results provided by these two studies complement the current state of the art with regard to the two complementary mediation and moderation hypotheses. Thus, we now dispose of some accumulated evidence on pathways linking socioeconomic position and work stress with reduced health of working populations.

3.5 Unfair employment: The context of national labour and social policies

3.5.1 Proximal and distal determinants of stressful work

In the Introduction we explained our conceptual framework of analysing associations of unfair employment conditions with unequal health. We argued that it is not possible to test such a comprehensive framework within a single empirical study or with a set of investigations. Yet, it was proposed that at least part of this complexity can be studied, in particular the links between proximal and distal determinants of unfair employment in terms of exposure to a stressful psychosocial work environment. In this context we proposed to test three innovative hypotheses on the basis of available data from SHARE, a cross-national longitudinal survey that offers retrospective life history data of persons with a substantial employment career in combination with a self-assessment of the quality of their main job. Moreover, as SHARE includes 13 European countries with different labour and social policies contextual information on these policies can be integrated in a multilevel analysis of this data set. The following hypotheses were proposed: With hypothesis 1, we assume a dose-response relationship between the degree of childhood adversity and the degree of stressful work experienced later on. With hypothesis 2, we assume that this association is partly mediated by a disadvantaged

access to the labour market. With hypothesis 3, we assume that the average level of stressful work among participants in a country is closely related to the extent to which protective and integrative policies are implemented at national level. Less developed policies go along with higher average levels of work-related stress.

In this section we provide the main finding of our test of these hypotheses using SHARE data. While details on the methods including the sample description and the justification of statistical analyses can be found in the original paper [21] the following information is needed to interpret the findings.

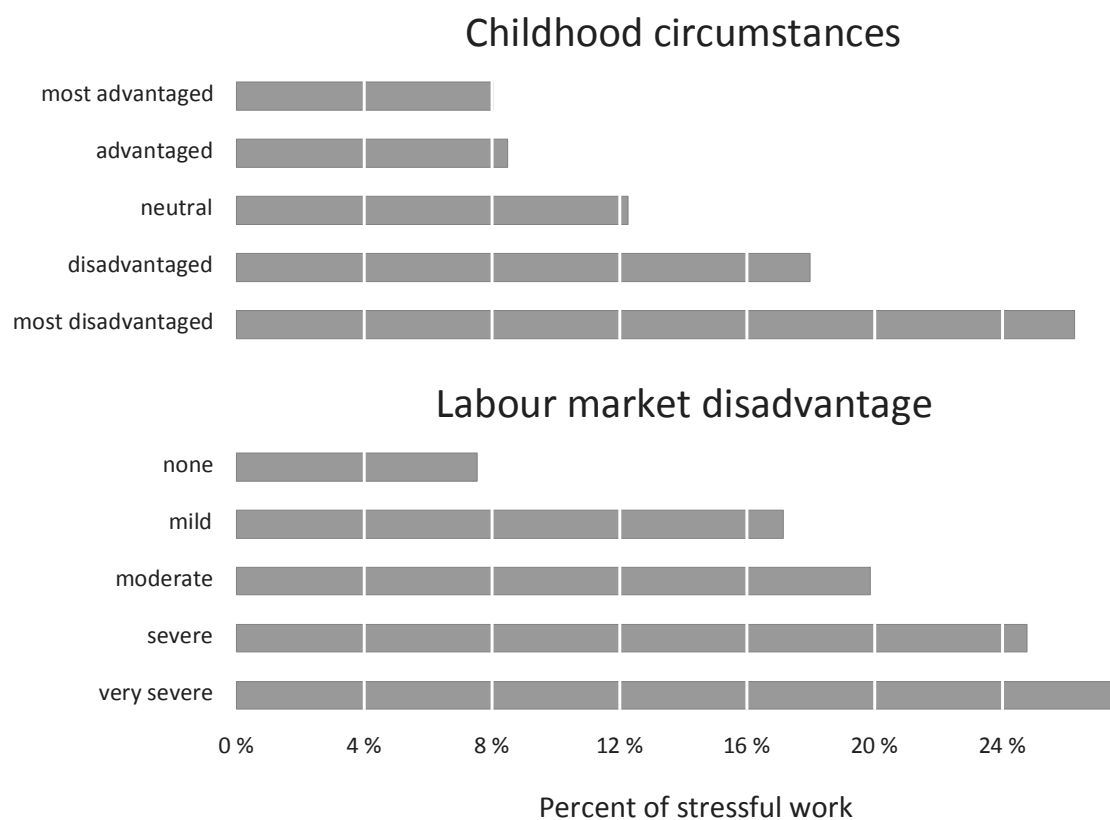
First, we use data from the third wave of SHARE, with retrospective information on individual life courses collected among 11,181 retired men and women in 13 European countries (2008-2009). The countries are Denmark, Sweden, Austria, France, Germany, Switzerland, Belgium, the Netherlands, Spain, Italy, Greece, Czech Republic and Poland. In all countries, the sample selection was based on probability household samples where all people plus their partners were interviewed. In total, 26,836 participants were interviewed at wave 3. In the following analyses we included all people who already left the labour market at the time of wave three, provided they documented an employment history of at least five years. Restricting the sample to people who left the labour market enabled us to compare employment careers over the whole life course. Importantly, we also excluded respondents older than 80 years as the time since last employment was considered too long for accurate retrospective assessment. We also excluded respondents with documented difficulties of answering the retrospective life history questionnaire (about 4% of the total sample). These restrictions resulted in a final sample with full available data of 5,552 men and 5,629 women (N= 11181), born between 1928 and 1959.

Second, concerning the measurement of core variables we assessed stressful work with a summary index of 16 Likert-scaled items, ranging from 0 (no stress) to 48 (high stress), and we constructed a binary variable (high vs. low stress; cut point >32). Proximal conditions in terms of adverse childhood conditions were assessed with four binary indicators reflecting respondents' circumstances at age 10: father's occupational position; overcrowding, housing quality, and sociocultural environment (estimated number of books at home). Additional data on labour market disadvantage (4 items) were included. With respect to distal conditions we used two indices, developed by OECD, that assess two relevant dimensions of labour market policies in case of threats to employment, in particular due to disability, i.e. compensation policies and integration policies [147,76]. Technically, each index is constructed by the availability and quality of ten policy programmes evaluated by experts for each country separately on a score ranging from 0 to 5. We included respective data for three years, 1985, 2000 and 2007. Thus, a country mean score was computed for each indicator. In addition to age, sex, age of retirement, we included two measures of disability, mainly as control variables in multivariate analyses.

Third, concerning statistical analyses, we first document associations of the two indices of proximal factors with stressful work. In Figure 18, we display percentages of stressful work by childhood adversity and labour market disadvantage. Next, to explore associations between distal factors, the two policy indices of compensation and integration, and stressful work, two scatterplots are displayed – one for each policy index (Figure 19). Importantly, to account for population compositions and its effect on work stress (e.g. more jobs in lower occupational positions in a country, and thus, more exposure to stressful work), mean scores of stressful work are adjusted for age, gender and all individual characteristics described above. To test our core research questions in detail, we estimated a series of multilevel linear models (random intercept only) using the sum score of stressful work as dependent variable with individuals (level 1) nested in countries (level 2). These data are not presented here, but can be retrieved from the original paper [21].

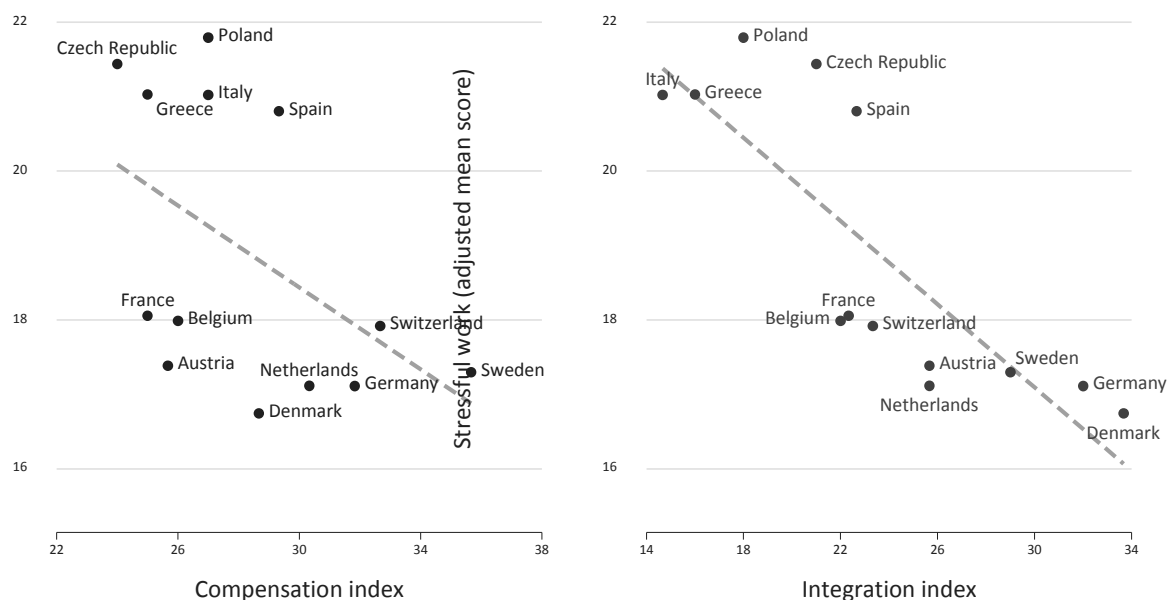
The results of hypothesis 1 are displayed in Figure 18. As can be seen, childhood circumstances and labour market disadvantage are clearly related to the prevalence of stressful work. For both variables, we see a stepwise increase of percentage of stressful work with each level of adversity, with significant results in both cases (Childhood circumstances: $\chi^2(4) = 329.35$, $p < 0.001$, labour market disadvantage: $\chi^2(4) = 164.47$, $p < 0.001$). The detailed results of multilevel analyses indicate that, when combining these two explanatory variables into one model, the regression coefficients of childhood circumstances are generally attenuated, indicating that part of the association between disadvantaged childhood circumstances and stressful working conditions is due to labour market disadvantage (hypothesis 2).

Figure 18. Percentage of stressful work according to level of childhood deprivation (upper part) and labour market disadvantage (lower part). N = 11,181 older men and women from the SHARE survey. Source: [21].



Hypothesis 3 maintains that the two distant policy indicators are associated with mean levels of stressful work at national level, such that more extensive integration and compensation policies go along with lower mean levels of stressful work. As can be seen from Figure 19 mean scores of stressful work (adjusted for country composition) are plotted against the two policy indices. In case of the compensation index, associations are slightly less pronounced as we observe a group of countries with low compensation scores (low levels of system generosity) and low mean level of stressful work (Austria, France, Belgium) ($R^2=24.2$). In contrast, an almost linear association is observed in case of the integration index where more pronounced integration policies are related to lower mean scores of stressful work ($R^2=66.5$).

Figure 19. Adjusted mean scores of stressful work among older men and women (N=11181) and policy indices. Mean scores of stressful work are adjusted for sex, age, retirement age, periods of disability, job absence due to disability, childhood circumstances (occupational position of main breadwinner, number of books, housing conditions and overcrowding) and labour market disadvantage (occupational position in main job, involuntary job loss (laid off and plant closure) and period of unemployment). Source: [21].



These results were substantiated by a series of regression models performed in the frame of multilevel analyses. They demonstrate that the variation of stressful work between countries is only moderately explained by country compositions. In contrast, in a model that includes one of the two distal determinants, the index of national integration policies, a proportion as high as 80 per cent of the between-country variation of stressful work is explained (hypothesis 3).

In conclusion, the findings of this study support the notion that the average level of stressful work experienced by employees of a country varies to some extent according to the degree to which distinct national labour and social policies are implemented. In our case, this holds particularly true for integration policies which support the efforts of disabled, chronically ill and unemployed people to return to paid work. As the risks of disability, chronic illness and unemployment are unequally distributed among employed populations, leaving those in lower socioeconomic positions at higher risk, these policies have the potential of contributing to a reduction of the social gradient of adverse working conditions and their negative effects on the health of working people [13]. However, it is not clear so far whether the strength of associations between stressful work and health at the level of national samples of employees can be attenuated at all by the existence of strong labour and social policies which are thought to provide some protection against the threats of fierce market forces to which vulnerable groups are exposed. It is this latter question that we addressed in a further study conducted in the context of the DRIVERS project.

3.5.2 Work stress and depressive symptoms: impact of national labour and social policies

It is of theoretical and practical interest to know whether distinct national labour and social policies have an influence on work-related health problems. Conceptually, these policies may be of importance in at least two ways: First, they may exert an influence on the prevalence of a stressful work environment. Second, they can modify the effect of stressful work on health and wellbeing [148]. The first assumption has been supported previously and existing evidence (based on comparative European data) indicates that national active labour market policies (ALMP) are related to better working conditions, in particular those policies that promote further education and workplace training among older people [24,25]. However, the evidence for the second assumption is still limited [149-151]. This limitation is partly due to a lack of cross-national studies, but also to the problem of how to define and measure relevant aspects of labour and social policies. While ALMP may promote psychosocial working conditions in general, one may assume that their impact on the health-adverse consequences is different. For instance, aspects of employment protection may be more important in this case. In this contribution we set out to overcome these limitations by studying the following research question: Can we observe protective effects of distinct favourable national labour and social policies on the strength of associations of stressful work with health, and specifically with the presence and severity of depressive symptoms?

Here, we propose to focus on core aspects of national labour and social policies which may represent protective resources in our context (see below). Rather than relying on established typologies of national welfare regimes [152,153], we maintain that the following more specific policy measures are better suited to reflect protective policy effects: (1) the amount of the state's investments in active labour market policies (ALMP), (2) the degree of employment protection provided by the state, and (3) the degree of distributive justice as reflected, e.g. in the amount of income inequality. The first measure may protect workers against the threat of being excluded from a core social role in adult life [108], whereas the second measure protects those who are at risk of being excluded due to job loss [154]. With the third measure a relevant collective sense of fairness is identified which may mitigate stressful experience of inequity at work [155]. All three aspects of national labour and social policies exert their effect on wellbeing of employees by reducing the amount of threat experienced in case of job instability, forced retirement, major income shocks, degradation, or loss of job autonomy.

In terms of theories of stressful experience, these threats to occupational status affect workers' mental and physical health as they undermine essential feelings of continued control and reward at work [114]. As the notions of control and reward are embedded in the two work stress models applied in a majority of our research projects – the demand-control and the effort-reward imbalance models – our conceptual approach enables us to link distinct macro-structural contexts with individual-level experience of work and health. The impact of stressful work on depressive symptoms, as well as potential protective resources provided by national labour and social policies, are of particular relevance in view of an ageing workforce. Therefore, in this contribution we analyse our research question by referring to three longitudinal surveys of older employees (50 to 64 years) with similar study designs and well comparable measurements of core variables.

Data were obtained from three longitudinal ageing studies, 'the Survey of Health, Ageing and Retirement in Europe' with information on 11 European countries (SHARE, Release 2.3.0), the English Longitudinal Study of Ageing (ELSA, Release 2, [156]) and the US Health and Retirement Study (HRS, 2004 Final V1.0, HRS 2006 Final V2.0, RAND Version J, [134]). To allow cross-national comparisons all studies were developed in close coordination. The countries are Denmark, Sweden, England, Austria, France, Germany, Switzerland, Belgium, Netherlands, Spain, Italy, Greece and the United States. The studies are based on representative samples of individuals aged 50 and older with ongoing waves of data collection in two-year intervals covering a variety of sociological, economic and health-related topics. The sample is restricted to men and women aged 50–64 years reporting to do

any paid work in 2004. Moreover, to study new incidences of clinically relevant depressive symptoms between both waves, all participants with increased depressive symptoms in 2004 were excluded. This restriction results in a total sample of 5,650 participants with full data.

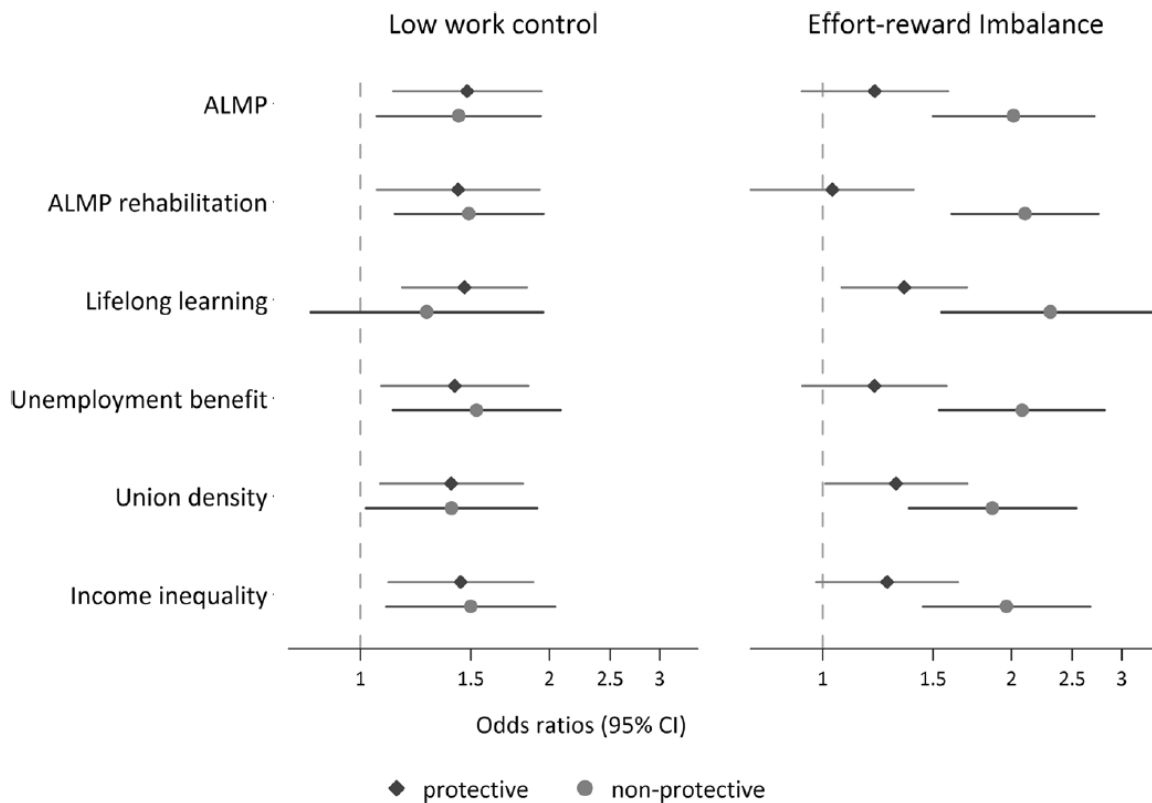
Macro-structural indicators: Six macro indicators were selected from OECD online databases [157,158]. The first three indicators represent the dimension of the state's active labour market policy, indicators four and five capture the degree of employment protection by the state, and indicator six measures the level of distributive justice in terms of income distribution. The six indicators are as follows: (1) the overall level of ALMP expenditures (percentage of gross domestic product (GDP)); (2) the amount of investments in rehabilitation services (percentage of GDP); (3) the extent to which older working people (55+) participate in continued learning (participation rate); (4) the extent of income maintenance and support for unemployed persons (percentage of GDP); (5) the degree of union density (percentage of workers belonging to any trade union); (6) the degree of income inequality measured by the Gini coefficient.

To test the hypothesis, i.e. the potential modification of the effect of work stress on depressive symptoms by the macro indicators, we first explored associations between work stress and depressive symptoms according to the macro indicators within stratified analyses [48]. More specifically, each macro indicator was dichotomised, based on the respective country rank order, and was labelled 'protective' or 'non-protective' accordingly. On this basis, Figure 20 presents odds ratios estimated for both macro groups separately, and thus, allows us to compare visually the strengths of associations between protective and non-protective policies (for each of the six macro indicators and for both work stress models). To allow for precise comparisons of odds ratios between protective and non-protective groups, we retain the symmetry of odd ratios and present them on a logarithmic scale.

The core result of these analyses is visualised in Figure 20. It demonstrates that odds ratios in the case of one of the two work stress models, demand-control (control only) are generally similar in the two groups. In contrast, with respect to the complementary work stress model (effort-reward imbalance), we see that the effect sizes of associations between work stress and depressive symptoms are generally stronger in a 'non-protective' policy context, compared to a 'protective' policy context, thus lending partial support to our research hypothesis..

The statistical analyses on which the visualisation is based included a formal test of whether the documented effect sizes are significantly different between protective and non-protective contexts. In fact, this was the case in four out of six indicators with regard to the effort-reward imbalance model (for detail see [48]). To our knowledge, this is the first study that indicates a potential moderating effect of selected indicators of 'protective' labour market policies on the strength of associations of work stress (effort-reward imbalance model only) with depressive symptoms, analysed on the basis of national samples of formerly employed men and women from 13 countries. Clearly, several limitations of the study need to be taken into account (see chapter 4, Discussion), and further empirical support will be required.

Figure 20. Associations of work stress and elevated depressive symptoms at follow up stratified by policy context (protective vs. non-protective). Results of multilevel models (odds ratios and 95% confidence intervals). Source: [48].



3.5.3 The social gradient of stressful work: does the policy context matter?

It has been shown in Section 3.3.2 that work stress often follows a social gradient, with higher levels of work stress among workers in more disadvantaged socioeconomic positions (SEP). This finding is relevant in so far as work-related stress is an important intermediate factor linking low SEP with poor health. Most existing studies supporting this 'mediation' hypothesis, show that associations between SEP and health are generally reduced once work stress is considered in multivariate analyses [30,159,160] (see also Section 3.4).

In the context of policy determination, however, it is essential to assess the influence of specific national policy regulations on the magnitude of the association between SEP and work stress by taking a cross-country perspective. An open question is whether different types of labour market policies also have an impact on the strength of socioeconomic differences in work stress. For example, policies offering financial compensation in case of job loss (e.g. replacement rate) may reduce socioeconomic differences in work stress, because they offer financial security employees can rely on [161]. In other words, as long as individuals' standard of living entirely depends on market performance, it is likely that levels of work-related stress are more pronounced amongst people in less advantaged social and economic circumstances. In a similar way, policies supporting those who experience difficulties on the labour market may be important as well. For example, active labour market policies (ALMP) and lifelong learning opportunities may enhance the skills of employees with lower educational levels and promote their (re-) integration into the labour market [162].

Hence, in this section we set out to investigate whether national policy regulations are associated with reduced socioeconomic differences of stressful work. To this end, we use cross-sectional data from the two studies on ageing as before, with information collected 2010/2011 in 16 European countries,

the 'Survey of Health, Ageing and Retirement in Europe' (SHARE, 15 countries) and the 'English Longitudinal Study of Ageing' (ELSA). In each country nationally representative samples of individuals aged 50 and older were drawn, and participants answered questions on a variety of sociological, economic and health-related topics in a face-to-face interview. The initial response rates at study onset are 70% in case of ELSA and 61% for the total SHARE sample. Because we were interested in work stress, we restricted the sample to all employed men and women. Further, we excluded men and women aged 65 or older, because they may both have better working conditions and higher education. This results in a sample of 13,695 respondents (51.7% women) aged 50 to 64 with full available data on all variables. For the analyses, calibrated weights are applied for descriptive purposes. These weights are calculated for each country separately and help to compensate for unit non-response.

In a first step, we study educational differences in work stress as measured by the two work stress models described in Section 3.3.1, the demand-control model (control only), and the effort-reward imbalance model. In the analyses, we use respondents' highest educational degree as a marker of people's socioeconomic position, as defined by the International Standard Classification of Education (ISCED). This measure explicitly considers national variations in educational systems, and thus, makes it accessible for cross-country comparisons. Education represents an important resource that predicts individuals' risks and chances in the labour market. This includes individuals' occupational position in working life and labour market disadvantage [163]. In addition, people with lower levels of education may profit specifically from the labour market policies described above, and thus, this indicator appears appropriate for our analyses (see [49]).

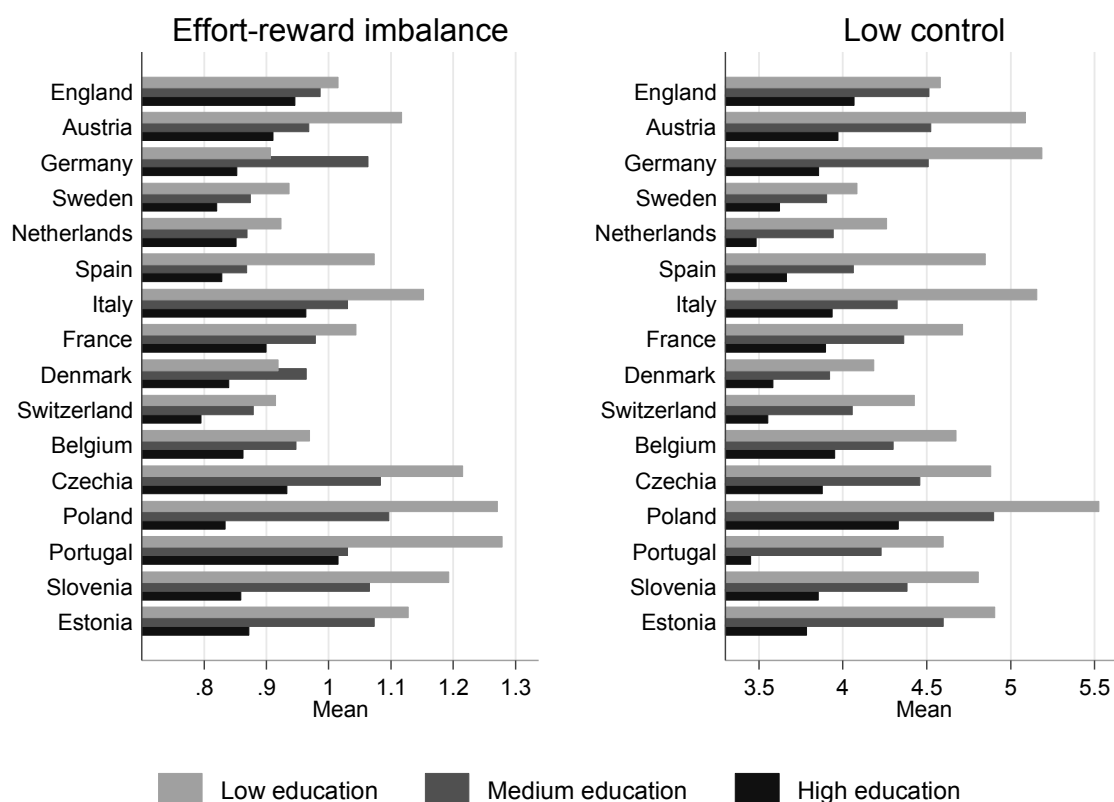
In a second step, we widen the scope of analysis by testing whether protective and integrative active labour market policies (ALMP) reduce socio-economic differences in work stress. We used four macro indicators of national labour market policies, each provided from official sources on a coherent and comparable basis. These indicators cover two relevant dimensions of labour market policies (two indicators for each dimensions), i.e. 'integrative' and 'protective' labour market policies. In case of 'protective' policies, the first measure is the so-called 'replacement rate'. This measure describes the expected financial support in the period directly after job loss as a percentage of the net income before job loss. Second, we use one indicator provided by the OECD that summarises the amount of a country's labour market expenditures into 'passive labour market policies' (PLMP), as expressed as percentage of GDP. PLMP includes two types of expenditures: investments that aim to compensate individuals for loss of wage or salary and in case of involuntary early retirement.

Turning to integrative policies, we applied one indicator measuring the extent of further education and workplace training in a country (lifelong learning), and another measuring the amount of investments into active labour market policies (ALMP). In case of lifelong learning, the indicator refers to older men and women (55 to 64) who stated that they received education or training in the last 12 months (in per cent). This information is provided by EUROSTAT and was collected in the 'Adult Education Survey' [137]. In case of ALMP, information is again expressed as percentage of GDP and comprises various policy measures of ALMP (usually classified into six different types of actions), in particular interventions that aim to promote labour market integration for groups that are disadvantaged on the labour market.

In a first set of statistical analyses, we compared levels of work stress by educational qualification for each country. To do so, Figure 21 presents average levels of work stress (for both work stress models) for each level of education. As was already apparent in the earlier analyses of Section 3.3.2, a clear-cut social gradient of stressful work is present in almost all countries, leaving those in lower positions at higher levels of stressful work. These bivariate analyses were confirmed in multivariate models, confirming the previous observation that countries with pronounced active labour market policies (ALMP) have lower levels of work stress. Similarly, the two indicators of 'protective' policies

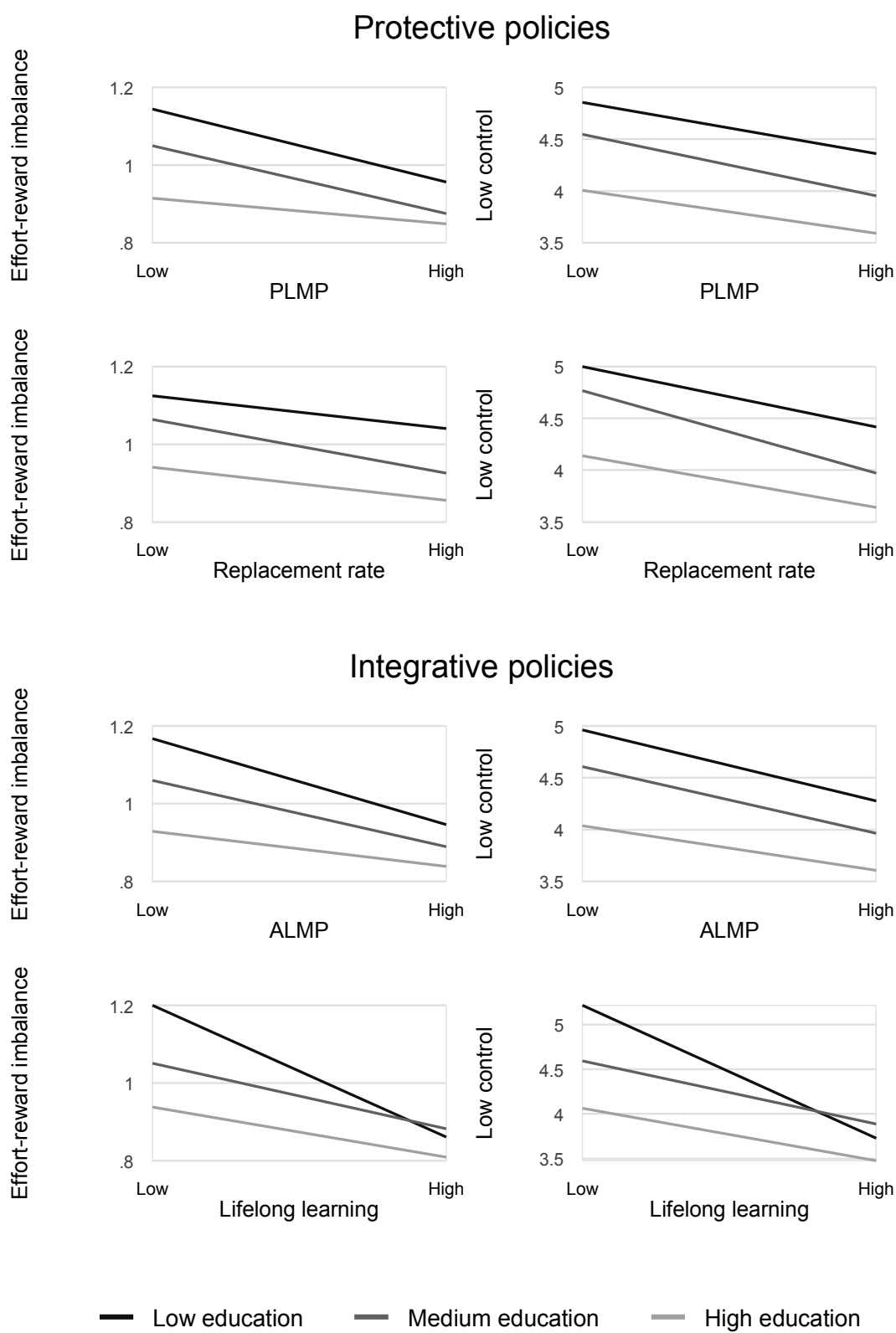
(PLMP and replacement rate) were related to lower levels of work stress, with significant results in three out of four cases (see [49]).

Figure 21. Average levels of work stress (mean score) by education and country. Results are based on weighted data. Source: [49].



In a second set of analyses, we combined all countries (pooled dataset) and studied the effects of the four policy indicators in more detail, applying linear multilevel regression models (with individuals nested in countries). In particular, for each macro indicator we estimated the two following statistical models: In model 1, associations of these macro indicators with work stress were analysed, taking into account core characteristics of population composition (e.g. age, employment status). In model 2, two cross-level interactions were added to the first model, one for medium education and another one for low education. Results of these two interaction terms inform us whether the strength of reported effects of educational level on work stress (i.e. the social gradient of work stress) differs according to degree of implementation of labour and social policies. The respective hypothesis assumes steeper gradients in countries with poorly implemented policies. The results of these analyses are visualised in Figure 22. As a general trend, they are in line with this assumption, specifically in case of indicators of integrative labour market policies. To check the robustness of respective trends, formal tests of significance were performed with likelihood ratio test.

Figure 22. Predicted levels of work stress by education at different levels of macro indicators. Expenditures into active (ALMP) and passive labour market policies (PLMP) are weighted by unemployment rate. Source: [49].



Before summarising the results of these analyses and discussing relevant recommendations that are proposed on their grounds (chapters 5 and 6), we present a summary of the achievements relating to the second aim of our project, i.e. to synthesise current evidence on feasibility and outcomes of work and health-related interventions at different levels, by critically evaluating applied methodologies and by comparing the methods of improving intervention effectiveness (chapter 4).

4 Worksite Interventions

4.1 Background

From the results of earlier sections it can be recognised that our knowledge on the distribution of occupational risks, work-related disease prevalence and causal mechanisms between occupational exposure to physical, chemical and psychosocial hazards and incidence of certain illnesses has greatly improved. At the same time, research on occupational health and safety has already delivered a large body of specific methodological and theoretical tools required for specific work settings [164]. As a general rule it has been acknowledged that interventions may be more effective at preventing the incidence of disease by giving priority to the structural characteristics of organisations, rather than concentrating on the individual behaviour of employees [165-167]. This so-called principle of hierarchy of controls has been already anchored in the European legislation on occupational health and represents the main principle of disease and injury prevention (EU Directive 89/391/1989).

However, a comprehensive methodological approach on how to achieve a substantial reduction of exposure and work-related diseases is not straightforward and depends largely on such factors as the type of organisation, the nature of work tasks, the willingness of organisations to prioritise health issues, and the degree of enforcement of occupational health and safety regulation. Moreover, workplace interventions are characterised among others by a high degree of heterogeneity regarding intervention methodology, mixed outcome results and insufficient reporting of the intervention and implementation strategies [168]. There is an ongoing debate over the definition of best-practice methods that should guide the design and implementation of interventions towards reducing the exposure to work-related hazards [169,170]. Some comprehensive approaches have been proposed based on grounded principles of occupational health and quality management. These methodological approaches of workplace interventions consist of: (1) preparation of the intervention by all stakeholders, (2) screening of available approaches and methods, (3) planning of specific measures (activities, device training, etc.), (4) implementation phase and monitoring, and (5) evaluation of the process [169].

It has been acknowledged that ‘one-size-fits-all’ solutions are not feasible in the context of organisational interventions, since these are to be understood as complex social processes involving the active participation of stakeholders within organisations [171]. There is consensus about the need to design interventions in a participative way by including workers’ representatives or the workers themselves in the planning and implementation of measures. In practical terms this implies that successful interventions depend not only on the correct identification of causality mechanisms from exposure to disease or injury, but also on the social processes that make possible the implementation of measures, the compliance to the necessary adjustments in the organisation, the engagement of employees and (line) managers and the continuous financial support to the intervention [169].

4.2 Systematic reviews on workplace interventions within DRIVERS

With this in mind, our research within the DRIVERS project aimed to (1) assess the effectiveness of workplace interventions at the individual and the organisational level on selected health outcomes, (2) evaluate potential differences of intervention effects across occupational classes, and (3) identify which improvements of the working conditions might reduce adverse health outcomes. In this final

report, we summarise some important results from two systematic reviews on workplace interventions conducted within WP3 of DRIVERS (see [32,31]). The results of this research may serve to estimate the potential benefits of workplace interventions and identify starting points for the improvement of occupational health policies aiming to reduce the burden of work-related health inequalities.

We reviewed a total of 75 workplace intervention studies involving approximately 32,000 workers and reporting 79 measurements of selected health outcomes. Depending on the units targeted by the interventions, studies were classified broadly as individual-level or organisational-level interventions. Individual-level interventions intend to elicit health-promoting behaviours and/or enhance individual resources to cope with work-related stressors. In contrast, organisational-level interventions target the structure of the organisation including the definition of work tasks and procedures, the leadership practices, the degree of autonomy and participation of employees and, in general, the structural components associated with increased exposure to work-related hazards. According to the principle of hierarchy of controls mentioned above, organisational-level interventions are expected to have a larger and long-lasting beneficial effect on workers' health by adapting the conditions of work and reducing occupational hazards from the source.

In general, the methods employed in the workplace interventions assessed in the systematic reviews can be synthesised according to the main intervention target as reported in Table 6. It should be remarked here that the intervention methods may be combined. For instance, organisational-level interventions may be extended by programmes enhancing individual coping strategies or promoting healthy behaviours.

Table 6. Principal intervention methods employed in the 75 workplace interventions reviewed in [32] and [31].

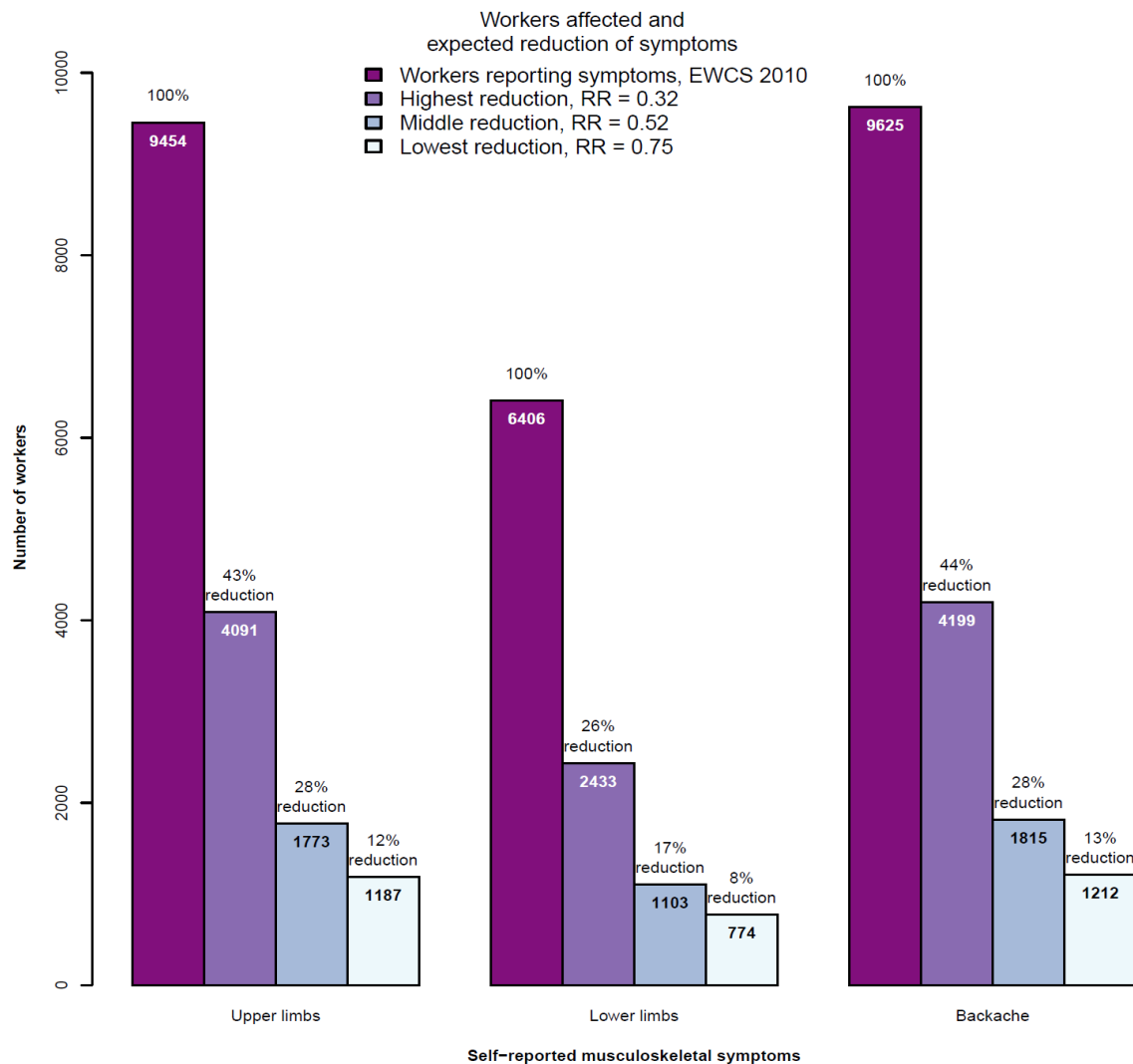
Individual level	Organisational level
Ergonomics and health education	Changes of work processes and work conditions without a participatory approach (i.e. hazards control, work brakes, changes of the decision making processes, etc.)
Health promotion and physical activity programmes	Participatory approaches such as Participatory Ergonomics and Participatory Research Action
Stress management training	Changes of shift schedules

In order to evaluate the effectiveness of interventions, i.e. to assess whether substantial reductions of exposure or incidence of adverse health outcomes were associated with the interventions, two analyses were conducted. First, randomised controlled trials (RCT) with a focus on individual behaviours were identified and a meta-analysis of intervention effects on selected health outcomes was performed [32]. Second, organisational-level intervention studies were identified and their results and implementation characteristics were synthesised in a narrative review [31].

The meta-analysis of randomised controlled interventions revealed statistically significant intervention effects comprising: a reduction of body mass index (BMI), an increase of consumption of fruits and vegetables, a reduction of self-reported musculoskeletal symptoms of the upper body, and a reduction of perceived work-related stress. Given the high prevalence of musculoskeletal symptoms and stress levels among workers (see 3.1.5 and 3.3), the results concerning these latter outcomes deserve a more detailed analysis. We would like to illustrate the potential benefits of interventions by considering

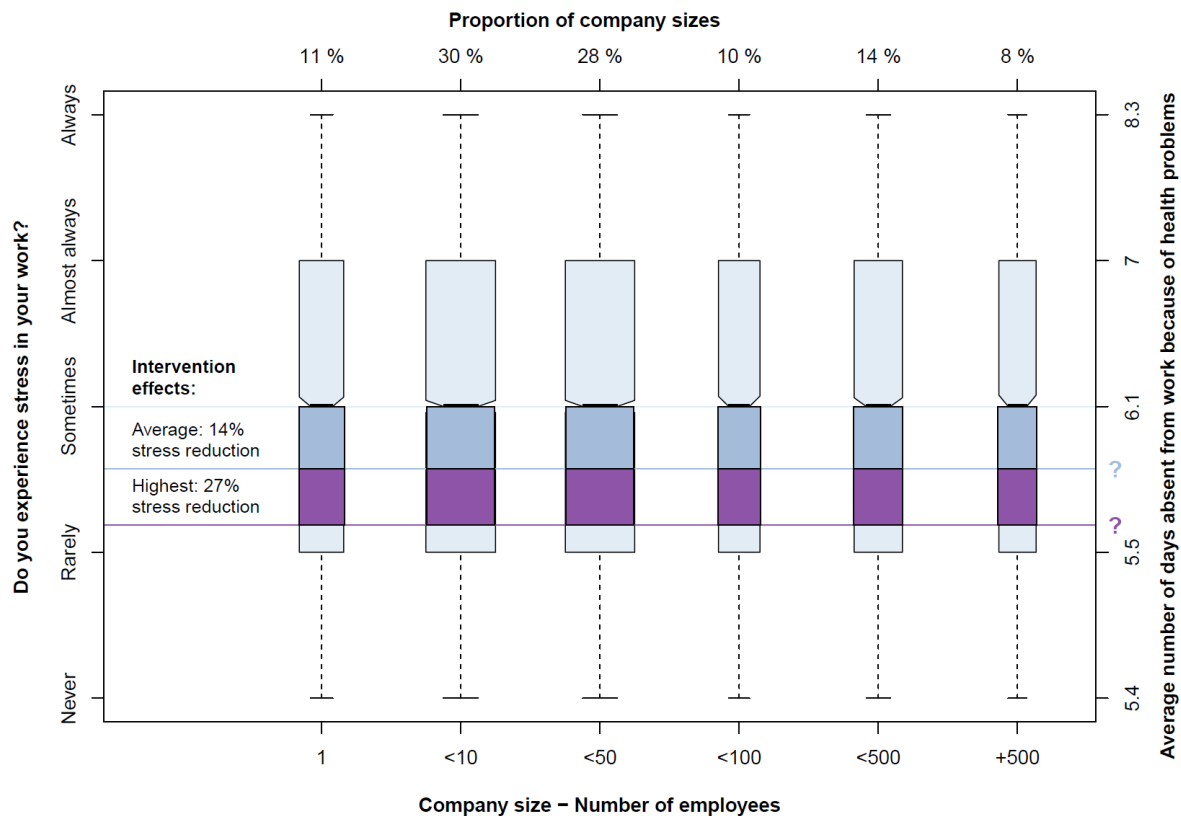
the expected reduction of prevalence of musculoskeletal symptoms and the reduction of reported stress levels.

Figure 23. Expected reduction in the number of workers reporting musculoskeletal symptoms assuming the overall intervention effects reported in [32]. RR = Relative risk calculation based on [172]. Expected percentage reduction of cases based on the population attributable fraction formula [173], p. 83 f.



In Figure 23 we considered the raw prevalence of musculoskeletal symptoms from the European Working Conditions Survey 2010 (EWCS) in the former EU-15 Member States. According to the results reported in [32], the expected intervention effect on musculoskeletal symptoms is -0.32 (95% CI -0.51, -0.14). In terms of relative risks (RR), this intervention effect would imply an average risk reduction of 0.52 (95% CI 0.32, 0.75) between workers participating in the intervention and workers excluded from the intervention. At the population level, these risk reductions mean that in the best-case scenario, workplace interventions would elicit a 43% reduction of the number of workers reporting musculoskeletal symptoms. On average, interventions may reduce the prevalence of symptoms by 28%, and in the case of lowest effects, the prevalence would still be reduced by 12%.

Figure 24. Potential beneficial effects of interventions on stress levels and average number of days absent from work by company size. Stress levels and company size proportion estimated from the EWCS 2010 (EU-15). The overall intervention effects are based on the estimates reported in [32]. The averages of the number of days absent from work were obtained by calculating a mixed hurdle model with data from the EWCS 2010 (EU-15 countries). Absenteeism estimates adjusted for country, region, demographic characteristics and several working conditions. Complete results from these models can be requested from the authors.



In Figure 24 we considered the raw prevalence of stress levels and the adjusted number of days absent from work by company size with data from the EWCS 2010 in the former EU-15 Member States. According to the results reported in [32], the expected intervention effect on perceived stress levels is -0.37 (95% CI $-0.71, -0.04$). This intervention effect would imply an average reduction of stress levels of 14% (95% CI 0%, 27%) between workers participating in the intervention and workers excluded from the intervention. Assuming that stress levels have some causal association with the number of days absent from work, a substantial reduction of stress levels may be paralleled by a substantial reduction of absent days. Since the majority of workers are employed in small to medium-sized enterprises with fewer than 100 employees (about 78%, see Figure 24) and since there is some evidence that smaller establishments report less psychosocial risk management in comparison to larger establishments [174], the results of our meta-analysis point to large potential benefits for a substantial proportion of the European workforce.

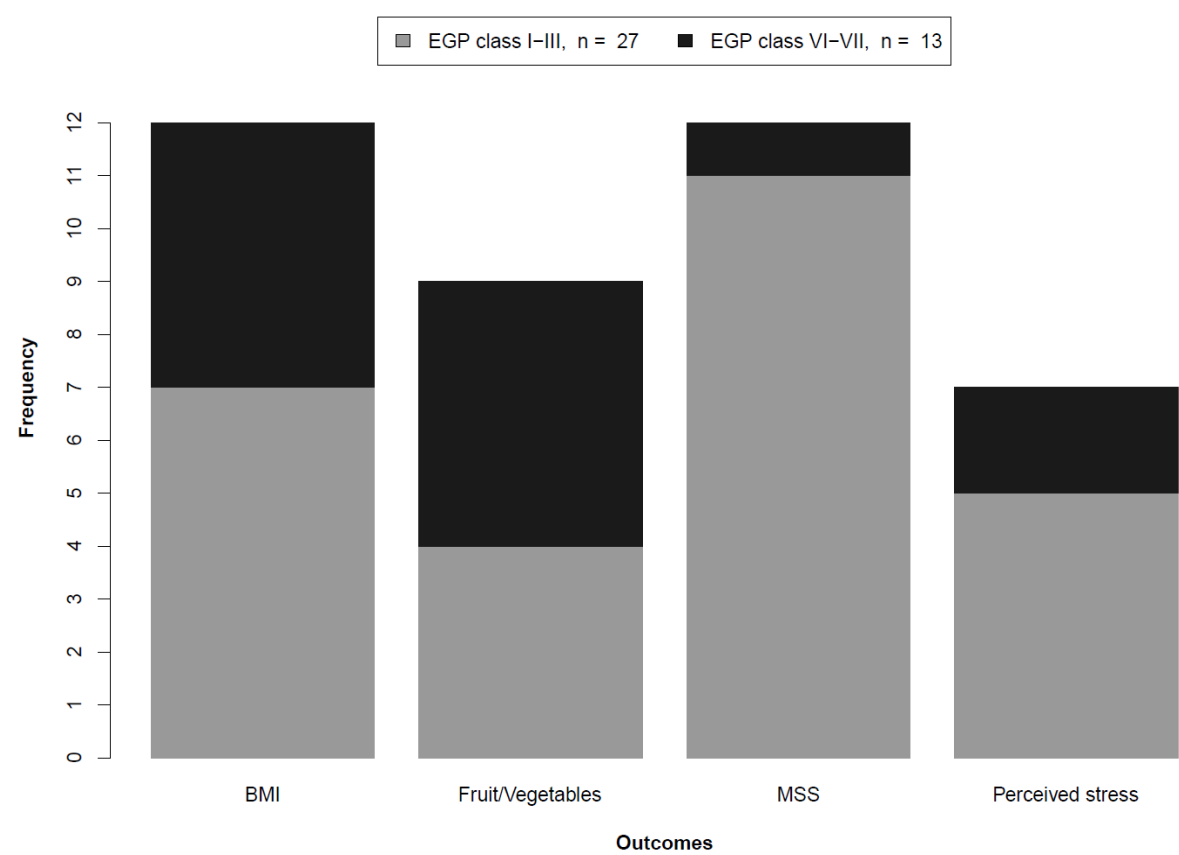
Even though the effects of organisational-level interventions on health could not be summarised by meta-analytical methods as before, and in spite of the mixed results and other methodological deficiencies of several studies considered in our review (see details in [31]), there were important results concerning the potential benefits of organisational-level interventions. First, 18 out of 39 studies reported significant improvements of health-related outcomes such as ischemic heart disease risk, burnout, lost time injury, perceived health, blood pressure, decreased mental distress and better sleep, reduction of sick-leave length, back-pain related lost working days, eczema incidence, mental

health, self-rated health and injury rates [31]. Second, our analyses suggest that more comprehensive interventions addressing several organisational-level targets simultaneously had a higher chance of reporting significant health improvements than those restricted to one intervention target. This means that the combination of a hierarchy of controls approach with specific improvements of technical, chemical or physical elements of the work environment and, at the same time, improvements of the division and organisation of work and time schedules, may contribute to a substantial reduction of risk exposure and related adverse health effects. Third, the analysis of failed interventions pointed to major barriers to the successful implementation of interventions. These barriers comprise among others the insufficient participation of employees in preparing the intervention, a lack of motivation to support and comply with organisational changes, and accidental or external events such as personnel turnover that impeded the implementation of measures as originally designed.

4.3 Some limitations and further research

The results summarised in sections 3.1, 3.2 and 3.3 highlight the social gradient associated with work-related exposure to physical, chemical, biological and psychosocial hazards. In the workplace interventions literature, however, the inequality of exposure does not seem to be sufficiently recognised. To some extent, this might be due to the fact that not only systematic risk assessments based on occupational health principles but also health surveillance strategies at the company level are usually inexistent. Thus, risk factors and exposure levels for the specific samples are not being systematically documented. These deficiencies may hinder the prioritisation of interventions among workers exposed to more adverse working conditions and explain the predominance of studies conducted among managerial, professional and clerical occupations. As a matter of fact, we found that at least 47 out of 75 intervention studies were conducted among managerial and services occupations, most notably among nurses or, in general, health care workers, whereas only 28 studies were conducted exclusively among skilled or semi-skilled manual occupations (see Figure 25). This situation might be aggravated if it is taken into account that the burden of exposure is usually higher among workers in temporary employment, manual occupations, and the self-employed [175].

Figure 25. Frequencies of the occupational class of samples and outcomes of randomised controlled interventions. Occupational class corresponds to the EGP classes I-III: managerial, professional and clerical occupations, and VI-VII: manual skilled and semi-skilled manual occupations. Source: [32].



Part III. Conclusions

5. Summary of results

In chapter 3 of the Results section we demonstrated how aims 1 and 3 of DRIVERS work package 3 on fair employment were achieved by our research programme. With findings drawn from systematic reviews and from secondary data analyses that we performed on the basis of newly available data from European surveys (esp. SHARE, EWCS) we updated and extended the knowledge base on associations of social inequalities, work and health in several respects.

First, we documented strong and persistent social inequalities in exposure to health-adverse work environments, resulting in unfair (because avoidable) employment. These inequalities became generally apparent as social gradients, with higher exposure rates among people in lower occupational positions. This was demonstrated for distinct chemical, physical and biological hazards, most convincingly for biomechanical and physical exposures inherent in jobs characterised by repetitive movements, rapid work pace, vibration, or high-force demands, among others, with elevated risks of musculoskeletal disorders (upper body symptoms) among workers classified by ISCO categories 6 to 9. People employed in jobs of ISCO categories 3, 8 and 9 were more often exposed to carcinogen substances, whereas biological pathogens were more prevalent among health care professionals as well as agricultural workers. On balance, workers with lower degrees of qualification and lower positions in occupational hierarchies suffer from substantially heavier exposure to these occupational hazards and, thus, carry a higher burden of disease following from this exposure. Importantly, social gradients were also demonstrated for elevated unemployment risks, job instability, lack of career prospects and low wages associated with riskier work environments. Inequalities in fair employment seem to be largely related to the opportunity structure of the labour market where those who are deprived from alternative choices are worst off. Finally, we demonstrated the social gradient of a health-adverse psychosocial work environment, as measured by two leading complementary theoretical models of stressful work, demand-control (control only) and effort-reward imbalance. We can conclude from these findings that in a majority of unhealthy working and employment conditions experienced by the European workforce, exposure to these conditions follows a social gradient, with higher prevalence the lower people's socioeconomic positions are.

Second, we produced new scientific evidence on associations of stressful psychosocial work (in terms of the two models mentioned) with reduced mental health (measured by clinically relevant depressive symptoms) and with elevated scores indicating disability risks (impairment and restriction in activities and participation). This evidence is prominent as it was largely drawn from longitudinal study designs (thus minimizing reverse causation) and as it was derived from large samples representing employed men and women from 10 or more European countries. The findings support previous results obtained from studies conducted within single countries which, however, documented further associations of stressful psychosocial work with additional health risks, in particular coronary heart disease (CHD). As no validated information on CHD was available in SHARE, this aspect could not been explored, but more recent results from a collaborative meta-analysis of different European cohort studies provided respective evidence for either work stress model [126,176].

Third, we contributed to a better understanding of pathways linking social inequalities with work-related poor health by studying the complementary hypotheses of mediation and moderation. The first hypothesis assumes that part of the association of socioeconomic position with health is due to the fact that people in lower positions experience unhealthy working conditions more often than those in higher positions. Results from our systematic review lend some support in favour of this hypothesis, specifically if working conditions are defined as a combination of physical hazards and job strain (i.e. high demand and low control). In one of our papers we tested this hypothesis with regard to links

between socioeconomic position, stressful work and disability risk, but the mediating effect was relatively weak. Overall, a higher degree of standardisation in this research area is needed in order to draw firm conclusions from respective results. This also holds true for the moderation hypothesis which claims that the effects of stressful work on health are more pervasive among employed people in lower social positions because protective mitigating resources and coping abilities are less frequent among them. Evidence of such moderation effects is of particular policy interest as it can instruct the choice of target groups and priorities in intervention efforts. We illustrated the relevance of moderation by referring to recent results from a representative study of the Danish workforce, where the combination of low occupational position and stressful work in terms of effort-reward imbalance resulted in a significantly increased risk of severe depression.

The fourth aspect by which we extended the current knowledge base on social inequalities, work and health, is probably the most interesting and challenging one as it simultaneously relates to aim 3 of our programme, i.e. the development and application of a theoretical model which links national labour and social policies with unhealthy work. We proposed an extended framework in analysing stressful work by integrating proximal determinants in terms of people's disadvantaged access to the labour market, partly reflecting social deprivation in childhood and adolescence. In addition, and most importantly, we claim that distinct well-developed labour and social policies at the national level contribute to an average improvement of health-adverse working conditions in respective national working populations. This holds particularly true for active labour market policies integrating disadvantaged groups of adult men and women.

In a next step, we tested these notions in the frame of a unique data constellation available from the SHARE study. This constellation is given by the fact that retrospective life history data were collected, together with data on stressful work, from samples recruited from different European countries. At the same time, indicators of distinct national labour and social policies could be retrieved from an OECD database and integrated in this SHARE data set by applying multilevel statistical analysis. Three innovative findings became apparent by this approach. First, we demonstrated higher levels of stressful work among people who were exposed to childhood deprivation and to disadvantaged conditions in their early stages of labour market participation (proximal determinants). We also showed an almost linear association of average national levels of stressful work with the degree to which integrative labour policies were developed at country level, where more developed policies go along with better quality of work and employment (distant determinants). With our second finding we observed that the strength of associations between stressful work and mental health (depressive symptoms) seems to be attenuated by well-developed social and labour policies, a preliminary finding that deserves further exploration. Third, it became apparent that the steepness of social gradients of stressful work, as assessed by educational degree, again at average country level, varies according to the degree of implementation of favourable social and labour policies, such that gradients tend to be shallow if these policies are widely implemented. These novel findings extend the traditional frame of analysis of social inequalities in work and health beyond the micro-social level of single organisations and enterprises to include the potential impact of distinct macro-social welfare policies.

The second aim of our research programme, a synthesis of evidence concerning intervention methods and findings, was met by the main findings reported in chapter 4. Here, we concluded from the results of our systematic reviews of workplace interventions, as well as from the secondary data analyses, that there is a considerable potential of reducing work-related exposures to occupational hazards and, therefore, of reducing the work-related burden of disease. In view of the social gradient of unhealthy work, this would result in a sizeable reduction of social inequalities in employed people's health across Europe. However, as evidenced by our review, only a small part of intervention research addressed the structural, organisational dimension of worksite health promotion programmes. Moreover, studies of lower-skilled occupational groups and their health benefits were

largely absent in the reviewed literature. Therefore, the need of implementing health-promoting working conditions among less privileged working populations is particularly high. These arguments lend support to the proposition of distinct recommendations for policy, practice, and further research that aim at reducing social inequalities in health by strengthening fair employment and working conditions. These recommendations are partly instructed by the conclusions of the Task Group Report on Employment and Working Conditions (as part of the WHO-Euro Review of Social Determinants of Health [2,13]) written by the principal investigator of the current document and his team, and supplemented by propositions resulting from our new evidence.

6. Recommendations

6.1 Recommendations for policy

1. It is important to raise awareness among policy makers, political leaders, and responsible stakeholders among employers, trade unions, and occupational health and safety professions, that the following issues deserve high priority in decision-making and planning processes:
 - There is solid evidence that distinct and defined characteristics of stressful psychosocial work environments in modern economies increase the risk of physical and mental disorders among workers, in addition to, or in combination with, more traditional occupational hazards;
 - Exposure to these work- and employment-related adversities follows a social gradient, with less exposure among more privileged parts of the workforce. Particularly pronounced exposure and the related burden of disease is therefore higher among lower skilled people and those in atypical, unstable and dangerous employment;
 - These adversities can be monitored with reliable tools, their health impacts can be assessed, and interventions to reduce adversity and to strengthen the health of working people can be implemented at different policy levels. Moreover, models of good practice of such interventions are available, including information on their cost-effectiveness, thus addressing the business case;
2. Country-level social protection policies, including active labour market policies and occupational health and safety regulations, deserve high priority in national budget allocation and tax policies, particularly under conditions of financial constraints and related austerity measures [177];
3. The solid body of currently available knowledge needs to be disseminated through professional declarations by scientific networks, public media campaigns and related channels to motivate responsible stakeholders, political movements, NGOs and the broader public to call for action and to develop targeted initiatives (e.g. [14]);
4. As a first step of action, work- and employment-related adversities should be monitored in a systematic and regular way, using scientifically approved tools, and their health impact should be assessed in collaboration with occupational health and safety professionals. Ideally, monitoring should be supported by national regulations and related investments (e.g. Management Standards in the UK, Working Conditions Act in the Netherlands, Work Environment Act in Denmark), but voluntary agreements at regional or local/ enterprise level are useful as well [13];
5. As a next crucial step, monitoring data need to be translated into policy plans, using an established implementation cycle. To this end, guidance tools on psychosocial risk management approaches are available from the PRIMA-EF Programme [171]. Policy plans can be developed

and implemented at different levels, such as organisational level or macro-social level of national policies;

6. Appropriate occupational health and safety services, including the above-mentioned monitoring and programme development tasks, should be developed, financed publicly and independent of employers, prioritising their support to underserved occupational groups;
7. Given the gaps existing between declared national policy regulations/legislation and their implementation in practice, additional efforts are needed to promote healthy work and reduce health inequalities through formalised collaboration between stakeholders, voluntary agreements, and different forms of social dialogue, where the workforce is given voice in appropriate ways;
8. In view of large variations in quality of work and employment and in health inequalities of employed populations across Europe, and specifically between Eastern compared to Western, and Southern compared to Northern countries, policies at the EU level should be developed to reduce these variations by coordinating their efforts across established political sectors and resorts and by promoting proactive strategies.
9. Even though price stability is a fundamental factor for ensuring stability of real income, and even though guaranteeing competitiveness of enterprises is essential for income maintenance, these economic priorities should not be realised at the expense of fair wages, as is often the case. The goal of attaining high quality standards of working and living conditions across Europe implies respective high production costs of high quality goods and services. These costs in turn should result in appropriately high real wages that guarantee a decent quality of life and work for all members of the society.

6.2 Recommendations for practice

1. The implementation of measures to reduce health-adverse work and employment characteristics at the level of organisations, enterprises and businesses needs to be encouraged by enhancing compliance with occupational health and safety regulation;
2. Measures addressing physical, chemical and biological occupational hazards and those concerning work time regulation should be integrated into this comprehensive set of measures of promoting good work, by prioritising occupational groups with highest needs;
3. Organisational-level interventions addressing working conditions should take a participatory approach, involving employers/managers, professional experts and employees in appropriate ways and addressing change at all levels of the hierarchy, including leadership behaviour;
4. As lack of control and reward at work are shown to be critical determinants of a variety of stress-related disorders and to be more prevalent among lower occupational status groups, focusing interventions around these dimensions and targeting less privileged groups within the workforce are high priorities;
5. Combined efforts in making changes to the setting-focused work environment and to the employee-focused behaviour are encouraged, especially if resources of coping and the promotion of a healthy lifestyle are encouraged;
6. Adequate resources should be allocated to reduction of work-related diseases, and integration of disabled and sick workers into full employment, based on evidence of successful and cost-effective vocational rehabilitation models (e.g. individual placement and support [178], see also our Final Report on Case Studies in the context of the DRIVERS research programme [179]);

6.3 Recommendations for further research

1. It is recommended that systematic reviews of studies analysing work and employment as determinants of health inequalities observe best practice principles in order to strengthen their case (e.g. focus on cohort studies, use of comprehensive, theoretically-grounded and reliable exposure measures, appropriate statistical analyses);
2. It is recommended that the design, reporting and evaluation of interventions should comply with the best available procedures in social science research designs and statistics (e.g. use of validated measurement instruments, conduction of power analysis, correction of attrition bias, etc.);
3. It is recommended that cross-country studies which analyse distal work-related determinants of health inequalities use comparable, well-justified indicators of relevant national labour and social policies, and that these distal determinants are linked with proximal determinants within a conceptual framework, such as the one proposed in our research programme, using appropriate statistical techniques of data analysis.

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The research is undertaken by a consortium including leading research centres and organisations representing the public health sector, civil society and businesses.